Journal of Open Innovation: Technology, Market, and Complexity

MDPI

Article

Model Development of Innovative Wood Substitutes for the Sustainable Growth of the Thai Wood Substitution Industry

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Received: 3 January 2020; Accepted: 28 February 2020; Published: 2 March 2020

Abstract: The continuously occurring problems of forest depletion have resulted in the deforestation of countries and climate change. In order to resolve this problem, the development of innovative wood substitutes is essential. This research strives to develop a model for innovative wood substitutes for the sustainable growth of the Thai wood substitution industry. Qualitative and quantitative studies were employed to collect data through interviews and questionnaires. The subjects in this study included 500 entrepreneurs from the timber, lumber, and wood substitution industries. The results showed that the model for innovative wood substitutes for the sustainable growth of the Thai wood substitution industry consists of four main components, i.e., (1) customer orientation; (2) innovation and technology; (3) research and development; and (4) resources. The focus group results revealed that the developed structural equation model simulation passed the criteria of the data model fit evaluation with a chi-squared probability level (p) of 0.274, CMIN/DF = 1.071, goodness of fit index (GFI) = 0.969, and root mean square error of approximation (RMSEA) = 0.012.

Keywords: innovative; wood substitute; sustainable; industry; structural equation model

1. Introduction

Forestry biodiversity in nature is valuable and important for mankind, especially for Southeast Asia, which is located in a tropical zone that presents natural diversity [1]. The three countries in this area that contain the highest forestry biodiversity are the Philippines, Indonesia, and Malaysia [2]. However, people in these countries unlimitedly deplete the forest resources in order to endlessly develop their economy, resulting in a significant deterioration of fertile soil and forest in this region. Thus, the Food and Agriculture Organization of the United Nations (FAO) conducted a survey of forest and forest areas in Southeast Asia from 1990 to 2015, and they discovered that the forested landscapes in this region have been continuously decreasing, with Thailand showing a declining tendency of its forests (Figure 1) [3].

According to the survey by the Royal Forest Department in 1973, the forest area in Thailand was 221,707 square kilometers or 48.21% of the country area, but in 2017, the forest area was only 163,450.16 square kilometers or 31.58% of the country area [4]. It can be clearly seen that during the past 40 years, the forest in Thailand has had the tendency to dramatically decrease due to illegal logging for timber and lumber used in the construction, furniture, and habitation industries. Moreover, deforestation is caused by trespassers who destroy the forest to utilize it for agricultural purposes as well as to produce charcoal.

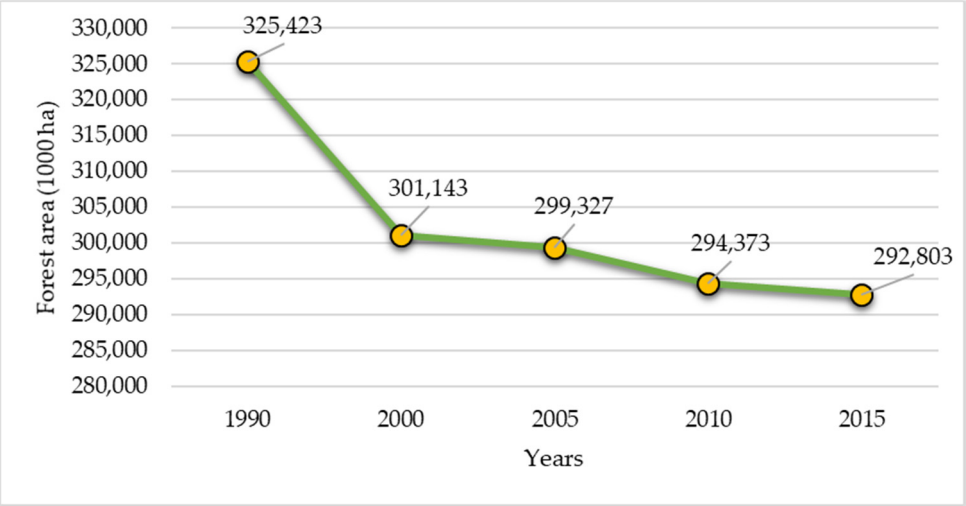

Figure 1. Forest area in Southeast Asia in 1990 to 2015 [3].

