

The Influence of Distribution Capacity, Market Penetration Capacity and Availability of Natural Resource on Competitive Advantage of Low-Carbon Hydrogen Business Development

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ABSTRACT

The world has a joint commitment to deal with global warming by limiting temperature increases to 1.5 °C–2 °C through emission reduction and setting a Net Zero Emission (NZE) target. Large-scale, low-carbon hydrogen production has the capacity to greatly aid in the battle against climate change by reducing the consequent carbon dioxide emissions. This research aim is to determine the influence of distribution capacity, market penetration capacity, and availability of natural resources on the competitive advantage of low-carbon hydrogen business development. The sample of this research covers 103 respondents using the purposive sampling method. Questionnaires are used to collect the data. SPSS is used as a tool for analysis. The findings of this research are distribution capacity, market penetration capacity, and availability of natural resources significantly influence the competitive advantage of low-carbon hydrogen business development. This finding will contribute to the previous research about the evaluation of supply chain optimization and modeling, as well as hydrogen production.

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1. INTRODUCTION

The majority of the energy supply is still produced from fossil fuels, despite the fact that the world's need for energy is expanding yearly. On the other hand, the world has a joint commitment to deal with global warming by limiting temperature increases to 1.5 °C–2 °C through emission reduction and setting a Net Zero Emission (NZE) target. This will ultimately bring the world into a period of energy transition. Energy transition to more sustainable and greener energy sources that can both meet the demand for energy while also improving the environment. Large-scale, low-carbon hydrogen production has the capacity to greatly aid in the battle against climate change by reducing the consequent carbon dioxide emissions. Hydrogen has the same potential for energy generation as natural gas. Gas turbines that run on synthetic gas, which can have up to 95% hydrogen by volume, have been in use for more than a decade and have been produced commercially on a large scale.

Several research has been conducted to investigate the development of low-carbon hydrogen. Jefferson *et al.* (2022) studied the models for optimizing hydrogen production and supply chains. They explained that the distribution system, market penetration, and availability of natural resources significantly influence the competitive advantage of low-carbon hydrogen business development. They also mentioned different technologies and methods to produce hydrogen. The most common technologies are steam methane reforming (natural gas) equipped with carbon capture and storage (CCS), water electrolysis using renewable energy, and SMR, all of which have a lot of trade-offs. According to Sinaga and Manullang (2022), green hydrogen technology has promise for development in Indonesia. The electrolysis of water, methanol, and biomass is a typical method for producing hydrogen. Hydrogen could cut greenhouse gas emissions. However, Indonesia faces issues developing green hydrogen technology, one of which is high production costs and insufficient infrastructure. Research in Pakistan by Irfan *et al.* (2018)

discovered that renewable and alternative energy sources can help alleviate Pakistan's energy issue. Hydrogen is expected to replace fossil fuels in the future due to political, financial, and environmental factors.

By examining the influence of distribution capacity, market penetration capacity, and availability of natural resources on the competitive advantage of low-carbon hydrogen business development, this research aims to close the current knowledge gap. This research is thought to raise the degree of knowledge in the low-carbon hydrogen businesses development in Indonesia by improving theoretical understanding of the variables examined and assessments of the hydrogen supply chain and production management.

2. LITERATURE REVIEW

2.1. Competitive Advantage

Based on [Hao Ma \(1999\)](#), competitive advantage results from a difference between firms along any dimension of firm qualities and characteristics that permits one firm to create more customer value than the others. Ownership of assets or positions, access to distribution and supply, and competency in business operation are all examples of generic sources of competitive advantage. It also incorporates aspects of the internal working of the business, e.g., resources and competencies, and factors in the external environment, e.g., market position and relationship with outside organizations. [Li et al. \(2006\)](#) in [Natasha and Devie \(2013\)](#) defined competitive advantage as a state in which a company can create a good defensive position above its competitors. The competitive advantage process includes sources of excellence based on [Arison Nainggolan \(2018\)](#), namely, superior resources, which are dimensions that can strengthen advantages such as a strong distribution network, production capacity, marketing strength, technology, and natural resources.

2.2. Distribution

Distribution is a marketing strategy that aims to expedite and facilitate the transfer of products and services from producers to consumers to meet customers' requirements, according to [Fandy Tjiptono \(2008\)](#). [Fajar and Laksana \(2008\)](#) explained that distribution is a series of organizations involved in all acts employed to distribute items and the status of their owners from producers to consumers. Petroleum transportation, [Andrew Chew Chun Kit \(2021\)](#) concluded, includes the transportation of crude oil as well as derivatives like gasoline. Oil products are transported via trucks, rail cars, pipelines, and tankers. The quantity touched, and the destination determines the raw material movement plan.

