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Energy Efficient Retrofits using Transaction Cost Theory: Evidence from Indonesia

(Penggunaan Kecekapan Tenaga Menggunakan Teori Kos Transaksi: Bukti dari Indonesia)

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ABSTRACT

The study aimed to analyze the factors that influence the energy-efficient retrofits decisions using transaction cost theory. The research was conducted from December 2020 to July 2021, involving 105 samples that comprise of Indonesian building owners, operations managers, and Chief of Operations. The data was analysed using Partial Least Squares model. The key findings were that uncertainty and asset specificity, rather than transaction costs, were the main factors influencing building owner and occupants' decisions to pursue energy efficiency retrofits. This highlights the need to address service guarantees, specialized assets, and uncertainty to facilitate adoption. This study contributes to the transaction costs of economics in green retrofitting financing models. Therefore, this research provides framework for developing ideas in implementing green retrofitting. The study suggests retrofit providers should prioritize reducing uncertainty and highlighting asset specificities, such as solid service guarantees, branding, expertise, and equipment quality, to drive greater adoption of energy-efficient retrofits. This research offers practical insights into owner-occupant motivations, benefiting the building industry in improving marketing, partnerships, contracts, and client relationships to boost retrofit adoption. Overall, the findings support the growth of retrofitting and related sectors by demonstrating their viability and emphasizing the key factors that influence adoption.

Keywords: Transaction cost economics; retrofitting; energy efficiency initiative; uncertainty; asset specificities; partial least squares

ABSTRAK

Kajian ini bertujuan untuk menganalisis factor-faktor yang mempengaruhi keputusan pengubahsuaian kecekapan tenaga menggunakan kos transaksi. Kajian ini dijalankan mulai Disember 2020 sehingga Julai 2021 dan melibatkan 105 sampel individu yang terdiri daripada pemilik bangunan, pengurus operasi dan Ketua Operasi Inodesia. Data dianalisis menggunakan model Kuasa Dua Terkecil Separa. Penemuan utama kajian ialah ketidakpastian dan pengkhususan aset merupakan faktor utama mempengaruhi keputusan pemilik bangunan-penghuni untuk meneruskan pengubahsuaian kecekapan tenaga, berbanding kos transaksi. Kajian ini menyumbang kepada kos transaksi ekonomi dalam model pembiayaan pengubahsuaian hijau. Oleh itu, kajian ini menyediakan kerangka kerja untuk membangunkan idea dalam melaksanakan pengubahsuaian hijau. Kajian ini mencadangkan pembekal pengubahsuaian harus memberi keutamaan dalam mengurangkan ketidakpastian dan memberi fokus terhadap pengkhususan aset, seperti jaminan perkhidmatan yang kukuh, penjenamaan, kepakaran dan kualiti peralatan untuk memacu penggunaan pengubahsuaian kecekapan tenaga yang lebih besar. Penyelidikan ini menawarkan pengalaman praktikal tentang motivasi pemilik-penghuni, memberi manfaat kepada industri bangunan dalam meningkatkan pemasaran, perkongsian, kontrak dan hubungan pelanggan untuk meningkatkan penggunaanpengubahsuaian. Secara keseluruhan, penemuan kajian menyokong pertumbuhan pengubahsuaian dan sektor berkaitan dengan menunjukkan daya maju dan menekankan faktor utama yang mempengaruhi penerimaan.

Kata kunci: Kos transaksi ekonomi; pengubahsuaian; inisiatif kecekapan tenaga; ketidakpastian; pengkhususan aset; kuasa dua terkecil separa
JEL: G4, L2, L8, M2, N6, Q3.
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INTRODUCTION

The economic growth drives increased average power needs. However, there are issues on energy scarcity and climate change. For example, one significant area for potential energy savings lies within the commercial building sector, where savings of up to 25% are feasible. Therefore, it is important to investigate the factors that influence the energy-efficient retrofits decisions using transaction cost theory. The research was conducted from December 2020 to July 2021, involving 105 samples that comprise of Indonesian building owners, operations managers, and COOs. The data was analysed using PLS model. The findings show that that uncertainty and asset specificity, rather than transaction costs, were the main factors influencing building owner and occupants' decisions to pursue energy efficiency retrofits. This highlights the need to address service guarantees, specialized assets, and uncertainty to facilitate adoption.

This research differs from Montalb'an-Domingo et al. (2018); Wang et al. (2012) in that it is the first to address transaction management, specifically in the context of green retrofit financing—a field not often included in the scope of transaction cost theory. This study closes a crucial gap by highlighting transaction management as the secret to the success of green retrofit finance arrangements. In contrast, previous studies by Hong et al. (2020) primarily focus on businesses or technical production elements. It explores the macro level and offers a thorough grasp of Indonesia's retrofit finance processes, a topic that has not received much attention. This study offers a distinct viewpoint that has not been sufficiently covered by other research and attempts to define transaction characteristics and construct a basic theory of transaction costs. This work adds a new perspective to the investigation of green retrofit finance within the transaction cost economics framework by focusing on transaction complexity and its effective management, setting it apart from previous research (Xing et al. 2011).

BACKGROUND OF THE STUDY

Indonesia is one of the world's most densely populated countries and is poised to reap long-term financial benefits from embracing an energy efficiency program, given its exponential growth (Sudarmaji et al. 2021a; Sudarmaji et al. 2021b; Frankel et al. 2013). Due to this rapid growth, Indonesia's state-owned electricity utility struggles to meet the nation's surging demand for reliable energy. This study focuses on investigating Indonesia's comprehension of and receptivity to the implementation of green retrofit finance in energy efficiency initiatives, particularly in the context of retrofitting LED lighting. The "National Energy Conservation Master Plan (RIKEN)" comprises a comprehensive set of guidelines for various governmental entities, including the national government, provincial and district/city governments, employers, and communities across different sectors. These guidelines aim to facilitate the implementation of national energy conservation activities, spanning energy supply, transformation, and utilization. The Indonesian government introduced RIKEN with the dual purpose of addressing energy scarcity and combating climate change. In building and construction, the Republic of Indonesia's Law No. 28 of 2002 is pivotal in regulating energy efficiency and establishing the National Energy Efficiency Standard. This legislation encompasses various aspects, including the building envelope, air conditioning systems, and lighting standards. In the context of energy efficiency, Indonesia has set ambitious targets. By 2025, the government aims to reduce energy demand to 251 million Tons of Oil Equivalent, resulting in approximately 17% savings compared to the Business as Usual (BaU) scenario.