The statistics that were collected by the Forest Protection and Fire Control Bureau, Royal Forest Department in 2017, showed that from 2013 to 2017, the forest area was continuously trespassed and destroyed [4]. The report revealed that illegally felled wood was cut in the form of logs and lumber that was to be used for housing construction or to make furniture. In contrast to the critical situation described above, from 2013 until now, the amount of wood product trading, both inside the country and in exports, has continuously decreased, which might be a result of global warming campaigns and rallies against the use of forest products [5]. Therefore, there is a need for the wood industry in Thailand to adjust itself to cope with this critical issue by developing innovative wood substitutes or artificial wood.

Nowadays, there are several wood substitute producers who have different ways of manufacturing their products by using different formulae, thus producing a variety of quality products. In the past few decades, a lot of interest has been shown in wood substitutes for use in a lot of construction industries, such as interior design (e.g., for artificial wooden floor terraces and staircase rails) and outdoor furniture in gardening. Moreover, wood substitutes can be used in the automobile industry [6]. This supports research by Ajang et al. [7], who studied the structural equations model (SEM) of demand and supply of wood veneer in Iran, revealing that the demand of wood veneer increased from 4% in 2000 to 6% in 2010. It can be concluded that there is a higher demand for wood substitutes. Presently, wood substitute producers are trying to develop the products in response to customer needs by making substitute characteristics that are similar to authentic wood including some better features such as durability, more attractive colors, and various patterns. These developments are in line with reports on the consumption of wood substitutes and plastic wood between 2010 and 2013, and the forecasts of growth tendency in 2014 and 2015 in North America, China, Europe, and Southeast Asia were 8%, 25%, 11%, and 13% annually, respectively [8]. However, wood substitutes cannot totally replace real wood on a commercial scale, even though their features and characteristics are better and of higher quality.

Therefore, this researcher tried to find the variables that explain why wood substitutes cannot respond to consumer needs. In order to find the consumer needs of these product, the researcher developed an innovative wood substitute model for the sustainable growth of the Thai wood substitution industry. The significance of this study will be very useful to resolve the deforestation issue and to suggest guidelines in creating innovative wood substitutes and developing other related industries for enhancing sustainable growth potential.

2. Literature Review

2.1. Definition of Wood Substitution

A wood substitute is a material that is produced from natural materials combined with others, such as rice husks, empty fruit bunches, bagasse, and agricultural residues after harvesting, or a product that is developed from synthetic polymers, such as plastic beads and recycled plastic. Such materials can be used instead of real wood from nature [9,10]. Nowadays, technology that utilizes wood waste and other agricultural residues for industrial production is highly advanced, creating industrial wood substitutes such as wood-based panels, particleboards, medium-density fiberboards, and wood–cement boards. Furthermore, technology to create synthetic polymers to be used as wood substitutes and conventional composites, such as plywood, polymer composites, and wood–plastic composites, has been developed [11–13].