2.3. Market

A market is defined as a group of people who are willing to spend money on shopping to attain fulfillment, according to [Stanton and Yohanes \(1993\)](#). Market potential, according to [Albi Panatagama \(2023\)](#), is the quantity of clients or revenue you could earn in a specific amount of time. Potential markets, according to experts in [Rosyida](#)

(2022); [Ehrenberg et al. \(2003\)](#), are a place where buyers and sellers come together. Goods or services are products exchanged by buyers and sellers. In this exchange, the price of the goods or services exchanged appears. The market is not just a place but also a mechanism that can organize the interests of buyers and sellers.

2.4. Natural Resources

The Natural Resources Endowment Theory was initiated by Harvey S. Perloff and Lowdon Wingo, Jr in [Dwi Widiarsih \(2017\)](#). The natural resource base theory states that growth in a region is greatly influenced by the availability of natural resources and the demand for commodities produced by these natural resources. [Manishiq \(2023\)](#) explained that natural resources are produced naturally from materials found in the environment. Natural resources include water, rocks, air, plants, sunlight, soil, fossil fuels, and animals. Natural resources include metals, textiles, water, food, geothermal energy and fertilizer. Experts cited several theories regarding natural resources in [Zakky \(2019\)](#). The term natural resources according to Ireland (1974) in [Soerianegara \(1977\)](#) is defined as the state of the natural environment which has value to meet human needs. Meanwhile, Isard (1972) in [Soerianegara \(1977\)](#) defines natural resources as environmental conditions and raw materials used by humans to meet their needs and improve their welfare.

3. METHODOLOGY

This research was carried out using quantitative methods. [Sugiyono \(2021\)](#) defines quantitative research methods as research methods that are based on the philosophy of positivism, used to research certain populations or samples, collect data using research instruments, and quantitative/statistical data analysis with the aim of testing predetermined hypotheses. This research studied the effect of distribution capacity, market penetration capacity, and availability of natural resources on the competitive advantage of low-carbon hydrogen business development. Survey method implemented to collect data from a population. The survey was carried out by giving responders a list of questions in the form of a questionnaire. Purposive sampling is the sample determination method used in this study, which employs a non-probability sampling strategy. Because obtaining samples at random is frequently hampered by several issues, purposive sampling is utilized in the hopes that the sample criteria acquired are consistent with the study that will be done. Given that low-carbon hydrogen is a relatively new commodity and has not yet been realized in Indonesia, the respondents for this research were 103 employees of Pertamina Group (Energy Company), who have basic knowledge related to the low-carbon hydrogen business, such as division of technology innovation, low carbon energy business development, Pertamina International Refinery, Pertamina Power Indonesia. Minimum sample size is calculated using the Cochran formula explained [Sugiyono \(2021\)](#); n = number of samples required; z = standard value from the normal distribution table Z (deviation of 5%, z value is 1.96); p = proportion value from previous research, if the

TABLE I: SUMMARY OF OPERATIONAL VARIABLES

Variables	Operational variable	Indicator	Scale
Competitive advantage	Everything that a company does very well compared to its competitors which includes a strong distribution network, technical capabilities/production capacity, marketing strength, technology, natural resources, research and development.	a. Competitive aspect b. Distribution capacity c. Market penetration capacity d. Availability of natural resources	Likert
Distribution capacity	Marketing efforts designed to speed up and simplify the distribution of fuel goods/products from producers to consumers via transportation modes like as trucks, trains, pipelines, and tankers.	a. Distribution by truck. b. Distribution by shipping. c. Distribution by pipe. d. Storage with tanks.	Likert
Market penetration capacity	Capacity to enter potential customers that may be obtained in a certain period.	a. Refinery industry b. Fertilizer industry c. Methanol industry d. Ammonia industry e. Power industry f. Steel industry	Likert
Availability of natural resources	Resources that are produced naturally from materials found in the environment that humans need to fulfill their needs to meet their requirements and increase their well-being. Natural resources include air, plants, sunlight, soil, fossil fuels and animals.	a. Natural gas b. Injection well for CCS c. Geothermal	Likert

proportion is not known, then the estimated proportion is 50% (0.5); $q = 1 - p$; $e =$ sample error rate, 10% = 0.1 of the 90% confidence level calculation:

$$n = \frac{z^2 pq}{e^2} = \frac{(1.96)^2 (0.5)(0.5)}{(0.10)^2} = 97 \tag{1}$$

Two variables are used in this study: dependent variable (Y) and independent variable (X). Independent variables are distribution capacity (X_1), market penetration capacity (X_2), and ownership of natural resources (X_3). The dependent variable is a competitive advantage in developing low carbon hydrogen business development (Y). Table I represents the summary of all variables.