LITERATURE REVIEW

The term "retrofit" entails the replacement of existing, outdated equipment with newer, more efficient alternatives, (Jafari & Valentin 2017; Luo & Oyedele 2022; Nasip & Sudarmaji 2018) as with the case in engineering (Galvin & Sunikka-Blank 2017; Luo & Oyedele 2022; I. Weber & Wolff 2018; World Economic Forum 2011). From a technical perspective, green retrofitting presents a financially sound investment with the potential to reduce waste over time by extending the lifespan of products (International Energy Agency 2018). At the heart of this research lies an in-depth analysis of the 'transactions' between green retrofitting providers and building owners or occupants. To guide this investigation, the study adopts "Transaction Cost Economics (TCE)" as its central theoretical framework.

TCE examines transactions that take place when goods or services are transferred across organizational boundaries, characterizing them by elements such as conflict, mutuality, and orders (Deng & Zhang 2020). Within the TCE framework, transactions vary in numerous aspects, including the specific relationship value attributed to each party, the level of uncertainty surrounding one party's actions toward the other and future expectations, the complexity of agreements, and their frequency of occurrence. This variation informs how companies make decisions regarding transaction management. The study delves into three critical factors: uncertainty, asset specificity, and economic utility, as antecedents influencing intentions related to participation in the Energy Efficiency Initiative using transaction cost economic theory. These variables are subsequently detailed, underpinning the formulation of seven hypotheses. The focus of the green retrofit transaction revolves around the asset specifications for investment, an aspect considered vital in TCE (Riordan & Williamson 1985). TCE's purview includes examining how trading firms safeguard their interests when engaging in transactions with other firms (Williamson 1981; Riordan & Williamson 1985). According to TCE, trading partners strive to secure arrangements that are most advantageous in terms of cost and investment protection (Williamson 1981). Success in business hinges on a company's capability to efficiently manage transactions while harnessing market forces, as underscored by Williamson's perspective. Similar to Resource-Based Theory (RBT), TCE places its focus on assets but emphasizes their organization and management, rather than purely prioritizing profit generation or performance (Amit et al. 2007).

In the existing research, there is little knowledge of how economic and non-economic variables influence decisions for energy efficiency initiatives (Curtis et al. 2017; Wu et al. 2017). The operation's costs significantly influence adopting the green retrofit decision (Bonetti et al. 2016). However, information access could lead to greater number of building owners, owner-occupants and other energy users adopting green retrofitting practices (Liang et al. 2016). Unfortunately, the uncertainty on the green retrofitting information further reduces the benefits of practical energy usage. Under the TCE theory, when a specific good or service is transferred across organizational borders, transactions are essentially the materialization of conflict, reciprocity, and order (Williamson 1979, 1981). In this perception every transaction has differences. The first factor is the level of interaction between the business owner and the retrofitting provider regarding the assets that initially form their transactional relationship (Qian et al. 2013; L. Weber & Mayer 2010). The second factor refers to the intricacy of the transactional agreement before the actual transaction occurs, while the last factor, which deals with uncertainty about the other parties' behaviour, is crucial (Riordan & Williamson 1985; L. Weber & Mayer 2010).

The main objects in this study are the intentions of the building owner and owner-occupant. The theory of reasoned action and planned behaviour on individuals' intentions and behaviour (Ajzen 2002b, 2002a, 2011) underlies the idea. Most researchers found a relationship between consumers' purchase intention and behaviour (Heesen & Madlener 2016). "Intentions" are subsequently used widely and have good predictive validity of purchase behaviour (Urban & Katz 1983; Infosino 1986). Dal Lago et al. (2017) found that behavioural intentions were associated with serviceability in the service area. Since the Energy Efficiency Initiative or green retrofitting is rather a new concept, most building owners and owner-occupants may face difficulty handling the situation, and the different levels of the owner-occupant may lead to diverse acceptance levels.

TRANSACTIONAL COSTS

TCE is used as an analytical tool to investigate by many industries, primarily manufacturers and their suppliers (Ketokivi & Mahoney 2020; Qian et al. 2013; Weber & Mayer 2010). The elements of TCE were used, such as bounded rationality, opportunistic behaviour, asset specificity, and uncertainty and frequency of relations. Bounded rationality (Safarzyńska 2018; Van Den Bergh & Gowdy 2000) leads to an escalation in the transaction cost due to the presence of restrictions or limitations among the involved parties in accumulating, processing, and transmitting the information, as well as the connection between the possibility of opportunistic actions to the asset specificity (Deng & Zhang 2020; Hence Leiblein 2003). This study used the same elements of TCE (Riordan & Williamson 1985), including the cost involved in the Energy Efficiency Initiative process, the cost associated with each of the retrofitting stages, such as comparison cost, examination cost, negotiation cost, delivery cost, and monitoring cost. Accordingly, we posit the hypothesis,

H_1 We hypothesized that Transaction Costs have a negative impact on owner-occupants' intention in retrofitting finance.

UNCERTAINTY

According to Weber and Mayer (2010) uncertainty plays a role in revealing that the transaction cost tends to rise due to the constraints of bounded rationality (Qian et al. 2013; Weber & Mayer 2010). Under the TCE, an appropriate response to the presence of numerous uncertainties in a transaction is to withdraw, as uncertainty is a significant contributing factor to the analysis of transaction costs analysis (Deng & Zhang 2020). Uncertainty is divided into four kinds of TCE (Riordan & Williamson 1985), i.e. product, process, service, and behavioural. Thus, we postulate hypotheses H_6 & H_7, as follows: We propose that uncertainty has a positive impact on Transaction Costs and owner-occupants' Intentions in retrofitting finance.

