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Integration of the Theory of Planned Behavior, Regulatory Pressures, Environmental Awareness, and Economic Perception in Influencing the Intention to Adopt Material Value Conservation Principles

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ABSTRACT

This study investigates the key factors influencing the intention of plastic-based medical device manufacturers in Indonesia to adopt Material Value Conservation (MVC) principles in sustainable product design. Using the Theory of Planned Behavior (TPB) as a foundation, this research integrates environmental awareness, regulatory pressures, knowledge of MVC, perceived ease of adoption, and perceived economic value to develop a comprehensive analytical model. A quantitative survey was conducted with 70 manufacturers located in the Greater Jakarta area, and the data were analyzed using Partial Least Squares-Structural Equation Modeling (PLS-SEM). The findings indicate that attitude, subjective norms, and perceived behavioral control have a significant direct effect on adoption intention, while regulatory pressure and knowledge of MVC influence intention indirectly through mediating constructs. Although environmental awareness and technical knowledge are high among respondents, perceived economic value remains the most significant barrier due to concerns over initial implementation costs. The study's novelty lies in its empirical extension of TPB within the context of circular economy adoption in the healthcare manufacturing sector. It provides practical implications for policymakers, particularly in low- and middle-income countries, to enhance sustainability through targeted incentives and regulatory frameworks. This research contributes to the academic literature by demonstrating the interaction between psychological, institutional, and economic variables in shaping green manufacturing intentions in an industry with high environmental impact.

Keywords: *Material Value Conservation (MVC); PLS-SEM; Theory of Planned Behavior (TPB); circular economy; green manufacturing*

INTRODUCTION

In recent decades, the use of plastic-based consumables has continued to increase in the healthcare sector worldwide. The use of single-use plastics is now the standard in various medical procedures. This step was taken to minimize the risk of spreading diseases through reusable medical devices, with reference to the *precautionary principle* in health policy (Reynier et al., 2021). This principle ensures that precautions are still taken despite scientific uncertainty, especially when serious threats to human health or the environment may occur (WHO, 2004). Plastic has also become the go-to choice for these tools because they are lightweight, inexpensive, and easy to mold according to medical needs (Joseph et al., 2021).

This trend is in line with the increase in demand for healthcare services, especially in the era of the *COVID-19* pandemic, where disposable personal protective equipment (*PPE*), such as masks and gloves, has also experienced a significant surge in demand (Cohen & Rodgers, 2020).

However, while it offers a number of advantages in terms of efficiency and safety, the use of single-use plastics in the health sector also poses significant challenges, particularly with respect to its environmental impact. According to MacNeill et al. (2020), the health sector contributes about 4.6% of global greenhouse gas emissions, with single-use plastic-based medical devices playing a major role due to the resources needed for their production, transportation, and disposal. These emissions mainly stem from the *"take-make-throw"* linear economic model, where medical devices are used once and then discarded. This model exacerbates environmental degradation through resource depletion, increased solid waste, and harmful emissions (MacNeill et al., 2020). During the *COVID-19* pandemic, the production of *PPE* such as masks and gloves increased by up to 40% (Patrício Silva et al., 2021), resulting in approximately 129 billion face masks and 65 billion gloves being used globally each month (Patrício Silva et al., 2020). These figures, as reported by Patrício Silva et al. (2021), highlight the magnitude of the plastic waste challenge during and after the pandemic.

Most of this plastic waste is not properly managed, leading to pollution of terrestrial and marine ecosystems. *Figure 1.2* shows an example of the number of single-use plastics used in a single adenotonsillectomy (lymph node surgery) operation, which resulted in 101 pieces of plastic. Rizan et al. (2020) note that one of the main ways to dispose of medical plastic waste is through incineration, which produces harmful pollutants such as dioxins and heavy metals, contributing to air pollution and health risks. The burning of medical plastics, especially in facilities that use low technology, often does not fully combust the material, leading to a greater release of pollutants (Rizan et al., 2020). Additionally, medical plastics, such as *polypropylene* and *polyvinyl chloride* (*PVC*), which are widely used in infusion bags, oxygen cylinders, and other equipment, when burned, release significant carbon emissions. This further exacerbates the negative impact on climate change and public health (Rizan et al., 2020).

Figure 1. Single-use Plastic Parts in One Adenotonsillectomy Surgery
Source : (Rizan et al., 2020)

To mitigate this impact, several strategies such as the transition to a *circular economy*, the development of recycling technology, as well as the use of plasma pyrolysis technology have been proposed. However, the main challenge remains the lack of adequate recycling facilities and incentives to reduce reliance on single-use plastics (Rizan et al., 2020).

While disposable medical devices provide great benefits in terms of infection control, the lack of sustainability in their life cycle—from production to disposal leads to increasingly unsustainable environmental costs. The transition to a *circular economy*, as proposed by Ganguly and Chakraborty (2024), is a viable solution. Circular practices such as reuse, recycling, and designing products for a longer lifespan can significantly reduce the environmental footprint of medical activities. Emerging technologies such as plasma pyrolysis, which can convert plastic waste into usable energy, offer a promising alternative to managing large amounts of medical plastic waste (Ganguly & Chakraborty, 2021). Rizan et al. (2020) highlight that this kind of technology can handle both waste volume and energy needs, creating a more sustainable waste management system. However, this requires significant policy changes, including *extended producer responsibility* (*EPR*) and stricter regulations regarding the design and disposal of medical devices (MacNeill et al., 2020).

Current design practices lead to a low acceptance rate of plastic waste for mechanical recycling. Therefore, a new approach is needed that supports existing plastic waste reduction efforts (Gabriel, 2016). Most plastic packaging designed with this system usually ends up in waste after its useful life has expired, otherwise known as *End-of-Life* (*EOL*), and is not suitable for recycling. With low consumable product values, this plastic packaging is no longer attractive for the recycling process and can even increase the environmental burden (Gabriel, 2018). The implementation of a material value conservation system in single-use plastic design can help maintain material value and increase the acceptance of plastic waste for recycling, while supporting a more environmentally friendly *circular economy*.

Conservation of material value in single-use plastic design in the health sector is a strategic approach that aims to reduce the environmental impact of single-use plastic-based products. This approach focuses on maximizing the use of recyclable materials while maintaining material value throughout the product lifecycle. One of the main challenges in medical plastic waste management is the quality of materials that often deteriorates because medical products are designed without regard to the recycling aspect. Gabriel et al. (2018) highlight that the excessive use of color pigments and printing inks in the design of plastic products reduces the quality and selling value of recycled materials.

Therefore, the application of the principle of conservation of material values in the design of medical products can help minimize the degradation of the value of plastic materials. By reducing the use of excess pigment and printing ink, the recycling process can be facilitated more efficiently. Gabriel et al. (2018) stated that if rigid plastic products are designed according to criteria that favor recycling, the residual material will be more readily accepted by the recycling industry, ultimately improving process efficiency and lowering costs.

Designs that consider the conservation of material values also have a positive impact on reducing greenhouse gas emissions and energy consumption during the recycling process. Wandani (2018) stated that the application of this concept to plastic packaging provides economic benefits, as well as positive impacts on the environment and society. By designing products that facilitate the recycling process, material value can be maintained, and this has a significant economic impact.

In the context of plastic products, Arifin (2020) and Tyani & Gabriel (2020) emphasized the importance of redesigning plastics that meet the criteria of conservation of material value. This involves reducing the use of unnecessary layers of material, choosing simpler plastic colors such as white, and avoiding excessive use of printing ink. These steps help maintain a higher material value after the recycling process.