2.2. Concepts and Theories about Customer Orientation

A consumer is anyone who possesses the needs of a product with purchasing power and, as a consequence, can create purchasing and using behaviors [14]. In other words, this is an individual, or individuals, who expresses their right in needs of a consuming product placed in the market. A consumer can buy a product that responds to their or their family's needs or for the satisfaction of the community. However, in the marketer's view, it cannot be concluded that every individual is the consumer of any particular product [15]. Therefore, it is required to define the four components of a consumer in the selection of the market target: (1) a consumer must possess needs; (2) a consumer must possess purchasing power; (3) a consumer must possess purchasing behavior; and (4) a consumer must possess consumption behavior [16]. After selecting the target market, consumer behavior needs to be studied to identify purchasing, consuming, evaluating, using, and services behaviors that are expected to respond to their needs. Consumer behavior analysis is necessary for all business operations [17]. In addition, a consumer's purchasing decision depends on economic needs, and some reasons [18] are influenced by four factors: (1) a cultural factor that consists of their fundamental culture, sub-culture, and social classes; (2) a social aspect that consists of their reference group, family, role, and status; (3) a personal factor that consists of their age, family life cycle, career, financial status, and way of living; and (4) a psychological aspect that consists of their motivation, perception, learning, beliefs, and attitudes [17].

2.3. Concepts and Theories about Research and Development

In the production industry, after realizing consumer behavior and needs, the research and development process is conducted to fulfill those needs. The process starts by using the researcher's knowledge as a foundation to transfer the intangible asset and develop it with modern technology to become tangible [19]. Thus, the continuous development of new products can reduce the risk of uncertain market needs. The change in technology and the shorter life cycle of a product are obstacle factors in marketing competition. Placing the importance on the efficiency of the new product development process is essential for an enterprise to survive. When a product reaches the marketing decline stage, R&D can help in creating a new product to meet the needs of the market by substituting the existing one in order to revive the product life cycle [20]. R&D plays an important role in creating a competitive edge by introducing a new product and a new service to the market, including the development of product extensions, to always get the newest and more differentiated product [21].

2.4. Concepts and Theories of Innovation

Innovation refers to the following stages: the invention, development, and implementation of the "better than and different from the previous one" products [19]. That is to say, innovation is the newness that can be in the form of a new idea, a new invention, a new method, new management, etc. [22]. Moreover, Porter defined innovation as the compilation of a new technology, new process, and new

approaches to create innovation. Innovation is important for an organization to obtain competition potential [23]. As a result, innovation influences business turnover and helps an organization achieve the trading target with higher benefits, reflecting the business growth [24,25]. Innovation development is the improvement of organizational characteristics or behavior from something that has never been changed before to be more novel and effective. The development of good products and services acts as a response to the stimuli of the globalization context, where knowledge and innovation are the main factors in adding value. First of all, all developments of organizations have to be of high quality, efficiency, and effectiveness to meet customer needs and satisfaction, as well as to have an advantage to compete in global competition [26]. Innovation is the core reason for modern existence, so companies need to more quickly develop new products and/or services and to change in order to be innovation sustainable.

2.5. Concepts and Theories about Resources

To create innovation for business competition, an organization must rely on its resource-based view (RBV) to create sustainable growth and benefits. The RBV of any organization can be defined as three types: (1) a physical resource that consists of factories, machines, locations, technology, raw materials, assets, etc.; (2) a human resource that consists of employees, knowledge, cleverness, teamwork, training, experiences, etc.; and (3) an organizational resource that consists of organizational structures, planning processes, organizational cultures, databases, IT systems, brands, copyrights, goodwill, etc. [27]. Important features of strategic resources that can create an advantage include four factors: (1) they must possess value in business operation to create opportunities and reduce obstacles; (2) they must be scarce, which means no competitor; (3) they must possess an identity that cannot be duplicated or costly for duplication; and (4) they cannot be replaced [28,29]. These four types of resources are obstacles for competitors and enable an organization to grow sustainable profit.

From the concepts and theories mentioned above, this researcher proposed components for developing a model for innovative wood substitutes for the sustainable growth of the Thai wood substitution industry, as shown in the research structure framework in Figure 2. Hypothesis 1 H1: The consumer orientation variable directly influences the research and development variable [30,31]. H2: The innovation and technology variable directly influences the consumer orientation variable [32,33]. H3: The resource variable directly influences the research and development variable [34,35]. H4: The innovation and technology variable directly influences the resource variable [36,37].