Data was collected for 2 months from January to February 2024. Data is analyzed using the Statistical Package for the Social Sciences (SPSS). Quantitative research relies heavily on SPSS, which provides a wide range of tools, methods, and best practices. SPSS provides a broad range of statistical techniques that enable researchers to conduct a variety of analyses, including descriptive statistics, inferential tests, regression analysis, factor analysis, cluster analysis, and survival analysis.

In this study, data quality testing will be conducted through:

3.1. Validity Test

The validity test determines if a questionnaire is valid or not. A validity test is an instrument used to measure data that has been obtained as truly valid or correct data. The purpose of the validity test is to find out which questions on the questionnaire should be replaced or discarded because they are considered irrelevant; this is done by comparing the calculated r-value with the r table value with degrees of freedom ($df = n - 2$ and alpha 0.05). The determining factors in testing the effectiveness of indicators are:

- If r counts > table, then the variable instrument is valid.

- If r count < r table, the variable instrument is invalid.

Determining whether an item is appropriate or not is determined by testing the significance of the correlation coefficient at a significance level of 0.1, which means an item can be said to be valid if it has a significant correlation with the total score.

3.2. Reliability Test

The reliability test determines the extent to which measurement results from the same object yield the same data. When evaluating the same symptom with the same measuring device more than once, reliability tests are done to assess how consistent the results are. Reliability is calculated based on the Cronbach Alpha coefficient formula. If the scale is grouped into five classes with the same bands, then the measure of alpha stability can be interpreted as follows:

- It is less reliable when Cronbach’s alpha value ranges from 0.00 to 0.20.
- A somewhat reliable Cronbach’s alpha ranges from 0.21 to 0.40.
- The Cronbach’s alpha ranges from 0.41 to 0.60, indicating it is quite reliable.
- 0.61 to 0.80 is Cronbach’s alpha range, which indicates reliability.
- The Cronbach’s alpha coefficient ranges from 0.81 to 1.00, indicating that it is very reliable.

3.3. Normality Test

To ascertain whether the data or variable distribution is regularly distributed, a normality test must be performed. The Kolmogorov-Smirnov Normality Test, which compares the distribution of the data to be tested for normality with a conventional normal distribution, is the most used

normality test. Data that has been converted to Z-Score form and is regarded as normal follows the conventional normal distribution. To find out if data is normally distributed, apply the Kolmogorov-Smirnov Normality test. If the significance is less than 0.05, it indicates that the data being evaluated differs significantly from conventional normal data.

3.4. Multicollinearity Test

To determine whether the regression model detects a link between independent variables, one component of the classical assumption test is the multicollinearity test. Regression models that are considered good should not exhibit multicollinearity or correlation between independent variables. One method of identifying strong connection between independent variables is to use the Variance Inflation Factor (VIF) and Tolerance measures. Here are the following statements that represent the Tolerance and Variance Inflation Factor (VIF) assumptions:

- There is multicollinearity if $VIF > 10$ and Tolerance value < 0.10 .
- The absence of multicollinearity is shown if $VIF < 10$ and Tolerance value > 0.10 .

4. HYPOTHESES DEVELOPMENT

An assumption that is based on some evidence is called a hypothesis. This is where any inquiry that turns the research questions into forecasts starts. Variables, population, and the relationship between the variables are some of its constituent parts. A hypothesis used to investigate the relationship between two or more variables is known as a research hypothesis. The following are some hypotheses that can be expressed in this research:

Hypothesis 1: The theory presented by [Andrew Chew Chun Kit \(2021\)](#) regarding fuel distribution and the theory from [Arison Nainggolan \(2018\)](#) regarding competitive advantage, one of which is having a strong distribution network. [Jefferson et al. \(2022\)](#) also explained that the distribution of low-carbon hydrogen could be done via trucks, ships, and pipes and can be stored in hydrogen tanks. Based on the explanation, it is suspected that distribution capacity has a direct positive effect on competitive advantage in developing the low-carbon hydrogen business in Indonesia.