Overall, the application of material value conservation in medical device design not only addresses the challenge of plastic waste, but also encourages the adoption of a *circular economy* in the health sector. By maintaining material value, medical products can be recycled more efficiently, reduce waste, and support long-term sustainability goals (Gabriel et al., 2018; Tyani & Gabriel, 2020).

The high production of plastic waste from medical devices and the potential application of the principle of material value conservation in overcoming plastic waste makes it important to determine factors that affect the intention of medical device manufacturers in adopting the principle of material value conservation in product design.

This study aims to: (1) Identify the factors that affect the intention of manufacturers in adopting the principle of conservation of material value in the redesign of medical devices. (2) Measure the level of intention of medical device manufacturers in adopting material value conservation as part of a sustainable design strategy. (3) Formulate strategies that can be used to encourage the adoption of material value conservation by stakeholders in the medical device industry to reduce the environmental impact of single-use plastics.

To address the environmental burden of single-use plastic medical devices, this study explores the behavioral intentions of manufacturers to adopt *Material Value Conservation* (*MVC*) principles in product design. While previous studies have applied the *Theory of Planned Behavior* (*TPB*) in various environmental contexts, few have specifically integrated *TPB* with environmental awareness and regulatory pressures in the context of sustainable product design in the medical device industry. This research fills that gap by extending the *TPB* framework to include two critical antecedents: environmental awareness, which reflects manufacturers' recognition of ecological impact, and regulatory pressures, which represent institutional forces influencing behavior.

The novelty of this study lies in its conceptual integration bridging *TPB*'s psychological constructs (attitude, subjective norms, and perceived behavioral control) with external drivers like regulatory mandates and ecological awareness. Such integration offers a more comprehensive understanding of the factors that shape sustainability-oriented design behavior, particularly within high-impact sectors like healthcare.

Thus, the objectives of this study are: (1) to identify the psychological and contextual factors influencing manufacturers' intention to adopt *MVC* principles; (2) to evaluate the strength of these influences using empirical data from Indonesian medical device producers; and (3) to formulate strategic recommendations for promoting sustainable design practices through policy, education, and industry collaboration. This research contributes both theoretically by refining *TPB* in a sustainability and *circular economy* context and practically by informing stakeholders of effective leverage points for green transition in medical manufacturing.

METHOD

This study employed an explanatory quantitative research design using a structured survey to examine causal relationships among variables based on the *Theory of Planned Behavior* (*TPB*) and its extensions. The target population consisted of decision-makers and senior managers in plastic-based medical device manufacturing companies located in the Greater Jakarta area (*Jabodetabek*).

The sampling technique used was purposive sampling, targeting respondents who have experience in sustainable product design or regulatory compliance. The sample size was determined based on the *PLS-SEM* requirement for minimum sample size per model complexity (Hair et al., 2021), with a minimum ratio of 10:1 between indicators and samples. With 21 indicators, a minimum of 63 responses was required. A total of 70 valid responses were collected and analyzed, meeting the recommended threshold.

The key constructs in this study were adapted from validated sources and operationalized as follows:

1. *Attitude* (*AT*), *Subjective Norms* (*SN*), and *Perceived Behavioral Control* (*PBC*) were measured according to Ajzen (2020) *TPB* framework using a 5-point Likert scale.
2. *Environmental Awareness* (*EA*), *Regulatory Pressure* (*RP*), *Perceived Ease of Adoption* (*PEA*), and *Perceived Economic Value* (*PEV*) were operationalized as reflective constructs with 3–4 items each, referring to sustainability and green innovation literature (Gabriel et al., 2018; Liu et al., 2019).
3. *Knowledge of MVC Principles* (*KMVC*) and *Intention to Adopt* (*INT*) were measured using 3-item reflective indicators each.

Partial Least Squares Structural Equation Modeling (*PLS-SEM*) was selected due to its suitability for:

1. Models with complex constructs and multiple indicators;
2. Predictive and exploratory research objectives;
3. Handling non-normal data and small to medium sample sizes;
4. Simultaneous testing of measurement (outer) and structural (inner) models.

Model testing included:

1. Measurement Model (*Outer Model*): Assessed through convergent validity (*factor loading* > 0.7, *AVE* > 0.5), reliability (*Cronbach's Alpha* and *Composite Reliability* > 0.7), and discriminant validity (*Fornell-Larcker* and cross-loading analysis).
2. Structural Model (*Inner Model*): Evaluated via path coefficient analysis, *t-statistics*, R^2, f^2 effect size, and model fit using *SRMR* (< 0.08).

This methodological approach ensures rigorous validation of the relationships among variables that influence the intention to adopt *Material Value Conservation* (*MVC*) principles in medical device manufacturing.

RESULTS AND DISCUSSION

Evaluation of the Outer Model

Evaluation of the measurement model (outer model) is a crucial stage to analyze the extent to which the indicators used in the research are able to reflect the latent construct to be measured. Basically, the outer model acts as an instrument for validating the relationship between the observed variable and the underlying construct. In the context of this research, the evaluation of the outer model was carried out through a series of comprehensive validity and reliability tests. The validity aspect serves to verify that the indicator accurately measures the intended construct, while the reliability aspect aims to ensure the internal consistency of the indicator in measuring the construct. This evaluation process includes three main components, namely convergent validity testing that measures the correlation between the indicator and its construct, discriminant validity which ensures that the indicator is not highly correlated with other constructs, and reliability test that assesses the reliability of the measurement instrument as a whole.

1. Convergent Validity and Reliability Tests

    Convergent validity tests are performed to ensure that each indicator used actually represents the same construct, so that the indicators show a strong relationship with each other. The convergence validity assessment was carried out by looking at the value of the loading factor and the Average Variance Extracted (AVE). Meanwhile, the reliability aspect is measured to determine the internal consistency between indicators in a single construct, which is evaluated through Cronbach's Alpha and Composite Reliability values.

    The validity of the convergence was evaluated by taking into account the outer loading value of each indicator against the latent variable measured. Referring to the criteria of Hair et al. (2017), the indicator is considered to have a strong enough contribution to latent constructs if the outer loading value obtained is ≥ 0.70.

    Convergent validity refers to the extent to which an indicator is positively correlated with an alternative indicator of the same construct. Based on the data in Table 4.11, all indicators in the research model have an outer loading value well above the threshold value of 0.708, which is the minimum standard to ensure that the construct explains at least 50% of the variance of the indicator.

    The highest outer loading value was found in the KMVC1 indicator (0.993), followed by AT1 (0.989), AT2 (0.985), and KMVC2 (0.989). Even the lowest outer loading value in the model, PEV1 (0.877), is still far above the required minimum limit. This high value of outer loading indicates that the indicators used have a very strong correlation with the latent construct, so it can be relied upon to measure the construct.