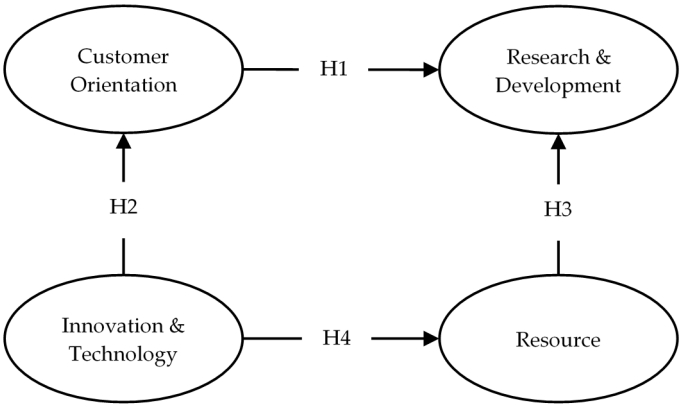

Figure 2. Framework of the study.

3. Methods

This study was designed as a mixed-methodology process that was divided into the following 3 phases:

Phase 1—Qualitative Research 1: The data from this qualitative research were derived from an in-depth interview that was constructed by the researcher in the form of open-ended questions that were based on the review literature. The informants were 9 experts with the qualifications that were required by the criteria. The results from the interview were employed to develop questionnaires in the form of rating scales.

Phase 2—Quantitative Research: The data for the quantitative research were developed from both previous studies and the content analysis of in-depth interviews to create a research tool. The instrument of this study was divided into two parts: (1) the characteristics of the organization, which were determined by using checklist questions; (2) factors in developing innovative wood substitutes, where all items were measured by using a 5-point Likert scale ranging from 1 ("strongly unimportant") to 5 ("strongly important"); and (3) opinions and suggestions. The questionnaires were validated by 5 specialists with a content validation between 0.6 and 1.0, the reliability of Cronbach's alpha = 0.990, a discriminant analysis of the question item with the correlated item–total correlation was between 0.335 and 0.895, the overall SD (standard deviation) of the checklist was between 0.430 and 1.931. After passing the validation with a very good result, the questionnaires were used to collect data from 500 entrepreneurs of the lumber and furniture industries [38]. Then, the results of the questionnaires were used to construct the simulation model.

Phase 3—Qualitative Research 2: The researcher designed a process that was based on the focus group method by 7 experts who had a discussion on a model developed for the sustainable growth of the wood substitution industry in which impact factors that influence the model were debated, expressing their resulting judgments. Then, the simulation model was analyzed by content analysis for more completeness.

3.1. Data Analysis

A descriptive statistics analysis was employed to SPSS to find frequencies, percentages, mean ($\overline{X}$), and standard deviation (SD). Influential statistics were used to find the difference between 2 independents, the sawed timber and furniture industry, by using a *t*-test. The structural equations model (SEM) analysis was done by AMOS. There were 4 statistic variables that were used to evaluate the data model fit [33]: (1) the chi-squared probability level: $p \geq 0.05$; (2) relative chi-squared (CMIN/DF) ≤ 2.0; (3) the goodness of fit index (GFI) ≥ 0.90; and (4) the root mean square error of approximation (RMSEA) ≤ 0.08.

3.2. Samples

The questionnaires were distributed to the samples from August 2018 to December 2018. In total, 500 contributors presented a summary of the organization characteristics in Table 1. The majority of respondents were small- and medium-sized businesses (80.20%) with 5–10 years of business operations (43.40%) and a capital investment of under USD 30,000 (51.20%). The ratios of industry types were 50% of the sawed timber industry and 50% of the furniture industry.

Table 1. Summary of the respondents' organization characteristics.