Hypothesis 2: [Stanton and Yohanes \(1993\)](#) explained the market, and [Arison Nainggolan \(2018\)](#) explained competitive advantage, one of which is having strong marketing capabilities. [Jefferson et al. \(2022\)](#) also explained that the potential market for low-carbon hydrogen is the refinery, fertilizer, methanol, steel, and electricity/power industries. Based on the explanation, it is suspected that penetration market capacity has a direct positive effect on competitive advantage in developing the low-carbon hydrogen business in Indonesia.

Hypothesis 3: According to [Hao Ma \(1999\)](#), competitive advantage results from a difference between firms along any dimension of firm qualities and characteristics that permits one firm to create more customer value than the

others. It also incorporates factors in the internal working of the organization, e.g., capabilities and resources. [Jefferson et al. \(2022\)](#) also explained that low-carbon hydrogen can be produced through the water electrolysis process using electricity from renewable generators such as Geothermal and Solar PV. Apart from that, it can also be produced from natural gas using Steam Methane Reforming technology equipped with CCS. Based on the explanation, it is suspected that the availability of natural resources has a direct positive effect on competitive advantage in developing the low-carbon hydrogen business in Indonesia.

5. RESULT AND DISCUSSION

The competitive advantage, distribution capacity, market penetration capacity, and availability of natural resources are the four research variables for which the validity test results show the calculated validity coefficient r , which is bigger than the r table (0.163). As a result, these items can be deemed valid and used as measuring tools in research.

Alpha Cronbach reliability test resulted that the four research instruments have reliability values more than 0.6, representing the validity and reliability of the questionnaire's questions as research measuring instruments.

The Kolmogorov-Smirnov method's normality test reveals that the significant value from calculations using SPSS is 0.067, which is bigger than 0.05. Thus, it concluded that the data is normally distributed.

The tolerance values for the distribution capacity variable were 0.725, the availability of natural resources was 0.709, and the market penetration capacity was 0.710 after the multicollinearity test was conducted using SPSS. Subsequently, the Variance of Tolerance (VIF) value for market penetration capacity = 1.409, distribution capacity = 1.379, and natural resource availability = 1.411. Given that the variance of tolerance (VIF) value is less than 10 and the tolerance value of these three variables is larger than 0.01, it is possible to conclude that the data is not skewed or multicollinear.

A linear regression model is used to ascertain the link and impact of independent variables on the dependent variable. If there is only one independent variable and one dependent variable in a regression, it is referred to as a simple linear regression. In situations when there are multiple independent or dependent variables, multiple linear regression is employed. A regression model with multiple independent variables is called multiple linear regression. Multiple linear regression analysis was performed to identify the direction and magnitude of the independent variable's influence on the dependent variable ([Ghozali, 2018](#)), to predict the magnitude and direction of the link between the dependent variable and the independent variable.

5.1. The Influence of Distribution Capacity on Competitive Advantage of Low-Carbon Hydrogen Business Development

Currently, Pertamina holds the greatest expertise and capability in the distribution of fuel oil, including gasoline

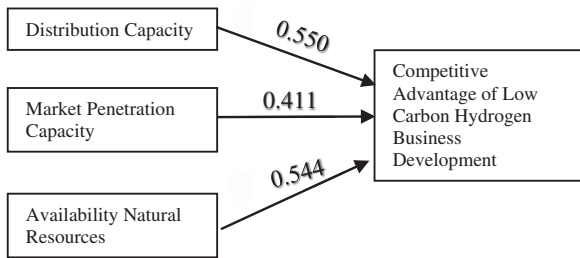


Fig. 1. Research framework with hypothesis results.

TABLE II: CALCULATION OF LINEAR REGRESSION HYPOTHESIS 1

Variable	Coefficient	T _{calculated}	P value	R square	(1-R square)
X ₁ – Y	0.550	6.612	0.001	0.302	0.698

TABLE III: CALCULATION OF LINEAR REGRESSION HYPOTHESIS 2

Variable	Coefficient	T _{calculated}	P value	R square	(1-R square)
X ₂ – Y	0.411	4.533	0.001	0.169	0.835

and gasoil, through trucks, ships, and pipelines. Pertamina also owns and operates many storage tanks. The calculated t-value of the distribution capacity variable was 6.612 (Table II), and the p-value was 0.001. The t-calculated value was 6.612 > t-table value (1.660) and the p-value (0.001) < 0.05. It can be proven that distribution capacity has a direct positive effect on competitive advantage in developing the low-carbon hydrogen business in Indonesia. The higher the distribution capacity to send low-carbon hydrogen via trucks, ships, pipes, and storage using tanks, the higher the competitive advantage will be in developing the green/low-carbon hydrogen business in Indonesia. The path coefficient value of 0.550 (Fig. 1) is positive in the results of this research, which is empirical evidence to prove the hypothesis. This finding is in line with the theory presented by Andrew Chew Chun Kit (2021) regarding fuel distribution and the theory from Arison Nainggolan (2018) regarding competitive advantage, one of which is having a strong distribution network. Furthermore, Jefferson et al. (2022) also explained that the distribution of low-carbon hydrogen could be done via trucks, ships, and pipes and can be stored in hydrogen tanks.