Table 1. Convergent Validity and Reliability Test Results

Variable	Indicator	*Outer Loading Value*	Information	*Cronbach's Alpha*	*Composite Reliability*	AVE
Attitude	AT1	0,989	Valid	0,975	0,984	0,953
	AT2	0,985	Valid			
	AT3	0,954	Valid			
Environmental Awareness	EA1	0,958	Valid	0,956	0,972	0,920
	EA2	0,978	Valid			
	EA3	0,941	Valid			
Intention to Adopt MVC Principles	INT1	0,961	Valid	0,948	0,967	0,906
	INT2	0,964	Valid			
	INT3	0,931	Valid			
Knowledge of MVC Principles	KMVC1	0,993	Valid	0,985	0,990	0,971
	KMVC2	0,989	Valid			
	KMVC3	0,975	Valid			

Perceived Behavioral Control	PBC1	0,943	Valid	0,888	0,947	0,899
	PBC2	0,953	Valid			
Perceived Ease-of-Adoption	PEA1	0,973	Valid	0,931	0,956	0,880
	PEA2	0,957	Valid			
	PEA3	0,882	Valid			
Perceived Economic Value	PEV1	0,877	Valid	0,918	0,942	0,803
	PEV2	0,898	Valid			
	PEV3	0,926	Valid			
	PEV4	0,882	Valid			
Regulatory Pressure	RP1	0,940	Valid	0,930	0,955	0,877
	RP2	0,919	Valid			
	RP3	0,951	Valid			
Subjective Norms	SN1	0,941	Valid	0,942	0,962	0,895
	SN2	0,951	Valid			
	SN3	0,947	Valid			

Source : Data Processed by Researchers

Another parameter for evaluating convergent validity is the Average Variance Extracted (AVE), which is a measure of how much variance a construct can explain compared to the variance caused by measurement errors. The AVE value for all constructs in the model is above 0.5, which is the recommended minimum. The highest AVE value was found in the Knowledge of MVC Principles construct (0.971), followed by Attitude (0.953) and Environmental Awareness (0.920). Even the construct with the lowest AVE value, namely the Perceived Economic Value (0.803), still has a very satisfactory value. These results show that the construct is able to explain more than 80% of the variance of its indicators.

Reliability in PLS-SEM can be evaluated through two main parameters, namely Cronbach's Alpha and Composite Reliability. Cronbach's Alpha is a measure of internal consistency that evaluates the extent to which indicators of the same construct are positively correlated with each other. From Table 1, all constructs have Cronbach's Alpha values above 0.7, which indicates good reliability. The highest score was found in the Knowledge of MVC Principles construct (0.985), followed by Attitude (0.975) and Environmental Awareness (0.956).

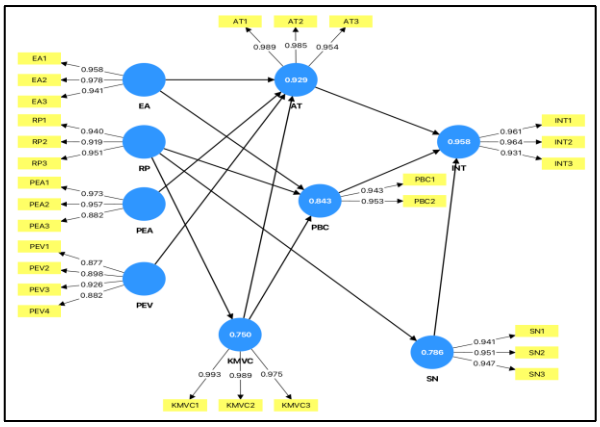

Figure 1. Models with Convergent Validity and Reliability Tests
(With Outer Loading Value and AVE values)

Source : Data Processed by Researchers

Meanwhile, Composite Reliability is a measure of internal consistency that takes into account differences in indicator weights based on the loading value of each indicator. The Composite Reliability value for all constructs in the model is also well above the threshold value of 0.7. The highest score was found in the Knowledge of MVC Principles construct (0.990), followed by Attitude (0.984) and Environmental Awareness (0.972). This high Composite Reliability value indicates that the indicators in the model have excellent internal consistency in measuring their latent constructs.

Overall, the results of the evaluation of the measurement model show that the research instruments used have excellent validity and reliability. All indicators have an outer loading value above 0.7, indicating a strong correlation with their latent constructs. In addition, the AVE, Cronbach's Alpha, and Composite Reliability values for all constructs were well above the required minimum, indicating that the measurement model has high internal consistency and is able to explain most of the variance of its indicators.

Thus, it can be concluded that the measurement model used in this research meets the criteria of convergent validity and reliability, so that it can be relied upon to evaluate the inter-construct relationship at the next stage, namely the evaluation of the structural model.

2. Discriminating Validity Test

Discriminant validity testing is performed to evaluate the degree of clear differentiation between one construct and another in a model. This means that in addition to having internal validity, each construct also needs to exhibit characteristics that are distinct from other constructs. When the validity of the discriminant does not reach the set standard, the accuracy of the interpretation of the model analysis results becomes questionable due to the potential for overlapping between constructs. Thus, the process of verifying discriminant validity is an essential component in ensuring the integrity of the designed structural model. In the context of PLS-SEM, some common analytical approaches implemented to assess discriminant validity include the Fornell-Larcker criterion as well as the evaluation of Cross-Loading values.

Table 2. Fornell-Larcker results

	AT	EA	INT	KMVC	PBC	AND	ENP	RP	SN
AT	0,976								
EA	0,928	0,959							
INT	0,942	0,949	0,952						
KMVC	0,905	0,900	0,912	0,985					
PBC	0,938	0,899	0,941	0,889	0,948				
AND	0,923	0,921	0,929	0,891	0,901	0,938			
ENP	0,821	0,878	0,812	0,815	0,873	0,823	0,896		
RP	0,926	0,913	0,921	0,866	0,881	0,905	0,873	0,937	
SN	0,900	0,883	0,926	0,839	0,893	0,858	0,858	0,886	0,946

Source : Data Processed by Researchers

The Fornell-Larcker criterion is one of the methods used to evaluate the validity of the discriminator in the PLS-SEM measurement model. This method requires that the square root of the Average Variance Extracted (AVE) for each construct must be greater than the highest correlation between that construct and the other constructs. The diagonal values given a green background in the table represent the square root of the AVE for each construct.

From Table 2 it can be seen that:

a. The diagonal values for all constructs (AVE square root) range from 0.896 (PEV) to 0.985 (KMVC), which indicates an excellent level of internal validity.
b. For each construct, the diagonal value is greater than the correlation value between that construct and the other constructs (values in the same column and row). For example, the diagonal value for the AT construct is 0.976, which is greater than all the correlation values of AT with other constructs, such as AT with EA (0.928), AT with INT (0.942), and so on.
c. Although some correlation values between constructs are quite high (above 0.9), such as between INT and EA (0.949), INT and PBC (0.941), and AT and INT (0.942), all of these values are still lower than the diagonal values of each construct, thus still meeting the Fornell-Larcker criteria.

The results of this Fornell-Larcker analysis confirm that the measurement model has good discriminant validity, meaning that each construct actually measures a different phenomenon and there is no significant overlap between the constructs. It is important to ensure that the structural model analysis to be carried out next can provide accurate and reliable results.

However, it should be noted that some constructs have a fairly high correlation, which suggests a strong relationship between them. Although this does not violate the criterion of discriminant validity, the high correlation indicates that the constructs are substantively interrelated in the context of the adoption of the principle of conservation of material value in the medical device industry.

Overall, based on the Fornell-Larcker criteria, the measurement model has met the requirements for discriminant validity and can be proceeded to the next stage of analysis.