ASSET SPECIFICITY

Asset Specificity refers to the extent to which assets that support a transaction are tailored to it and can also be considered as several opportunity costs for using the same assets in the next-best alternative should the transaction be prematurely terminated (Belloc et al. 2016; De Vita et al. 2011; Riordan & Williamson 1985). In practice, specificity in assets can be considered a durable investment that a firm should make to support its regular transactional activities. Asset specificity provides a glimpse into an investment, including physical and human capital, intangible assets, capabilities, and R&D abilities. In the transaction context, retrofitting efforts can be in the form of purchasing energy-efficient equipment (equity-based or direct expenditure) or implementing a debt (capital) lease. As a transaction cost model, retrofit financing is a strict and inflexible financial mechanism, whereas equity-based financing is more adaptable and discretionary. If the retrofit project fails, the provider assumes control over the underlying asset and may choose to liquidate it. Financing the retrofit to improve energy efficiency through debt is a high-cost governance arrangement for the retrofit provider due to the highly specific nature of the assets involved (i.e., not re-deployable). If the retrofit project succeeds, the payments for both interest and principal will be made according to the schedule. However, if the project fails, the retrofit provider cannot recover their investments by selling off the assets used in the project. These assets are highly specific and cannot be redeployed, thus presenting a high level of risk for the provider. In this cognizance, the interest rate required for financing the project would also be very high, creating liquidity problems for the company. Thus, our hypotheses in H_2 & H_3: We hypothesized that Assets Specificity has a positive impact on transaction Costs and owner-occupants' intentions in retrofitting finance.

ECONOMIC UTILITY

Economic utility was the main factor that affected the perceived transaction cost (Howarth et al. 2000; Baker et al. 2012). Weirich (2005) found that it negatively impacts transaction costs. Heukelom (2015) also indicated that economic utility is critical for business owners to make decisions. It refers to the economic quality or practical usefulness to the business owner. Two elements of economic utility adopted in this research were perceived value and perceived risk. Perceived value in this Energy Efficiency Initiative focuses on benefits through retrofit value features. Under the TCE, the perceived risk of economic utility occurs in the risky energy efficiency initiative environment. Consumers' intention decision depends on both the perceived value and risk. Past empirical studies have investigated the relationship between consumers' perceived values (de Cannière et al. 2010; Kimita et al. 2016; Roig et al. 2009). Perceived risk was used in this research, as theorized by Chin and Lin (2016) and Polzin et al. (2016). The consumers' perceived risk developed from the act and subjective feelings that the results were not favourable to the customer. However, the dimensions of perceived risk may depend on the product (or service) class (Ardolino et al. 2016; Eastlick & Feinberg 1999; Ulaga & Reinartz 2011). This study is the first to integrate the variable perceived risk in TCE perspectives. Thus, we propose the following hypotheses, H_4 & H_5: We hypothesized that Economic Utility has a positive impact on transaction Costs and owner-occupants' intentions in retrofitting finance.

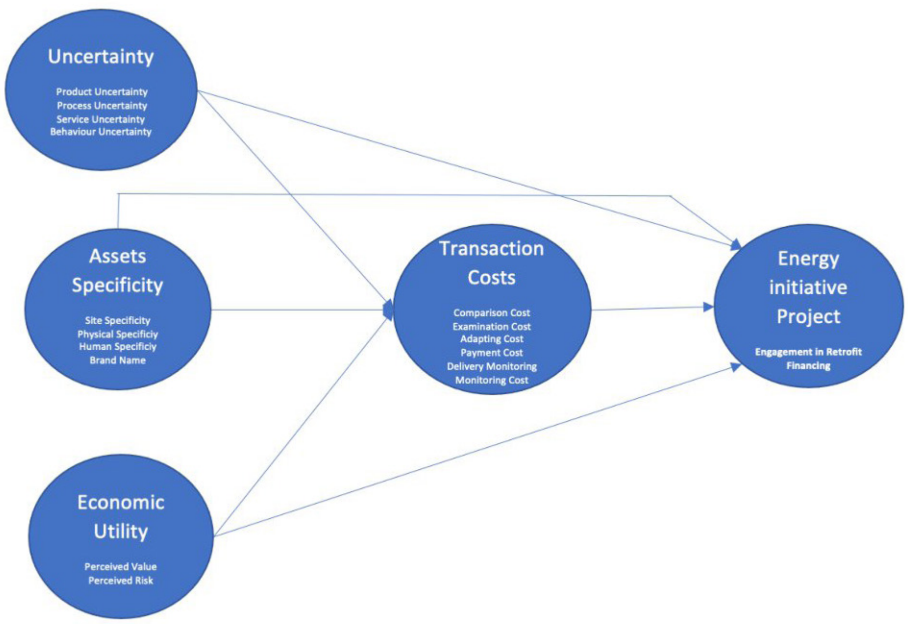

FIGURE 1. The transaction cost economic research framework

Based on the framework in Figure 1, this study investigates the engagement in retrofit financing using the TCE perspectives, coupling with the independent variables of asset specificity, uncertainty and economic utility synthesized with transaction costs. A theoretical model was proposed that may explain the relationships between the building owner and owner-occupant. The research framework examines the financial advantages of implementing an energy efficiency program in Indonesia, a country with a large population and fast economic expansion. Using Transaction Cost Economics (TCE) as a critical theoretical framework, it investigates the nation's preparedness for green retrofit financing in energy-efficient projects, mainly LED lighting replacement. TCE looks at the dynamics of interactions between building stakeholders and retrofitting providers, accounting for variables such as economic utility, asset specificity, and uncertainty that affect the objectives of the Energy Efficiency Initiative. This study closes a knowledge gap on the influence of both economic and non-economic factors on energy efficiency initiative choices. It also offers insightful information in this unexplored field, which may help shape future practices and policies to improve relationships and transaction management.

METHODOLOGY

Sampling of energy efficiency was conducted in the building industry located in the DKI Jakarta area. The authors limited the research area to 'Commercial and industrial business buildings, Residential customers and MUSH (municipalities, universities, schools and hotels). The respondent target, aligned with the market for those new investments, is growing significantly in the incentivizing green retrofit finance lately (Ottinger & Bowie 2015). Furthermore, the sample buildings must already exist and have been established for over two years. The DKI Jakarta area was selected since it already had approximately 1336 buildings in 2015, according to the DKI Regional Government Spatial Planning Department. The number of buildings can be considered to represent other regions in Indonesia.

The number of registered buildings for offices, hotels, campuses and schools is approximately 183 buildings. The main targets are owners or operational managers, administrators and building managers representing building owners and investors. The criteria for sampling the experimental group was based on the equipment used by the company, which must be energy-intensive and utilised/operated for more than 12 hours in one day. The usage requirement will determine the maximum energy cost savings or that can be felt by the company. The authors excluded municipalities in the sampling for particular reasons.