Variables	Description	Frequencies	Percentages (%)
Industry Types	Sawed timber	250	50.00
	Furniture	250	50.00
Business Sizes	Small and Medium	401	80.20
	Large	99	19.80
Business Operations	<5 years	108	21.60
	5–10 years	217	43.40
	>10 years	175	35.00
Business Capital	<30,000 USD	256	51.20
	30,000–150,000 USD	86	17.20
	>150,000 USD	158	31.60

Note: USD: United States Dollar.

4. Results

4.1. Qualitative Research 1 Results

The qualitative results from the in-depth interview showed that the model for innovative wood substitutes for the sustainable growth of the Thai wood substitution industry consists of four main components: (1) customer orientation; (2) innovation and technology; (3) research and development; and (4) resources. The data were then used to write 100 questions with 25 items for each component.

4.2. Quantitative Research Results

The quantitative results revealed that the important level of the variables in the development of innovative wood substitutes was at a high level with an average of 3.81. When considering each item, it was found that all four variables were rated at a high level, with the highest variable rating being for resource with 3.83, followed by customer orientation with 3.82, innovation and technology with 3.79, and research and development with 3.77. When comparing the different types of industries and the importance level of the four variables, it was found that there was no statistical difference (Table 2).

Table 2. Summary of descriptive and inferential statistical analysis.

Innovative Development Factor	$\overline{X}$	SD	*t*-Value	*p*-Value
Overall	3.81	0.55	0.03	0.97
Customer Orientation	3.82	0.54	−0.44	0.66
Research & Development	3.79	0.57	−0.24	0.81
Innovation & Technology	3.77	0.63	0.14	0.88
Resource	3.83	0.58	0.62	0.53

The results of the data model fit evaluation of the SEM model of innovative wood substitutes for the sustainable growth of the Thai wood substitution industry were: RMSEA = 0.061 and χ^2/df = 2.864, passed the evaluation criteria. However, the chi-squared probability level = 0.000, the CMIN/DF = 2.864, and the GFI = 0.615, which did not pass the evaluation. Therefore, the researcher adjusted the simulation model by considering the modification indices that were suggested by Arbuckle [39]. After the adjustment, the chi-squared probability level was 0.274, the CMIN/DF = 1.071, GFI = 0.969, and the RMSEA = 0.012; thus, the four statistics level passed the evaluation criteria. The model of innovative wood substitutes for the sustainable growth of the Thai wood substitution industry fit the evaluating criteria and the empirical data as shown in Figure 3, Tables 3 and 4.

Table 3. Summary of fit indices for the structural model.

Model	CMIN/DF	GFI	RMSEA	*p*-Value
Measurement Model	2.864	0.615	0.061	0.000
Revised Model	1.071	0.969	0.012	0.274
Recommended value	≤2.0	≥0.90	≤0.08	≥0.05

Table 4. Results of total effects for a path analysis in the structural model.

Path			Estimate β		R^2	Variance	C.R.	p
			STD	Un STD				
Innovation & Technology	→	Customer Orientation	0.98	1.08	0.96	0.01	11.84	***
Innovation & Technology	→	Resource	0.89	0.87	0.80	0.05	10.85	***
Customer Orientation	→	Research & Development	0.30	0.34	0.98	0.01	2.39	*
Resource	→	Research & Development	0.71	0.90	0.98	0.01	5.05	***
Customer Orientation	→	co10	0.67	1.00	0.45	0.42	-	-
	→	co11	0.53	0.74	0.28	0.48	10.70	***
	→	co18	0.67	0.97	0.45	0.39	13.31	***
	→	co20	0.60	0.88	0.35	0.49	11.92	***
	→	co23	0.65	0.95	0.42	0.43	12.88	***
Research and Development	→	re3	0.63	1.00	0.39	0.66	-	-
	→	re6	0.64	0.82	0.41	0.41	12.26	***
	→	re16	0.70	0.91	0.49	0.37	13.05	***
	→	re19	0.75	1.00	0.56	0.34	13.75	***
	→	re21	0.68	0.99	0.47	0.48	12.84	***
Innovation and Technology	→	in1	0.61	1.00	0.37	0.48	-	-
	→	in4	0.55	0.90	0.31	0.53	10.49	***
	→	in7	0.65	1.08	0.43	0.45	11.95	***
	→	in14	0.57	1.06	0.32	0.66	10.75	***
Resource	→	rs3	0.63	1.00	0.39	0.41	-	-
	→	rs16	0.65	1.18	0.42	0.51	12.04	***
	→	rs17	0.64	1.08	0.41	0.45	11.93	***
	→	rs22	0.64	0.99	0.41	0.38	11.93	***