Table 3. Cross Loading Results

	AT	EA	INT	KMVC	PBC	AND	ENP	RP	SN
AT1	0,989	0,919	0,922	0,895	0,944	0,844	0,815	0,904	0,866
AT2	0,985	0,915	0,930	0,891	0,950	0,840	0,806	0,898	0,862
AT3	0,954	0,883	0,923	0,864	0,911	0,876	0,875	0,909	0,908
EA1	0,888	0,958	0,915	0,866	0,846	0,879	0,852	0,891	0,847
EA2	0,903	0,978	0,912	0,927	0,874	0,809	0,862	0,877	0,841
EA3	0,879	0,941	0,904	0,940	0,866	0,860	0,812	0,859	0,852
INT1	0,923	0,869	0,961	0,848	0,904	0,864	0,851	0,909	0,908
INT2	0,920	0,895	0,964	0,882	0,924	0,805	0,806	0,918	0,901
INT3	0,880	0,922	0,931	0,878	0,858	0,786	0,846	0,888	0,832
KMVC1	0,896	0,940	0,903	0,993	0,879	0,791	0,815	0,864	0,840
KMVC2	0,901	0,933	0,903	0,989	0,884	0,802	0,826	0,864	0,836
KMVC3	0,879	0,905	0,892	0,975	0,866	0,839	0,768	0,833	0,804
PBC1	0,867	0,821	0,839	0,822	0,943	0,818	0,797	0,781	0,768
PBC2	0,936	0,881	0,921	0,862	0,953	0,788	0,856	0,886	0,919
PEA1	0,833	0,911	0,820	0,797	0,784	0,973	0,808	0,794	0,864
PEA2	0,837	0,868	0,797	0,835	0,876	0,957	0,881	0,794	0,837
PEA3	0,771	0,809	0,790	0,769	0,769	0,882	0,804	0,746	0,703
PEV1	0,809	0,870	0,875	0,832	0,866	0,800	0,877	0,832	0,818

PEV2	0,803	0,763	0,825	0,676	0,759	0,780	0,898	0,761	0,803
PEV3	0,794	0,740	0,779	0,681	0,758	0,796	0,926	0,769	0,740
PEV4	0,780	0,760	0,777	0,716	0,731	0,820	0,882	0,758	0,704
RP1	0,830	0,848	0,846	0,820	0,784	0,819	0,783	0,940	0,778
RP2	0,866	0,895	0,911	0,834	0,825	0,879	0,815	0,919	0,841
RP3	0,903	0,821	0,912	0,780	0,865	0,842	0,853	0,951	0,869
SN1	0,839	0,879	0,885	0,843	0,846	0,801	0,775	0,856	0,941
SN2	0,859	0,806	0,878	0,763	0,837	0,826	0,836	0,817	0,951
SN3	0,857	0,819	0,864	0,775	0,854	0,809	0,825	0,843	0,947

Source : Data Processed by Researchers

Based on Table 3, it can be observed that each indicator has the highest loading value on the construct that should be measured (the value given a green background on the diagonal), compared to the loading value on the other construct. Overall, the diagonal loading value ranges from 0.877 (PEV1) to 0.993 (KMVC1), which far exceeds the recommended minimum value of 0.70.

Some of the key findings from this cross loading analysis include:

1) Construct Attitude (AT) - All three indicators AT1, AT2, and AT3 have excellent loading values (0.989, 0.985, and 0.954) on their own constructs, and this value is much higher than cross loading on other constructs. This shows that the AT indicators accurately measure the Attitude construct.
2) Environmental Awareness (EA) constructs - The EA1, EA2, and EA3 indicators have loading values of 0.958, 0.978, and 0.941 respectively on EA constructs, which are also significantly higher than cross loading values on other constructs. This indicates a good discriminant validity for EA constructs.
3) Construct Intention to Adopt (INT) - The three indicators INT1, INT2, and INT3 also performed well with loading values of 0.961, 0.964, and 0.931 on the construct itself, which is also higher than cross loading on other constructs.
4) Construct Knowledge of MVC Principles (KMVC) - The KMVC1, KMVC2, and KMVC3 indicators have very high loading values (0.993, 0.989, and 0.975) on the KMVC construct, which is the highest loading value among all the indicators in the model.
5) Perceived Behavioral Control (PBC) constructs - The PBC1 and PBC2 indicators have loading values of 0.943 and 0.953 on their own constructs, indicating good discriminant validity.
6) Constructed Perceived Ease of Adoption (PEA) - The PEA1, PEA2, and PEA3 indicators, with loading values of 0.973, 0.957, and 0.882, also show adequate discriminant validity.
7) Constructed Perceived Economic Value (PEV) - The four indicators PEV1, PEV2, PEV3, and PEV4 have loading values of 0.877, 0.898, 0.926, and 0.882 respectively in the PEV construct, which is also higher than the cross loading in the other constructs.
8) Construct Regulatory Pressures (RP) - RP1, RP2, and RP3 indicators with loading values of 0.940, 0.919, and 0.951 indicate good discriminant validity.

9) Construct Subjective Norms (SN) – All three indicators SN1, SN2, and SN3 have loading values of 0.941, 0.951, and 0.947 respectively on the SN construct, which also shows excellent discriminant validity.

Although there are some fairly high cross loading values (above 0.8) between several constructs, for example between AT and PBC, INT with SN, and EA with KMVC, overall each indicator still has a higher loading value in its own construct than in other constructs. This confirms that the measurement model has adequate discriminant validity.

Based on the results of the cross loading analysis, it can be concluded that the measurement model has good discriminant validity, where each indicator correlates more strongly with the construct it is measuring compared to other constructs. All indicators have loading values above 0.70 in their respective constructs, which meet the criteria recommended in the PLS-SEM literature. Thus, the results of this cross loading provide empirical evidence that supports the accuracy of the placement of indicators in the research model, so that the analysis of the structural model can be continued with a high level of confidence in the quality of the measurement model.

Inner Model Evaluation

1. Determination Coefficient Test (R2)

The determinant coefficient (R^2) is a measure that explains the magnitude of the variation of endogenous variables that can be explained by exogenous variables in the research model. This value indicates the predictive power of the structural model and reflects the ability of independent variables to predict dependent variables. In the context of PLS-SEM, the determinant coefficient serves as an indicator of the predictive accuracy of the model and measures how well the observation value can be reproduced by the model and its parameters.

Table 4. Determination Coefficient Test Results (R2)

Source : Data Processed by Researchers

Variable	R-square	R-square adjusted
AT	0,929	0,925
INT	0,958	0,956
KMVC	0,750	0,747
PBC	0,843	0,836
SN	0,786	0,782

Based on the results of the analysis presented in Table 4, the value of the determinant coefficient (R^2) for all endogenous variables shows an excellent value. The Intention to Adopt MVC Principles (INT) variable had the highest R^2 value of 0.958, indicating that 95.8% variation in the intention to adopt the principle of conservation of material values can be explained by the predictive variables in the model. This very high R^2 value indicates the very substantial predictive power of exogenous constructs against adoption intentions.

The Attitude (AT) variable has an R^2 value of 0.929, which means that 92.9% variation in the attitude of medical device manufacturers towards the adoption of the principle of conservation of material values can be explained by the predictors in the model. Meanwhile, the Perceived Behavioral Control (PBC) variable had an R^2 value of 0.843, indicating that

84.3% of the variation in the perception of behavioral control was explained by the constructs that influenced it.

The variables Subjective Norms (SN) and Knowledge of MVC Principles (KMVC) showed R^2 values of 0.786 and 0.750, respectively, which were also substantial. These results indicate that respectively 78.6% and 75.0% variations in subjective norms and knowledge of the principle of conservation of material values can be explained by the predictive variables in the model.

Referring to the criteria put forward by Hair et al. (2014), R^2 values above 0.75 are categorized as substantial, values between 0.50 to 0.75 are categorized as moderate, and values below 0.25 are categorized as weak. Based on this classification, all endogenous variables in this research model have a substantial R^2 value, which indicates the excellent predictive power of the model.