The research employed a quantitative approach to investigate the financing activities, current business risks, and owner-occupant behaviour in the energy-efficiency lighting industry through the perception of contemporary finance and transaction cost theory. The research methodology involved utilizing TCE Theory principles and administering a structured questionnaire and interviews to industry practitioners in Indonesia, with the PLS-SEM methods adopted to test the theoretical framework. The focus of analysis was the relationship between the building owner or owner-occupant and the sample respondent involved in retrofitting. Interviews were subsequently conducted with the prospective participants. The owner-occupant executive was identified by retrofitting provider as the most responsible for managing the retrofit business relationship. To comprehend the present practice scenario, the study developed the conceptual framework as a fundamental construct or model of what exists and what is happening with retrofit finance.

The sample consisted of both potential building owners and owner-occupants who were knowledgeable on the ongoing process of retrofit project activities, including current technology, new energy-efficiency products, and finances. In the sample, the target individual respondents were differentiated between building owners or operations managers, or operations directors (Chief of Operations) who were in charge of technology policy that directly interact with energy costs, within their companies. The sampling of the individual respondent is purposive since only the management and owners of the building can provide information on energy efficiency technologies adopted by them. Executive groups and owners were selected through purposive sampling to reflect knowledge, experience and attitudes towards energy efficiency in Indonesia. A total of 105 respondents out of 130 was selected, which was more than the required 98 samples determined based on a standard formula (Dekanozishvili 2023). The authors did the Pre-test analysis of 10% of the samples to gauge the effectiveness of the questions directed to the target respondents.

The questionnaires used a five-point Likert scale with the lower scores that gauge disagreement. The initial pre-test was conducted on a few individuals and the results used to reframe the questionnaire for more precise response. The survey garnered 91% response rate, with complete answers, within one month out of 105 questionnaires distributed. The respondents comprised a group of executives or managers with exceptional knowledge of the energy efficiency initiative project. They were highly educated and fully comprehended energy-saving operations. The engagement of retrofit financing combined with the Likert scale, as adopted in this research was consistent with the approach by Galvin & Sunikka-Blank (2017).

The framework of this study can be explained in four parts, namely identifying research problems and research gaps in stage 1; analysis of the causal/impact factors in the 2nd stage; and mapping of problems with theoretical models and discussion of the analysis of the results in the third and fourth stages. In stage 3, the collected data was processed using the PLS-SEM analysis tool with the bootstrapping method. The author used the 'Rule of Thumb' for the reflexive indicator construct adopted from Ghozali & Latan (2012); see Table 1, where the validity test determines the respondent's interpretation of each statement item in the research instrument. On the other hand, the reliability test was carried out to test the respondent's interpretation of the statement items contained in the research instrument, as indicated by the consistency of the answers. The Cronbach's alpha coefficient formula is the cut-off value used to assess or test whether each variable is reliable and accurate.

TABLE 1. Validity and reliability parameter

Validity and Reliability	Parameter	Rule of Thumb
Validity Convergent	Loading Factor	> 0.60
	Average Variance Extracted (AVE)	> 0.50
	Communality	> 0.50
Discriminant Validity	Cross Loading	> 0.70 for each variable
	AVE square root and correlation between latent constructs	The square root of AVE > correlation between latent constructs
Reliability	Cronbach's Alpha	> 0.60
	Composite Reliability	0.60 – 0.70

RESULT AND DISCUSSION

The PLS path modelling was employed to analyse the proposed model. A total of 16 items were utilized to measure five constructs, and it was necessary to examine the relationship between them and their respective measurement items. To achieve this, we conducted a loading factor analysis to eliminate any factor with a loading less than 0.6, following the method outlined by Ghozali & Latan (2012). Four items were thus deleted. One was the indicator on site specificity which, as in Energy Efficiency Initiative projects, was not directly supporting the services. Ketokivi & Mahoney (2020) stated that site specificity incurred significant transaction cost on manufacturing companies such as the auto suppliers and GM automakers. The others were two indicators, i.e., post-delivery cost (monitoring cost) and negotiation cost with less than 0.6 loading factors, and followed by the indicator on perceived risk.

Figure 2 illustrates the demographics of the respondents. A total 71% of the building management respondents are located in the South Jakarta area, 23% in the Central Jakarta area, 4% in the West Jakarta area, and only 1% are in the East Jakarta area. Each building managed by the respondents on average had been established for more than two years; namely, 43% had been established for more than 11 years, 11% for 8 to 11 years, 21% for 5 to 8 years, and 24% for 2 to 5 years.

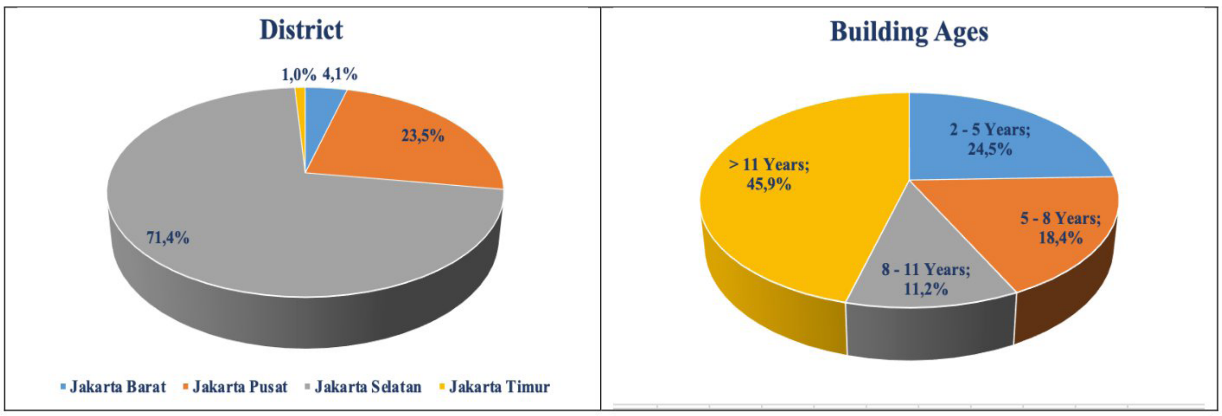

FIGURE 2. Respondent characteristic

Figure 3 describes similar statistics. The buildings managed by the respondents comprised 35% offices, 35% apartments and 31% hotels. The built area on average covers 10,000 m² to 20,000 m². The average operational hour usage of electricity per day were 73% for the duration of 12 hours to 16 hours, 13% for 16 hours to 20 hours and 3% for 20 hours to 24 hours. The use of electrical energy was 55% for air conditioners, 41% for elevators, 3% for lamps/lighting and 1% for water pumps.