Note: C.R.: critical ratio, *: $p < 0.05$, ***: $p < 0.001$, STD: standardized.

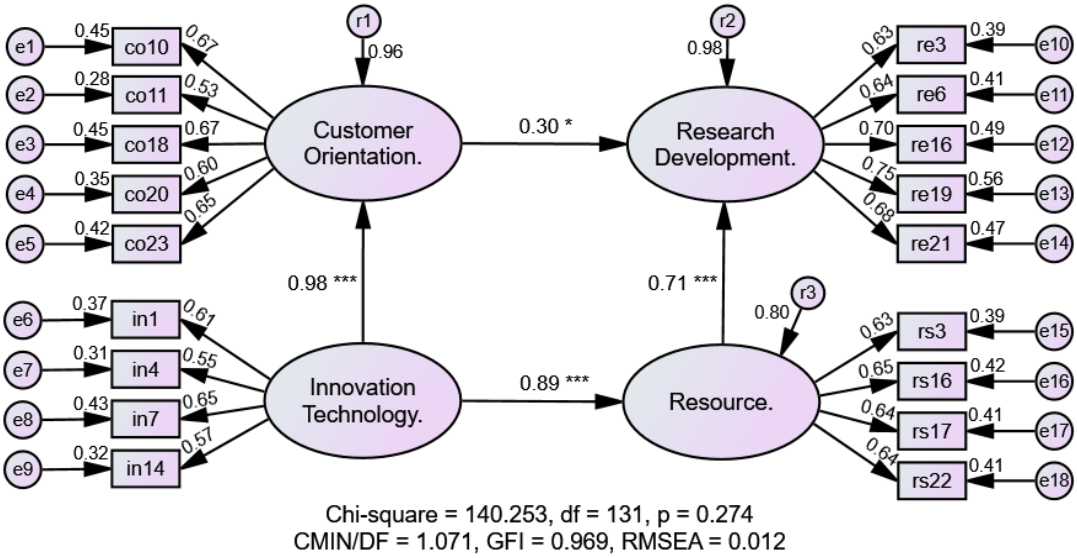

Figure 3. The results of the path diagram for the structural model.

4.3. Abbreviation Definitions

Innovation and Technology

in1 To use a highly advanced and precise instrument/machine for producing wood replacement materials.

in4 To create innovation and technology by forming networks through outsourcing, e.g., wood replacement material industry associations.

in7 To develop a unique wood replacement material producing technology that is difficult for rivaling industries to imitate.

in14 To develop a wood replacement material innovation with an advanced technology under green society trends and green products.

Customer Orientation

co10 To develop useful wood replacement materials matching with customers' needs.

co11 To present wood replacement materials in various prices, shapes, and qualities that satisfy different groups of customers.

co18 To elicit customers' future need of wood replacement material innovation by continually supporting their usage and development of wood replacement materials.

co20 To develop a wood replacement material innovation that fulfills target customers' needs, thus leading to their positive impression on wood replacement materials (project reference).

co23 To take part in international fairs and present a product's usage to be well-known throughout the world.

Resource

rs3 To build a learning culture to encourage ones' creativity in developing wood replacement materials.

rs16 To support internships from a target school for future recruitment.

rs17 To suitably manage the time for staff to have an adequate amount of time to creatively think of wood replacement material development.

rs22 To bring an effective resource restriction to the organization.