To control for the possibility of model overfitting, the R^2 adjusted value was also evaluated. R^2 adjusted is a modified version of R^2 that adjusts values based on the complexity of the model (the number of predictor variables). In the context of this research, the adjusted R^2 values for all endogenous variables also showed excellent results and were not much different from the usual R^2 values, indicating that the model was not overfitted and that the predictive variables made a meaningful contribution.

Overall, the results of the determination coefficient test show that the structural model of this research has very high predictive power. The exogenous constructs in the model are able to explain most of the variation in endogenous constructs, in particular the intention of adopting the principle of conservation of material value which is the main focus of this research. These findings provide strong empirical support for the relevance and suitability of the variables identified in the model to explain the factors influencing medical device manufacturers' intentions to adopt the principle of conservation of material value in their product designs.

2. Uji Effect Size (f2)

After evaluating the coefficient of determination (R^2), the next step is to conduct an effect size (f^2) test to assess the substantive impact of each exogenous construct on the related endogenous construct. The value of f^2 measures how much a predictive variable contributes relative to the model's predictive ability for the variables it affects. This effect size test is calculated using the formula:

$$f^2 = (R^2 \text{ included} - R^2 \text{ excluded}) / (1 - R^2 \text{ included})$$

Where R^2 included is the value of the determination coefficient when all exogenous variables are included in the model, whereas R^2 excluded is the value of the determination coefficient when a particular exogenous variable is excluded from the model.

Table 5. Effect Size Test Results (f2)

Variable	f-square
AT -> INT	0,882
EA -> AT	0,011
EA -> PBC	0,019
KMVC -> AT	0,084
KMVC -> PBC	0,084
PBC -> INT	0,001

PEA -> AT	0,116
PEV -> AT	0,207
RP -> KMVC	3,006
RP -> PBC	0,144
RP -> SN	3,663
SN -> INT	0,297

Source : Data Processed by Researchers

Referring to the criteria of Cohen (1988), the value of f^2 can be interpreted as follows:
$f^2 \geq 0.02$ indicates a small effect
$f^2 \geq 0.15$ indicates a medium effect
$f^2 \geq 0.35$ indicates large effect

Based on the results of the analysis shown in Table 5, it can be observed that some pathways show very substantial effects. The RP -> SN line had the highest f^2 value (3.663), followed by KMVC's RP -> (3.006), both of which far exceeded the threshold for large effects (0.35). These findings indicate that Regulatory Pressures (RP) have a very dominant contribution to Subjective Norms (SN) and Knowledge of MVC Principles (KMVC). This shows the crucial role of regulatory pressure on the formation of subjective norms and knowledge of the principle of conservation of material value among medical device manufacturers.

The AT -> INT pathway also showed a large effect with an f^2 value of 0.882, confirming the significant influence of Attitude (AT) on the Intention to Adopt MVC Principles (INT). Meanwhile, the SN -> INT (0.297) and PEV -> AT (0.207) tracks showed moderate to large effects, indicating that Subjective Norms (SN) had a moderate influence on Intention to Adopt, and Perceived Economic Value (PEV) made a significant contribution to the formation of Attitude.

Some pathways such as PEA -> AT (0.116), RP -> PBC (0.144), KMVC -> AT (0.084), and KMVC -> PBC (0.084) show small to moderate effects. Meanwhile, the EA -> AT (0.011), EA-> PBC (0.019), and PBC -> INT (0.001) lines show very small or even non-substantive effects, as the f^2 value is below the threshold of a small effect (0.02).

Overall, the results of this effect size test show that the factors that contribute the most to the model are regulatory pressure (RP) towards subjective norms (SN) and knowledge of the principle of conservation of material value (KMVC), as well as attitudes (AT) towards adoption intentions (INT). These findings are consistent with the theory that effective regulatory implementation and the formation of positive attitudes play a key role in encouraging the adoption of sustainable practices in the medical device industry.

Model Validation

1. Test Model Fit (SRMR)

The fit model test is one of the important stages in the SEM-PLS analysis to ensure that the built model is in accordance with empirical data. One of the commonly used indicators is the Standardized Root Mean Square Residual (SRMR). SRMR measures the average of the difference between the observed correlation matrix and the correlation matrix predicted by the model. The smaller the SRMR value, the better the model's match to the data.

Table 6. Model Fit Test Results (SRMR)

Source : Data Processed by Researchers

	Saturated model	Estimated Model	Condition	Information
SRMR	0,047	0,073	<0.8	Good Fit Model

Based on Table 4.16, the results of the fit model test show that the SRMR value for saturated model is 0.047. This value is well below the maximum recommended limit, which is 0.08 or even <0.10 according to some references. Thus, the model used in this research can be categorized as having a very good level of compatibility with the observed data.

The low SRMR value indicates that the constructed structural and measurement models are able to represent the relationships between variables well, and that there are no significant deviations between the actual data and the data predicted by the model. Therefore, the model is feasible to use in the next stage of analysis, such as hypothesis testing and interpretation of research results.

2. Construct Relationship Evaluation

In the next crucial stage, an analysis of the strength and significance of the relationship between variables needs to be carried out. This process is identified as Path Coefficient analysis and significance testing. The path coefficient provides an overview of the orientation and magnitude of the influence of a variable on other variables in the model framework, while significance testing serves to confirm the degree of confidence of the influence from a statistical point of view (not just a random event).

As the Path Coefficient gets closer to the extreme (+1 or -1), this indicates the more intense the influence that independent constructs exert on dependent constructs. It should be noted that the Path Coefficient spectrum that can be recognized as valid is also affected by the sample size and the complexity of the model, where according to the study of Hair et al. (2022), the spectrum of the minimum path coefficient that can be validated is in the range of 0.11 – 0.20 with a minimum sample condition of 155 at a significance level of 5%.

Meanwhile, significance testing was analyzed through t-statistic and p-value parameters resulting from the bootstrapping mechanism. Results can be formulated based on the following criteria:

a. If the p-values > 0.05 or the t-statistic < 1.96, then the null hypothesis (Ho) is accepted and the alternative hypothesis (Ha) is rejected.
b. If the p-values < 0.05 or the t-statistic > 1.96, then the null (Ho) hypothesis is rejected and the alternative hypothesis (Ha) is accepted.

3. Direct Effect

The study of direct effects within the framework of this research model is aimed at tracing and assessing the impact of free variables on bound variables without the involvement of mediating variables. The quantification of the impact was carried out through the observation of the value of the path coefficient that reflects the direction and intensity of the relationship between constructs, as well as by conducting a significance test through a bootstrapping technique that pays attention to the t-statistic and p-value quantities. This interpretation of the direct effect pattern forms the basis for the validation of the main hypotheses proposed in the study, while providing preliminary insights into the specific functions of each variable in the overall model that has been constructed.