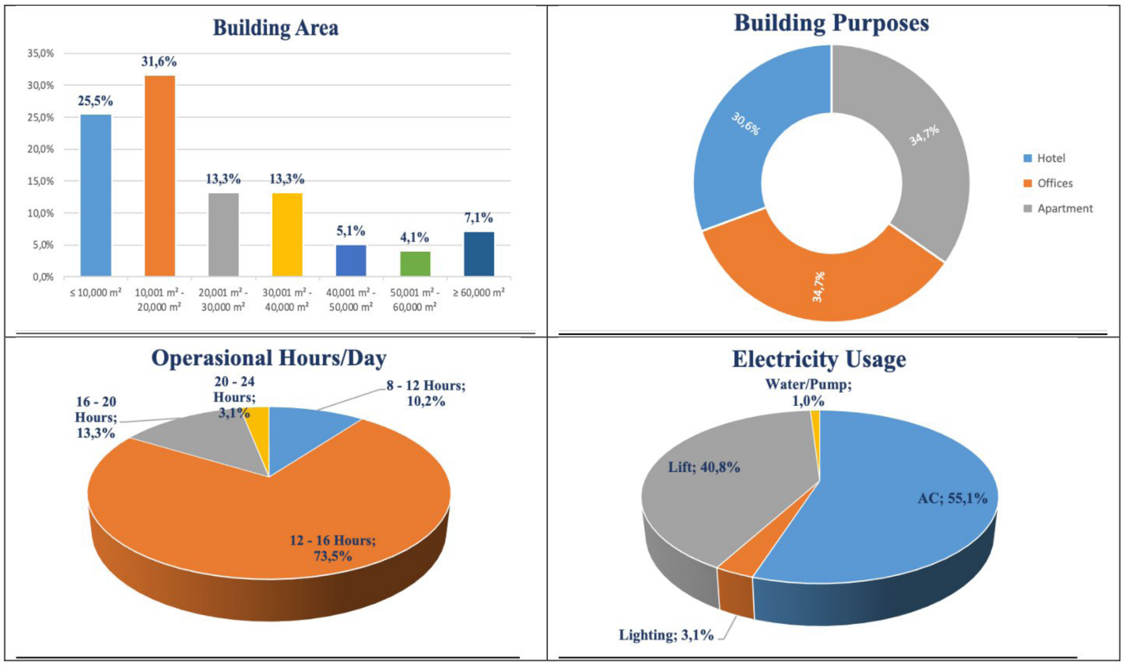

FIGURE 3. Building characteristic

TESTING THE MEASUREMENT MODEL

The objective of the construct validity test used in the study was a test of generalization. It assesses whether the research variables were addressed in the testing; namely how well a test or experiment conducted lives up to its claims or whether the operational variables reflect the actual concept.

TABLE 2. The construct reliability and validity

Construct Reliability & Validity		Outer Loading	Cronbach's Alpha	Composite Reliability	Average Variance Extracted (AVE)
	Brand Name Specificity	0.695			
Assets Specificity	Human Specificity	0.814	0.625	0.792	0.661
	Physical Specificity	0.732			
Economic Utility	Perceived Value	1.000	1.000	1.000	1.000
Energy Initiative - engagement in retrofit financing	Behaviour Intention	1.000	1.000	1.000	1.000
	Comparison Cost	0.816			
Transaction Costs	Delivery Cost	0.808	0.720	0.838	0.633
	Examination Cost	0.761			
	Process Uncertainty	0.902			
Uncertainty	Product Uncertainty	0.801	0.849	0.908	0.768
	Service Uncertainty	0.922			

As shown in Table 2, the outer loading of each variable indicator in the study has good reliability since all the outer value of loading has a minimum toleration score of 0.60 (Ghozali & Latan 2012). Further, two criteria—the Alpha Cronbach's and Composite Reliability—were measured as part of the construct reliability test. The readings indicate the reliability of all the indicators utilized in the study. The alpha level of 0.7 is the minimum acceptable value and the results showed that all indicator variables exceeded this value, except for assets-specificity indicators that were below the minimum. Fortunately however, the composite reliability test on assets-specificity exceeded 0.7 and the value is interpreted the same as the value of Alpha Cronbach.

The discriminant validity test was the second test. The correlation between each construct and the other constructs in the model was compared with the individual root of the Average Variance Extracted (Root AVE). The discriminant validity was tested to see how well the remaining items with loading factors greater than 0.6 could distinguish between various constructs or measure them. Table 3 shows the findings of the discriminant validity analysis, which assesses how differentiable are certain constructs or variables from one another in the study. Five dimensions were taken into consideration in this analysis; transaction costs, uncertainty, energy efficiency initiative (including participation in retrofit finance), asset specificity, and economic utility. The correlations between these constructs are shown by the readings in the table, where the square root of the Average Variance Extracted (AVE) for each construct is indicated by the values along the diagonal. Discriminant validity is proven when a concept's square root of the AVE is higher than the correlation coefficients between that construct and other constructs.

TABLE 3. The discriminant validity

Discriminant Validity	Assets Specificity	Economic Utility	Energy Efficiency Initiative	Transaction Costs	Uncertainty
Assets Specificity	0,657				
Economic Utility	0,559	0,741			
Energy Efficiency Initiative - engagement in retrofit financing	0,534	0,404	1,000		
Transaction Costs	0,457	0,287	0,351	0,651	
Uncertainty	0,180	0,167	(0,234)	0,185	0,876

Based on the scores in Table 2 and Table 3, we concluded that most indicators were statistically significant. Each component placed a more significant burden on its connected structures than on any other construct. The fit between the data and the theoretical model was also acceptable. As a result, we concluded that the measurement model sufficiently distinguished between the constructs and the study satisfied the criteria for the testing.

TESTING THE STRUCTURAL MODEL

We verified the measurement model and then examined closely the structural model. The assessment included determining the standardized path coefficients' magnitude, sign, and significance. The results show that the coefficient of determination (R2) is 36.7% of the variance in Energy Initiative; the model accounts for the retrofit and 25.5% of the variance in Transaction Costs. Table 4 below shows the correlations between the many elements examined in the study. With a total effect of 0.466 above the sample mean, asset specificity has a considerable and statistically significant positive impact on transaction costs shown in the second row. In contrast, a positive total effect of 0.273 is shown in the fifth row when examining the impact of economic utility on participation in retrofit finance under the Energy Efficiency Initiative. This effect is not statistically significant although showing positive trend. On the other hand, economic utility, in the fourth row, has a non-significant and small overall influence on transaction costs (0.038). Furthermore, in the first row, transaction costs have little and non-significant impact (0.228) on participation in retrofit finance. With a total effect of -0.353 in the last and seventh row, which matches the sample mean although non-significant, it is clear that uncertainty significantly lowers participation in retrofit finance under the Energy Efficiency Initiative. These results reveal substantial but non-significant impacts on the Energy Efficiency Initiative, adding to a more refined understanding of the relationship between involvement in retrofit finance and asset specificity, economic utility, transaction costs, and uncertainty. Our assumptions are supported by the data, which show that asset specificity has a substantial effect on transaction costs (H_2), a favourable impact on owner-occupant intentions (H_3), and a negative effect on those intentions (H_6).