5.2. The Influence of Market Penetration Capacity on Competitive Advantage of Low-Carbon Hydrogen Business Development

According to the test results above, the Market Penetration Capacity variable's has t-calculated of 4.533 (Table III), and the p-value of 0.001. The T calculated is more than the t-table value of 1.660, and the p-value (0.001) is less than 0.05. It is, therefore, evident that competitive advantage in low-carbon hydrogen business development is directly impacted by its market penetration capacity. Pertamina's experience in supplying energy to the refinery, fertilizer, methanol, steel, and power industries will increase Pertamina's competitive advantage in developing the low-carbon hydrogen business in Indonesia. The path coefficient value of 0.411 (Fig. 1) is positive in the results of this research, which is empirical evidence to prove the hypothesis. This result is consistent with the

TABLE IV: CALCULATION OF LINEAR REGRESSION HYPOTHESIS 3

Variable	Coefficient	T _{calculated}	P value	R square	(1-R square)
X ₃ – Y	0.544	6.512	0.001	0.296	0.704

thesis of competitive advantage, which includes having great marketing capabilities, as put forth by Arison Nainggolan (2018). The refining, fertilizer, methanol, steel, and electricity/power sectors are prospective markets for low-carbon hydrogen, according to Jefferson et al. (2022).

5.3. The Influence of Availability of Natural Resources on Competitive Advantage of Low-Carbon Hydrogen Business Development

The T calculated for the Natural Resources variable is 6.512 (Table IV), and the p-value is 0.001, where the t-calculated is 6.512 > t-table value (1.660) and the p-value (0.001) < 0.05, as can be seen from the test results above. Therefore, it can be demonstrated that Pertamina's competitive advantage in developing the low-carbon hydrogen market in Indonesia is directly impacted positively by natural resources. Pertamina will have a greater competitive advantage thanks to its natural resources, which include natural gas supplies for hydrogen production, geothermal energy sources, and potential depleted/basin reservoirs for CCS implementation. The path coefficient value of 0.544 (Fig. 1) is positive in the results of this research, which is empirical evidence to prove the hypothesis. This result is consistent with Hao Ma (1999) assertion that competitive advantage includes elements related to an organization's internal operations, such as resources and capabilities. Additionally, according to Jefferson et al. (2022), low-carbon hydrogen can be created using the water electrolysis method with power from renewable sources like solar and geothermal energy.

6. CONCLUSION AND RECOMMENDATION

This research objective is to determine the impact of distribution capacity, market penetration capacity and availability of natural resources on the competitive advantage of low-carbon hydrogen business development in Indonesia. Sample taken from Pertamina Group employees in January–February 2024. Multiple linear regression is used to ascertain the direction and extent of the independent variable's influence on the dependent variable. The conclusion indicates that, with respective coefficients of 0.550, 0.411, and 0.544, distribution capacity, market penetration capability, and natural resource availability all positively directly affect the competitive advantage of low-carbon hydrogen business development in Indonesia. The variable that has the biggest influence is distribution capacity.

The findings of this study have the potential to assist the Company in creating a low-carbon hydrogen business, thereby facilitating Indonesia's energy transition and assisting the government in reaching Net Zero by 2060 or earlier. When it comes to the competitive advantage of low-carbon hydrogen business development, the company shall focus more on the answers provided to questions about variable distribution capacity.

This research has limitations because it only involves 103 Pertamina employees who already have basic knowledge regarding low-carbon hydrogen, so it does not adequately represent businesses in the oil and gas and other energy industries. Further research can involve more respondents from several energy company employees. Apart from that, further research can also focus on identifying the best technology that Indonesia can use to produce hydrogen (such as the most efficient renewable energy source & electrolyzer), determining the most appropriate mode of transportation/distribution of hydrogen (in liquid/presurized form or converted into other commodities, for example, ammonia), as well as business schemes that can help the economics of the low carbon hydrogen business development.

CONFLICT OF INTEREST

The authors declare that they do not have any conflict of interest.

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