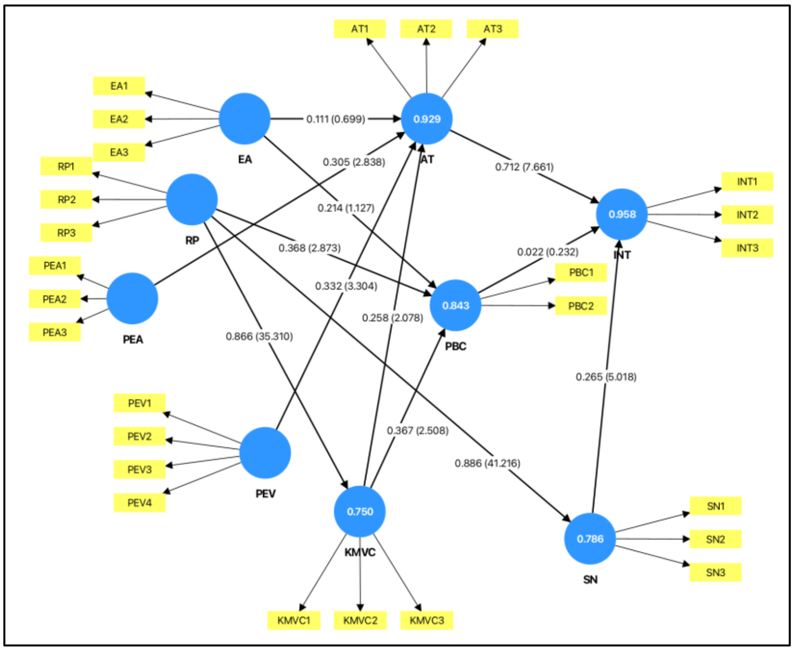

Figure 2. Models with Path Coefficient, t-statistic and R-square
Source : Data Processed by Researchers

Table 7. Direct Effect Hypothesis Test Results

Hypothesis	Relationships Between Constructs	Path Coefficient	T statistics (>1,96)	P values (<0.05)	Information
		Direct Effect			
H1	EA -> AT	0,077083333	0,485416667	0,336111111	Positive Effect, Insignificant
H2	EA -> PBC	0,148611111	1.127	0,180555556	Positive Effect, Insignificant
H3	RP -> PBC	0,255555556	2.873	0.004	Positive, Significant Effect
H4	RP -> SN	0,615277778	41.216	0.000	Positive, Significant Effect
H5	RP -> KMVC	0,601388889	35.310	0.000	Positive, Significant Effect
H6	PEA -> AT	0,211805556	2.838	0.005	Positive, Significant Effect
H7	PEV -> AT	0,230555556	3.304	0.001	Positive, Significant Effect
H8	KMVC -> AT	0,179166667	2.078	0.038	Positive, Significant Effect
H9	KMVC -> PBC	0,254861111	2.508	0.012	Positive, Significant Effect
H10	AT -> INT	0,494444444	7.661	0.000	Positive, Significant Effect
H11	PBC -> INT	0.022	0,161111111	0,566666667	Positive Effect, Insignificant
H12	SN -> INT	0,184027778	5.018	0.000	Positive, Significant Effect

Source : Data Processed by Researchers

Table 7 shows the results of hypothesis testing for direct effects between variables in research. Of the 12 hypotheses tested, 9 hypotheses showed significant results (H3, H4, H5, H6, H7, H8, H9, H10, and H12), characterized by t-statistical values >1.96 and p-values <0.05. While the other 3 hypotheses (H1, H2, and H11) showed a positive but insignificant influence.

From these results, it can be seen that Regulatory Pressures (RP) have a positive and significant influence on PBC, SN, and KMVC with a fairly high path coefficient, especially on the influence of RP on SN (0.615). Attitude (AT) also has a strong positive and significant influence on Intention to Adopt (INT) with a path coefficient of 0.494. However, Environmental Awareness (EA) did not show a significant effect on AT or PBC, nor did PBC have a significant effect on INT.

4. The Indirect Effect of Mediation

In addition to analyzing the direct effects between variables, it is also important to examine the indirect effects that occur when a variable affects other variables through intermediate or mediation variables. The analysis of the mediating effects allows researchers to uncover more complex mechanisms in research models, where one construct can have an indirect influence on another. In the context of this research, the analysis of the effects of mediation was carried out to understand how external and internal factors influence the intention of adopting the principle of conservation of material value through various mediation channels.

Table 8. Indirect Effect Evaluation Results

	Path Coefficient	T statistics (>1,96)	P values (<0.05)	Information
KMVC -> PBC -> INT	0.008	0.219	0.827	Positive Effect, Insignificant
RP -> SN -> INT	0.234	4.935	0.000	Positive, Significant Effect
EA -> AT -> INT	0.079	0.699	0.484	Positive Effect, Insignificant
RP -> KMVC -> AT	0.223	2.070	0.039	Positive, Significant Effect
KMVC -> AT -> INT	0.184	1.939	0.053	Positive Effect, Insignificant
RP -> PBC -> INT	0.008	0.218	0.828	Positive Effect, Insignificant
PEA -> AT -> INT	0.217	2.672	0.008	Positive, Significant Effect
PEV -> AT -> INT	0.236	2.989	0.003	Positive, Significant Effect
RP -> KMVC -> PBC	0.318	2.495	0.013	Positive, Significant Effect
RP -> KMVC -> PBC -> INT	0.007	0.218	0.827	Positive Effect, Insignificant
EA -> PBC -> INT	0.005	0.168	0.867	Positive Effect, Insignificant
RP -> KMVC -> AT -> INT	0.159	1.929	0.054	Positive Effect, Insignificant

Source : Data Processed by Researchers

Table 8. shows the results of hypothesis testing for indirect effects in the research model. Of the 12 mediation pathways tested, 5 pathways showed a positive and significant influence, which was characterized by t-statistical values of >1.96 and p-values of <0.05. Significant mediation pathways included RP -> SN -> INT (0.234), RP -> KMVC -> AT (0.223), PEA -> AT -> INT (0.217), PEV -> AT -> INT (0.236), and RP -> KMVC -> PBC (0.318).

These findings indicate that Regulatory Pressures (RP) have a significant indirect influence on Intention to Adopt (INT) through Subjective Norms (SN), as well as on

Attitude (AT) through Knowledge of MVC Principles (KMVC). In addition, Perceived Ease of Adoption (PEA) and Perceived Economic Value (PEV) also have a significant indirect influence on Intention to Adopt through Attitude. Meanwhile, the other 7 mediation pathways showed a positive but not statistically significant influence.

5. Total Effect

Total effect analysis is an important stage in the evaluation of structural models that combine direct effects and indirect effects between variables in the research model. Total influence provides a comprehensive picture of how an exogenous variable affects an endogenous variable through all possible pathways, either directly or through a mediating variable. Total influence evaluation is very useful for understanding the overall mechanism of influence and identifying the variables that have the greatest contribution to the target variable in the research model, in this case the intention to adopt the principle of conservation of material value in the design of medical devices.

Table 9. Total Effect Evaluation Results

	Path Coefficient	T statistics (>1,96)	P values (<0.05)	Information
EA -> INT	0.084	0.720	0.471	Positive, insignificant effect
KMVC -> INT	0.192	2.101	0.036	Positive, Significant Effect
PEA-> INT	0.217	2.672	0.008	Positive, Significant Effect
ENP -> INT	0.236	2.989	0.003	Positive, Significant Effect
RP -> AT	0.223	2.070	0.039	Positive, Significant Effect
RP -> INT	0.409	4.481	0.000	Positive, Significant Effect
RP -> PBC	0.318	2.495	0.013	Positive, Significant Effect

Source : Data Processed by Researchers

Table 9. shows the results of the evaluation of the total influence of various exogenous variables on endogenous variables in the research model. Of the 7 pathways analyzed, 6 pathways showed a positive and significant influence, as evidenced by t-statistics values >1.96 and p-values <0.05. The strongest total influence was shown by the RP -> INT pathway (0.409) with a very high level of significance (p=0.000), followed by RP -> PBC (0.318) and PEV -> INT (0.236).

The only pathway that showed a positive but insignificant effect was EA -> INT (0.084) with a t-statistic of 0.720 and a p-value of 0.471. These findings indicate that Regulatory Pressures (RP) have a dominant total influence on the Intention to Adopt MVC Principles (INT), either directly or through mediation. Meanwhile, although Environmental Awareness (EA) has a positive influence on adoption intentions, the total effect is not statistically significant enough.