Based on their p-values and T statistics, each hypothesis is carefully evaluated for statistical significance. Firstly, a significant difference between the sample mean, and the original data is shown by a very high T statistic (3.187) and an extraordinarily low p-value (<0.01), both of which support the acceptance of H_2, which examined the link between Assets Specificity and Transaction Costs. Hypothesis H_5, on Economic Utility regarding Energy Efficiency Initiative participation in retrofit finance, is accepted at the 10% level based on a p-value of 0.079 and a T statistic of 1.758, indicating a statistically significant difference. Hypotheses H_1, H_3, H_4, and H_6, on the other hand, are not rejected, suggesting that there is no significant relationship between Transaction Costs and Energy Efficiency Initiative engagement (H_1), Assets Specificity and Energy Efficiency Initiative engagement (H_3), Transaction Costs and Economic Utility (H_4), and Transaction Cost Uncertainty (H_6). Finally, H_7, which examines the effect of uncertainty on participation in the Energy Efficiency Initiative, is supported by a comparatively high T statistic of 3.059 and a low p-value of 0.002, highlighting a significant difference between the sample mean and the original dataset.

Figure 4 depicts the graphical representation of the proposed model along with the regression coefficients. PLS-SEM is nonparametric; hence, the parametric tests of significance based on standard distribution assumptions were not worked on for parameter estimates. Therefore, the precision of the estimates needs checking through standard errors when we conduct the bootstrap procedure. When the bootstrap was processed, 'N' samples were replaced from the original data set. Hence, 'N' estimates for each parameter in this model were obtained, and its standard deviations (standard errors) were computed. This study employed a bootstrap facility with a 95% confidence interval to obtain 5000 samples. Figure 4 illustrates the output generated by the bootstrap model showing factor loadings and confirmatory factor analysis (CFA). Results in Table 4 and Figure 4 indicate that the data did not support our initial hypothesis, which stated that perceived transaction costs impact owner-occupants intention to retrofit. Conversely, they specifically demonstrated that consumers' perceived transaction costs of time and effort were not correlated with owner-occupant intentions.

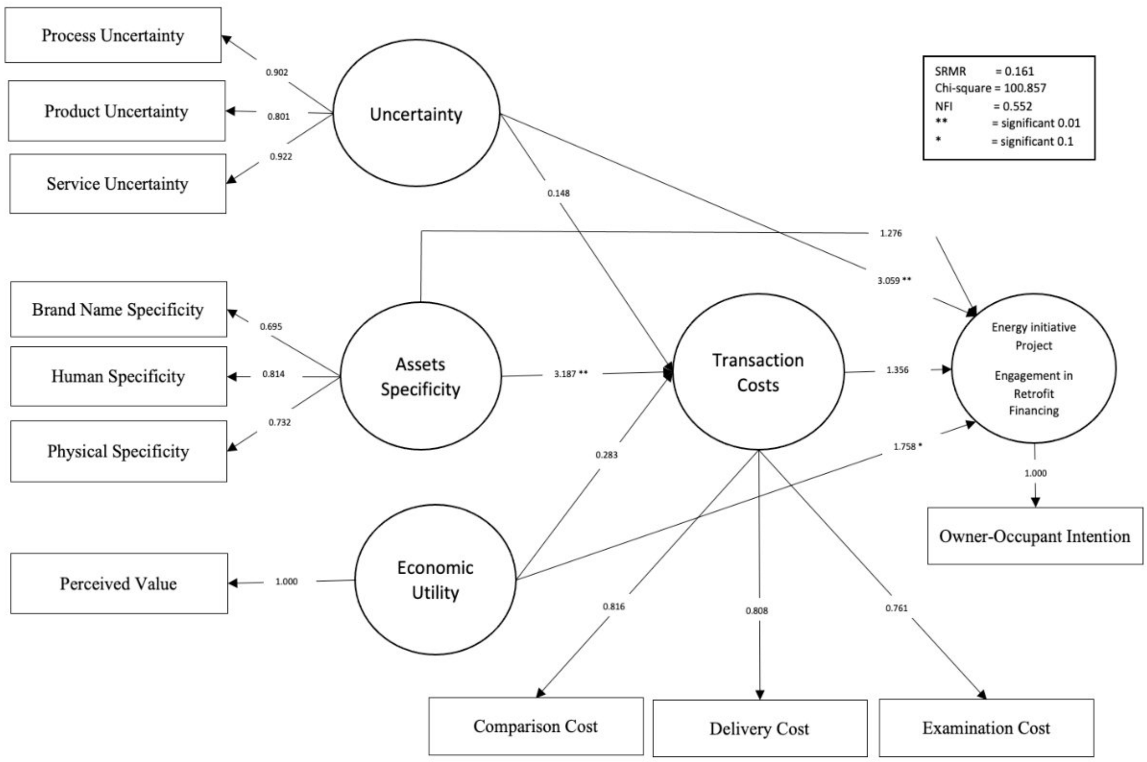

FIGURE 4. Illustrates a graphical representation of the model, including the loadings

TABLE 4. Total effects with bootstrapping

	Original Sample (O)	Hypothesis	Sample Mean (M)	Standard Deviation (STDEV)	T Statistic		P Values
Transaction Costs to Energy Efficiency Initiative - engagement in retrofit financing	0.228	H_1 - Rejected	0.236	0.168	1.356		0.175
Assets Specificity to Transaction Costs	0.466	H_2 - Accepted	0.483	0.146	3.187	** 0.01	0.001
Assets Specificity to Energy Efficiency Initiative - engagement in retrofit financing	0.212	H_3 - Rejected	0.227	0.166	1.276		0.202
Economic Utility to Transaction Costs	0.038	H_4 - Rejected	0.031	0.133	0.283		0.778
Economic Utility to Energy Efficiency Initiative - engagement in retrofit financing	0.273	H_5 - Accepted at 10% Level	0.247	0.155	1.758	* 0.1	0.079
Uncertainty about Transaction Costs	0.020	H_6 - Rejected	0.020	0.135	0.148		0.882
Uncertainty to Energy Efficiency Initiative - engagement in retrofit financing	-0.353	H_7 - Accepted	-0.353	0.115	3.059	** 0.01	0.002