Research and Development

re3 To always enhance and update the database of wood replacement materials.

re6 To determine processes and critiques used in researching and developing wood replacement materials that conform to the objectives and value.

re16 To always research and enhance wood replacement materials to be cheaper, fairer, and easier to use.

re19 To have an idea of using available local materials in researching and developing wood replacement materials.

re21 To arrange a wood replacement material research competition to discover new knowledge of developing wood replacement materials.

4.4. Qualitative Research 2 Results

The results of the qualitative focus group discussion of seven experts showed an agreed consensus on the model development of innovative wood substitutes for the sustainable growth of the Thai wood substitution industry, with some suggestions for further practical usage.

5. Discussion

The customer orientation variable directly influences the research and development variable. When conducting research and development to meet customer needs, the process starts by using the researcher's knowledge as a foundation to transfer the intangible asset and develop it with modern technology to become tangible [19]. That is to say, the customer needs have a direct influence on research and development [30–32]. Therefore, entrepreneurs need to research and develop to keep up with market trends before producing products by using marketing data from actual consumer needs to make a product that is widely accepted and to successfully maintain a competitive edge.

The innovation and technology variable directly influences the customer orientation variable, because, nowadays, innovation and technology are important in business development to endlessly respond to customer needs and to create a business advantage in the competition. In order to create a business advantage, innovation is used to search for new inventions along with the use of modern technology to improve existing products, as required by the customer [40]. In addition, innovation has an influence on the marketing ability of an organization and the index of competitive advantage and business capability [7,33]. Entrepreneurs should turn their attention to the development of innovation and technology in the production of products because fierce global competition makes consumers always look for new products. Therefore, if any entrepreneur neglects the development of innovation and technology, they may be disrupted by other products in the market and experience business failure.

The resource variable directly influences the research and development variable because a resource is a very important variable to create a competitive advantage. The research and development process requires resources, humans, materials, equipment, funds, etc., to achieve the goals of the organization with the belief that research and development will provide new options or methods that will help to gradually increase the effectiveness of the work. Furthermore, resources are the key to the operations that lead to processes, such as operational methods, planning, problem-solving, and other operations-related factors [41,42]. These factors need R&D to achieve competitive capability. Thus, the resource variable has a direct influence on research and development [34,35]. Because of the aforementioned reasons, entrepreneurs need to continually rely on resource management, and they have to ascertain for valuable resources for research and development to produce products that are different from the general market, resulting in a competitive advantage to regularly surpass competitors.

The innovation and technology variable directly influences the resource variable because resources are very important in conducting research and development. It is necessary to rely on a diversity of resources to develop innovation and invention [43]. Innovation and technology have a direct influence on the resources of an organization, including as human and financial resources [36,37]. Therefore, entrepreneurs should develop organizations to be innovative by improving their resources in order to

be able to create innovation. This growth development requires a huge capital infusion, but the result will create value with enormous profits, leading entrepreneurs to business success.

6. Conclusions

It can be concluded from the research on the model development of innovative wood substitute for the sustainable growth of the Thai wood substitution industry that four main variables for developing innovative wood are those of customer orientation, innovation and technology, research and development, and resources. An entrepreneur should adjust and develop for the extension of their business. Research and development for wood substitutes is directly and indirectly influenced by innovation and technology, customer orientation, and resources. The researcher expects that an entrepreneur can employ the results of this study to create a competitive advantage for the sustainability of the wood substitution industry in the future.

Author Contributions: Conceptualization, T.A. and T.R.; methodology, T.A. and T.R.; software, T.A.; validation, T.A. and T.R.; formal analysis, T.A.; investigation, T.A.; resources, T.A.; data curation, T.A.; writing—original draft preparation, T.A.; writing—review and editing, T.A. and T.R.; visualization, T.A.; supervision, T.R. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

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