Hypothesis Proof

This section presents an in-depth discussion of the findings of the research results. The analysis is carried out by re-evaluating the research objectives and relating them to the empirical data and theoretical framework that have been described earlier. Each analysis was examined in conjunction with previous theories and studies to identify their convergence or divergence. It is hoped that this elaboration can provide a comprehensive understanding of the phenomenon being studied.

H1 (rejected): Environmental Awareness has a significant positive influence on Attitude

Statistical analysis produced a positive direction path coefficient value of 0.077 which indicates that the Environmental Awareness variable contributes positively or encourages an increase in the Attitude variable by 7.7%. Inferential statistical evaluation resulted in a t-statistical value of 0.485 that did not reach a critical t-value of 1.96 and a p-values of 0.336 that exceeded the significance threshold of 0.05, so it can be concluded that the contribution of Environmental Awareness to Attitude has no statistical significance. Based on these findings, the H1 hypothesis that "Environmental Awareness has a significant positive influence on Attitude" cannot be supported by empirical evidence in this research.

H2 (rejected): Environmental Awareness has a significant positive influence on Perceived Behavioral Control

The results of data analysis showed a positive orientation coefficient value of 0.149 which indicated that the Environmental Awareness variable contributed positively or stimulated an increase in the Perceived Behavioral Control variable by 14.9%. Inferential statistical calculations resulted in a statistical t-value of 1.127 which was below the critical value of t 1.96 and a p-values of 0.181 which exceeded the significance threshold of 0.05, so it can be concluded that the contribution of Environmental Awareness to Perceived Behavioral Control is not statistically supported. Therefore, the H2 hypothesis that "Environmental Awareness has a significant positive influence on Perceived Behavioral Control" is not supported in this research.

H3 (accepted): Regulatory Pressures have a significant positive influence on Perceived Behavioral Control

Statistical evaluation showed a positive path coefficient value of 0.256 which indicated that the Regulatory Pressures variable contributed positively or resulted in an increase in the Perceived Behavioral Control variable of 25.6%. The results of inferential statistical analysis produced a t-statistical value of 2.873 which exceeded the critical value of t 1.96 and a p-value of 0.004 which was below the significance threshold of 0.05, confirming that the contribution of Regulatory Pressures to Perceived Behavioral Control has statistical significance. Thus, the H3 hypothesis that "Regulatory Pressures have a significant positive influence on Perceived Behavioral Control" has empirical support in this research.

H4 (accepted): Regulatory Pressures have a significant positive influence on Subjective Norms

The analysis data produced a path coefficient value with a positive orientation of 0.615 which illustrates that the Regulatory Pressures variable contributes positively or induces a substantial increase in the Subjective Norms variable by 61.5%. Inferential statistical calculations resulted in a t-statistical value of 41.216 which far exceeded the critical value of t 1.96 and a p-values of 0.000 which was well below the significance threshold of 0.05, confirming that the contribution of Regulatory Pressures to Subjective Norms has very strong statistical significance. Consequently, the H4 hypothesis which states that "Regulatory Pressures have a significant positive influence on Subjective Norms" has received very strong empirical support in this research.

H5 (accepted): Regulatory Pressures have a significant positive influence on Knowledge of MVC Principles

Quantitative analysis produced a path coefficient value with a positive direction of 0.601 which showed that the Regulatory Pressures variable had a positive impact or stimulated an increase in the Knowledge of MVC Principles variable by 60.1%. Inferential statistical testing yielded a t-statistical value of 35.310 which greatly exceeded the critical t-value of 1.96 and a p-values of 0.000 which was well below the significance threshold of 0.05, validating that the contribution of Regulatory Pressures to the Knowledge of MVC Principles has a very high statistical significance. Therefore, the H5 hypothesis which states "Regulatory Pressures have a significant positive influence on the Knowledge of MVC Principles" has very strong empirical support in this research.

H6 (accepted): Perceived Ease of Adoption has a significant positive influence on Attitude

The results of the statistical evaluation showed that the value of the path coefficient with a positive direction of 0.212 indicated that the Perceived Ease of Adoption variable contributed positively or encouraged an increase in the Attitude variable by 21.2%. Inferential statistical data processing yielded a t-statistical value of 2.838 which exceeded the critical value of t 1.96 and a p-values of 0.005 which was below the significance threshold of 0.05, confirming that the contribution of Perceived Ease of Adoption to Attitude has statistical significance. Thus, the H6 hypothesis that "Perceived Ease of Adoption has a significant positive influence on Attitude" has empirical support in this research.

H7 (accepted): Perceived Economic Value has a significant positive influence on Attitude

Data analysis produced a path coefficient value with a positive orientation of 0.231 which shows that the Perceived Economic Value variable has a positive effect or stimulates an increase in the Attitude variable by 23.1%. Inferential statistical calculations yielded a statistical t-value of 3.304 which exceeded the critical value of t 1.96 and a p-values value of 0.001 which was below the significance threshold of 0.05, confirming that the contribution of Perceived Economic Value to Attitude has statistical significance. Therefore, the H7 hypothesis which states that "Perceived Economic Value has a significant positive influence on Attitude" has empirical support in this research.

H8 (accepted): Knowledge of MVC Principles has a significant positive influence on Attitude

The results of statistical analysis showed that the value of the path coefficient with a positive direction of 0.179 which illustrates that the Knowledge of MVC Principles variable has a positive impact or resulted in an increase in the Attitude variable by 17.9%. Inferential statistical evaluation resulted in a t-statistical value of 2.078 which exceeded the critical value of t 1.96 and a p-values of 0.038 which was below the significance threshold of 0.05, validating that the contribution of Knowledge of MVC Principles to Attitude has statistical significance. Thus, the H8 hypothesis which states that "Knowledge of MVC Principles has a significant positive influence on Attitude" has empirical support in this research.

H9 (accepted): Knowledge of MVC Principles has a significant positive influence on Perceived Behavioral Control

Quantitative analysis produced a path coefficient value with a positive orientation of 0.255 which indicated that the Knowledge of MVC Principles variable contributed positively or encouraged an increase in the Perceived Behavioral Control variable by 25.5%. Inferential statistical testing yielded a t-statistical value of 2.508 which exceeded the critical value of t 1.96 and a p-value of 0.012 which was below the significance threshold of 0.05, confirming that the contribution of Knowledge of MVC Principles to Perceived Behavioral Control has statistical significance. Therefore, the H9 hypothesis which states that "Knowledge of MVC Principles has a significant positive influence on Perceived Behavioral Control" has empirical support in this research.

H10 (accepted): Attitude has a significant positive influence on Intention to Adopt

The results of the statistical evaluation showed that the value of the path coefficient with a positive direction of 0.494 which showed that the Attitude variable made a substantial positive contribution or stimulated a significant increase in the Intention to Adopt variable of 49.4%. Inferential statistical data processing resulted in a t-statistical value of 7.661 which far exceeded the critical t-value of 1.96 and a p-values of 0.000 which was well below the significance threshold of 0.05, validating that Attitude's contribution to Intention to Adopt had a very high statistical significance. Thus, the H10 hypothesis that "Attitude has a significant positive influence on Intention to Adopt" has very strong empirical support in this research.