*significant at 0.10; **significant at 0.01

The t-test results in Table 4 and Figure 2, clearly do not support the negative relationship (H_1). The owner-occupant had lowered the delivery cost and compare-cost but raised the examination cost. Accordingly, the energy efficiency initiative taken by the owner-occupants was found to be quite acceptable since they have taken the advantage of reducing the delivery cost and compare-cost. The study used the same TCE elements (Riordan & Williamson 1985) including the cost involved in the Energy Efficiency Initiative process and the cost associated with each stage, such as comparison, examination, negotiation, delivery, and monitoring costs. The comparison, examination, negotiation affecting the owner-occupant transaction cost in time and effort were used to compare, analyse, and negotiate information regarding various products, services, and other characteristics among different retrofitting providers. The delivery and monitoring costs affecting the owner-occupant transaction cost in time and effort were related to overseeing the products and services provided during the implementation phase. This ensured compliance with the terms of the contract, as well as providing support throughout the retrofitting agreement. In the final decision, the owner-occupants chose to minimize perceived transaction costs.

Our hypothetical model posited that asset-specificity positively impacted perceived transaction costs (H_2) and owner-occupant intentions (H_3). It was also hypothesized to positively impacted the transaction costs (H_2). Four kinds of asset specificity were used to investigate retrofit financing; Site specificity, Physical asset specificity, Human asset specificity and Brand specificity. The first three elements were adopted from Williamson (1981). Site specificity refers to a nearby location that improves coordination and thus save on inventory and transportation costs. Physical asset specificity refers to specific capital investments, and Human asset specificity refers to a particular expertise or specialized knowledge (De Vita et al. 2011). Finally, Brand specificity pertains to utilizing product brands from third-party entities in retrofit financing.

The results revealed that assets-specificity invested by the retrofitting provider positively affects the owner-occupants perceived transaction costs (H_2) at 1% significance level. However, in the case of owner-occupant intentions (H_3), the findings were not significant. Owner-occupants tended to have higher expectations regarding Brand specificity, Human specificity, and Physical specificity. Accordingly, the study established that assets-specificity by the owner-occupants was found to be quite acceptable since they take advantage of the three elements of Brand-specificity, Human-specificity and Physical-specificity. The findings were in line with most of the empirical studies in TCE. As an independent variable, asset specificity may be identified as site, physical, human, and brand assets (Belloc et al. 2016; Deng & Zhang 2020; Riordan & Williamson 1985) that are committed to a specific transaction.

These assets are considered barriers to opportunistic behaviour and exchange threats as they would minimize the transaction costs. The greater the specificity leads, the greater the risks, which may induce higher transaction costs. During the bootstrap process, the original dataset was replaced with 5000 samples using the bootstrap tool, and a 95% confidence interval was utilized. The findings were consistent with the theory that maintains that a company incurs costs to do the transaction which can be reduced through some elements as per TCE perspectives (Riordan & Williamson 1985; Williamson 1979, 1981).

The study elucidated the match function of the economic utility related to the Energy Efficiency Initiative of the owner-occupant against transaction cost of economics attributes, adopted as the strategy. We believe that the simple transaction cost model and no upfront investment in energy efficiency products make it possible for owner-occupants to achieve greater economic utility. The study hypothesized that economic utility positively impacts consumers' perceived transaction costs (H_4). However, according to the results of t-test in Table 4, such a relationship was found not significant. The economic utility was positive at 90% confidence interval and related to owner-occupant intentions (H_5), which suggests a 10% significance level. The owner-occupant had comprehensibly lower expectations of economic utility since the retrofit project naturally created this function over the new equipment.

Based on information from the field survey, an interpretive analysis was used to identify the characteristics of TCE uncertainty selected in this study. Four different types of uncertainty related to retrofit financing were examined; namely product uncertainty, process uncertainty, service uncertainty, and behavioural uncertainty which comprise transaction-based components of retrofit financing. There was a weak positive correlation between uncertainty and transaction costs (H_6) that was not significant in the other hypothesized model. However, the service uncertainty of the retrofitting provider produced the most substantial effect on owner-occupant intentions (H_7) instead of the owner-occupant perceived transaction costs among the various kinds of uncertainty. The findings were significant at 1% level. The findings confirmed our initial argument for (H_6) but not for (H_7).

The findings showed that in the retrofit project, the owner-occupants make prior decision on whether their interests can be protected in a service-guarantee agreement. These findings prompted owner-occupants to perceive greater service uncertainty over product and process uncertainty in retrofit projects. The findings were consistent with earlier studies since the first three types of uncertainty determine the calibre of goods and services promised in the contract's conditions in accordance to the owner-occupants' expectations. The difficulty in determining a retrofitting provider's performance or adherence to a contract was found related to behavioural uncertainty (Heukelom 2015). The two elements of uncertainty and TCE asset specificity were consistent with past empirical results, confirming the merit of the TCE for firms' strategies (Ketokivi & Mahoney 2020). Becerik-Gerber & Rice (2010), examined the perceived value of Building Information Management (BIM) in the United States construction industry as observed by diverse industry players. The study focused on the actual advantages and costs of using BIM at the project level. Their finding was found to be quite similar to that reported in our study (H_6).

The past studies mentioned above generally supported the original claim in this study that retrofit finance is relatively a new type of financing. In our analysis, uncertainty for the hypothetical models (H_6) and (H_7) and asset specificity for the models (H_2) and (H_3) were more likely to have an impact on owner-occupant intention than on economic utility for the models (H_4) and (H_5) transaction costs (H_1). This situation primarily depends on how differently owner-occupants perceive the costs of transactions. Individuals were less inclined to finance retrofits if perceived transaction costs were higher. The TCE model provides indication on which variables are more appropriate for funding retrofits. The outcomes of the studies suggested that the transaction cost was not the primary consideration, and owner-occupants basically hesitated to undertake retrofit initiatives. Moreover, it showed that, at least in its present version, retrofit finance is less popular with owner-occupants.