H11 (rejected): Perceived Behavioral Control has a significant positive influence on Intention to Adopt

Data analysis produced a path coefficient value with a positive but very marginal orientation of 0.022 which indicates that the Perceived Behavioral Control variable only made a minimal positive contribution or a very small increase in the Intention to Adopt variable of 2.2%. Inferential statistical calculations yielded a t-statistical value of 0.161 which is well below the critical value of t 1.96 and a p-values of 0.567 which greatly exceeds the significance threshold of 0.05, confirming that the contribution of Perceived Behavioral Control to Intention to Adopt has no statistical significance. Based on these findings, the H11 hypothesis that "Perceived Behavioral Control has a significant positive influence on Intention to Adopt" did not receive empirical support in this research.

H12 (accepted): Subjective Norms have a significant positive influence on Intention to Adopt

The results of statistical analysis showed a positive path coefficient value of 0.184 which illustrates that the Subjective Norms variable has a positive impact or resulted in an increase in the Intention to Adopt variable of 18.4%. Inferential statistical evaluation resulted in a t-statistical value of 5.018 which far exceeds the critical t-value of 1.96 and a p-values of 0.000 which is well below the significance threshold of 0.05, validating that the contribution of Subjective Norms to Intention to Adopt has high statistical significance. Therefore, the H12 hypothesis that "Subjective Norms have a significant positive influence on Intention to Adopt" has strong empirical support in this research.

CONCLUSION

This study investigated the key factors influencing the intention of plastic-based medical device manufacturers in Indonesia to adopt *Material Value Conservation* (*MVC*) principles in product design. The findings confirmed that *attitude*, *subjective norms*, and *perceived behavioral control* significantly affect adoption intention, with *attitude* showing the strongest direct effect. Among external variables, *regulatory pressures* and *perceived economic value* were the most influential, shaping both intention and other mediating variables such as knowledge and *attitude*. *Knowledge of MVC principles* and *environmental awareness* were found to be high among respondents, providing a strong foundation for adoption, although *environmental awareness* had no statistically significant direct effect. Conversely, *regulatory pressure* emerged as a major driver, significantly influencing *subjective norms*, knowledge, and *perceived behavioral control*. *Ease of adoption* was perceived as moderate, while economic concerns remained the key barrier due to anticipated implementation costs. Nonetheless, most respondents indicated a positive intention to adopt *MVC* principles in the near future, with 68.09% showing strong commitment. The study contributes theoretically by extending the *Theory of Planned Behavior* (*TPB*) in the context of the *circular economy* and offers empirical insights for policymakers and industry stakeholders. It highlights the importance of improving *regulatory frameworks*, increasing awareness, and offering economic incentives to accelerate sustainable practices in the medical device sector.

REFERENCES

Ajzen, I. (2020). The theory of planned behavior: Frequently asked questions. *Human Behavior and Emerging Technologies, 2*(4). https://doi.org/10.1002/hbe2.195

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Lawrence Erlbaum Associates.

Cohen, J., & van der Meulen Rodgers, Y. (2020). Contributing factors to personal protective equipment shortages during the COVID-19 pandemic. *Preventive Medicine, 141*, 106263. https://doi.org/10.1016/j.ypmed.2020.106263

Gabriel, D. S. (2016). How to increase plastic waste acceptance for mechanical recycling: An introduction to material value conservation and its phenomenon. *Key Engineering Materials, 705*, 362–367. https://doi.org/10.4028/www.scientific.net/KEM.705.362

Gabriel, D. S., Habiburrahman, M., & Endthen, P. J. (2018). Material value conservation: Development of design criteria for rigid plastic packaging. *Materials Science Forum, 936*, 110–115. https://doi.org/10.4028/www.scientific.net/MSF.936.110

Gabriel, D. S., & Maulana, J. (2018). Impact of plastic labelling, coloring and printing on material value conservation in the products of secondary recycling. *Key Engineering Materials, 773*, 384–389. https://doi.org/10.4028/www.scientific.net/KEM.773.384

Gabriel, D. S., Pratama, B. A. J., & Hapsari, C. (2018). Plastic packaging material value conservation and the structure of stakeholder role. *Key Engineering Materials, 773*, 396–404. https://doi.org/10.4028/www.scientific.net/KEM.773.396

Ganguly, R. K., & Chakraborty, S. K. (2021). Integrated approach in municipal solid waste management in COVID-19 pandemic: Perspectives of a developing country like India in a global scenario. *Case Studies in Chemical and Environmental Engineering, 3*, 100087. https://doi.org/10.1016/j.cscee.2021.100087

Ganguly, R. K., & Chakraborty, S. K. (2024). Plastic waste management during and post COVID-19 pandemic: Challenges and strategies towards circular economy. *Heliyon, 10*, e25613. https://doi.org/10.1016/j.heliyon.2024.e25613

Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2017). *Multivariate data analysis* (8th ed.). Cengage Learning.

Hair, J. F., Hult, G. T. M., Ringle, C. M., Sarstedt, M., Danks, N. P., & Ray, S. (2021). *An introduction to structural equation modeling*. Springer.

Hair, J. F., Hult, G. T. M., Ringle, C. M., Sarstedt, M., Danks, N. P., & Ray, S. (2022). *Partial least squares structural equation modeling (PLS-SEM) using R: A workbook*. Springer Nature. https://doi.org/10.1007/978-3-031-10153-7

Joseph, B., James, J., Kalarikkal, N., & Thomas, S. (2021). Recycling of medical plastics. *Advanced Industrial and Engineering Polymer Research, 4*(3), 199–208. https://doi.org/10.1016/j.aiepr.2021.06.003

Liu, L., Zhang, M., & Ye, W. (2019). The adoption of sustainable practices: A supplier's perspective. *Journal of Environmental Management, 232*, 692–701. https://doi.org/10.1016/j.jenvman.2018.11.067

MacNeill, A. J., Hopf, H., Khanuja, A., Alizamir, S., Bilec, M., Eckelman, M. J., Hernandez, L., McGain, F., Simonsen, K., Thiel, C., Young, S., Lagasse, R., & Sherman, J. D. (2020). Transforming the medical device industry: Road map to a circular economy. *Health Affairs, 39*(12), 2088–2097. https://doi.org/10.1377/hlthaff.2020.01118

Patrício Silva, A. L., Prata, J. C., Walker, T. R., Duarte, A. C., Barceló, D., & Rocha-Santos, T. (2021). Increased plastic pollution due to COVID-19 pandemic: Challenges and recommendations. *Chemical Engineering Journal, 405*, 126683. https://doi.org/10.1016/j.cej.2020.126683

Patrício Silva, A. L., Prata, J. C., Walker, T. R., Campos, D., Duarte, A. C., Soares, A. M. V. M., & Rocha-Santos, T. (2020). Rethinking and optimising plastic waste management under COVID-19 pandemic: Policy solutions based on redesign and reduction of single-use plastics and personal protective equipment. *Science of the Total Environment, 742*, 140565. https://doi.org/10.1016/j.scitotenv.2020.140565

Reynier, T., Berahou, M., Albaladejo, P., & Beloeil, H. (2021). Moving towards green anaesthesia: Are patient safety and environmentally friendly practices compatible? A focus on single-use devices. *Anaesthesia Critical Care and Pain Medicine, 40*(4), 100907. https://doi.org/10.1016/j.accpm.2021.100907

Rizan, C., Mortimer, F., Stancliffe, R., & Bhutta, M. F. (2020). Plastics in healthcare: Time for a re-evaluation. *Journal of the Royal Society of Medicine, 113*(2), 49–53. https://doi.org/10.1177/0141076819890554

Tyani, D. R., & Gabriel, D. S. (2020). Redesign rigid plastic packaging for material value conservation. *International Journal of Advanced Science and Technology, 29*(7), 73–87.