The impact of learning of retrofit initiatives is another problem. Both asset specificity and uncertainty influence the decision-making of owner-occupants. The former is a primary concern for owner-occupants, who tend to have higher expectations for brand specificity, human specificity, and physical specificity when making their choices. The distinctiveness of the assets, as seen by the owner-occupants, was shown in this study be widely accepted and valued. In addition, uncertainty positively correlates with transaction costs in our predicted scenario (H_6). In particular, the uncertainty effects on the intention to conduct retrofit financing (H_7) are more strongly felt than those experienced by owner-occupants in perceiving transaction costs. The most significant loading indicator factors were for three uncertainty indicator factors: namely service uncertainty, process uncertainty, and product uncertainty.

It is possible that the owner-occupants become used to the procedure after they have met the retrofitting provider and had some experience with it, which would explain the interesting results for both asset specificity and uncertainty. These procedures eliminate the issue of transaction fees. The data generally support the transaction cost model for the retrofit project conducted in Indonesia. Uncertainty and asset specificity impact the choice of owner-occupant intention more significantly than transaction cost. Products, processes, service issues, and the engagement of certain assets should be carefully handled to ensure that a given market can effectively accept the energy efficiency initiative idea. In many ways, this study added to the theory of transaction cost economics. Furthermore, as an analytical tool for retrofit finance, we have created and evaluated a retrofit model utilizing the transactional cost approach. Additionally, the findings may help managers better comprehend engagement in retrofit financing in the future and as such be more inclined to participate. The idea of an energy efficiency initiative may be utilized to deal with uncertainties using a very straightforward way of transactional management since it is a relatively new idea in goods and services.

The study elucidated the factors of asset specificity and uncertainty, supported with a literature analysis, that significantly influenced the decision of the owner-occupant to adopt an energy-efficient retrofit project. It thus assisted in understanding the steps required by the building industry players in developing this retrofitting business, its business model, the value of the investment, and the issue of financing options. Retrofits in Indonesia are technically feasible and economical. The findings should be able to assist government policies in developing retrofitting practices to maintain savings in energy needs, increasing employment and to protect the environment through reducing carbon emissions. The development of the retrofitting business will also be economically beneficial for other supporting industries such as leasing and green technology. For this reason, the study is expected to help the government create a comprehensive set of policies to spur the building industry and navigate the energy gap.

Sudarmaji et al. (2021a) suggested that industry professionals identify the strategy for energy-efficient business. Thus, developing the owner-occupant perspective on retrofit finance in this study addressed such a business plan. There are however some limitations to this research. The study basically evaluates transaction costs regarding perceived expenses, but not actual financial or real-time costs. In addition, the modelling strategy used was solely computed using structural equations and SmartPLS. Even if the fit analysis findings of the coefficients were satisfactory, certain inherited restrictions could be responsible for the lower validity and reliability ratings. It is thus recommended that future studies should also focus on identifying other computation strategies.

CONCLUSION

The empirical findings underscore the anticipated benefits of implementing retrofit projects, which are expected to outweigh the associated costs and complications. Additionally, the study emphasizes the concept of "green retrofit financing" as a transactional method that can reduce initial investment costs by incentivizing payments based on current and future electricity expenses (Said et al. 2022). By employing the transaction cost economics framework, the research centers on the challenge of securing contractual agreements after securing retrofit financing commitments from clients, highlighting the significance of management perceptions in achieving firm-level commitment. While the paper delves into the advantages of using LED lighting in detail, it underscores that the technical aspects of LED lighting are not the primary focus. Green retrofitting, from a technical standpoint, represents a financially viable investment that can yield long-term benefits by extending product lifespan. However, the paper also notes that this advantage is not universally embraced by business owners and is not yet widely acknowledged as one of the most effective ways to save energy. Despite growing recognition of the advantages of energy-efficient equipment, many companies remain daunted by the upfront investments associated with these technologies.

The deployment of the Energy Efficiency Initiative through green retrofitting financing presents a potential solution to overcome the financial barrier associated with substantial investments in energy-efficient equipment (Barkhordar 2019). According to the the US Department of Energy (2016), the success of green retrofitting in energy-efficient lighting could pave the way for optimizing Indonesia's energy-saving scenario. With an emphasis on upgrading LED lighting, this study explores Indonesia's readiness and desire to embrace green retrofit financing for energy-efficient projects. It examines factors affecting occupants' and property owners' decision-making regarding energy-efficient retrofit projects. The paper examines interactions between green retrofitting providers and building stakeholders, using Transaction Cost Economics (TCE) as the theoretical foundation. It examines how asset specificity, economic value, and uncertainty affect the Energy Efficiency Initiative's intended behaviour within this framework.

This study broadens the use of transaction cost economics (TCE) theory by applying it to the new energy efficiency retrofit uptake domain. It also provides empirical support for important TCE concepts that influence intentions, such as asset specificity and uncertainty. This study highlights the usefulness of TCE in decision-making modelling for novel and complex transactions such as retrofit finance. It also advances theoretical viewpoints by highlighting the significance of asset specialization and uncertainty over transaction costs. It also implies that TCE variables could change due to learning, providing fresh theoretical perspectives on adoption processes. This research demonstrates the critical role that service uncertainty plays, highlighting significant subtleties in the TCE uncertainty architecture. It also offers a parsimonious theoretical model that combines behavioural objectives with TCE that might be duplicated. This work validates the usefulness of TCE in shedding light on drivers and obstacles in a setting that has not received enough attention by expanding its scope from focusing on costs and production to modelling service interactions using a consumer-focused approach. Ultimately, it shows how TCE may influence procedures and rules to handle connections and transactions efficiently.

By extending the application of transaction cost economics (TCE) theory to the as-yet-unexplored domain of energy efficiency retrofit adoption, the study makes a substantial contribution to the literature. It advances theoretical viewpoints by highlighting the significance of crucial TCE constructs—such as asset specificity and uncertainty—in affecting intentions and by providing empirical evidence in favour of these concepts over transaction costs. Furthermore, the research demonstrates how TCE parameters may change due to learning, offering fresh perspectives on adoption procedures. In addition, it presents a theoretical framework that combines behavioural intents with TCE in a frugal manner, which may facilitate replication. It suggests that the effectiveness of green retrofit financing contracts rests in effectively managing these transactions, emphasizing organization and management rather than just profit generation by concentrating on transactions rather than firms and highlighting contract complexities instead of technical production aspects. Furthermore, the study thoroughly analyses the macro, holistic, ethical, and general context of retrofit finance methods in Indonesia—a specialized field with less preceding research and little available data.

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