FPT Education

FPT UNIVERSITY

ANALYZING CRITICAL SUCCESSFUL FACTORS OF VINFAST IN SELECTING GREEN SUPPLIERS

Meet Our Team

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OUTLINE

01 Introduction

Brief introduction about the background, objective, and research question as well as the methodology

02 Literature Reviews

Relevant theories that are the basis to develop research questions and different methods

03 Methodology

Research methods (qualitative, quantitative, and observational studies) and data collection and analysis methods

04 Empirical Case Analyses of VinFast

Analyses and applies the model and methods proposed in Chapter 3 to evaluate and group green suppliers for VinFast

05 Conclusions and Implications

Summarizes the findings and suggest implications for VinFast company to choose suitable green suppliers

CHAPTER I: INTRODUCTION

1. BACKGROUND

Green Supplier Selection

TOPIC BACKGROUND

- Over the past decades, GSS has been broadly gaining increasing interest among researchers and practitioners due to the growing awareness of environmental protection and its long-term effects on business and marketing issues.

- GSS is one of the most critical factors for environmental protection and for the world's sustainable development as well.

GREEN ECONOMY TREND IN THE WORLD & VIETNAM

The world

- ❑ Green economy is one where economic growth and environmental responsibility go hand in hand and mutually support each other, and support the social development process.
- ❑ Some specifically developed countries have adopted this trend: US, EU, Korea, etc.

Vietnam

- ❑ The trend has been affirmed since 2000
- ❑ Completed a number of specific practical activities.

COMPANY BACKGROUND

VinFast Manufacturing and Trading Limited Liability Company

- A Vietnamese automobile and electric motorcycle manufacturer
- Established in 2017 as a Vingroup Joint Stock Company subsidiary and CEO: Mr. Pham Nhat Vuong
- The headquarters is located in Cat Hai District, Hai Phong City, Vietnam
- 4 Gasoline car model: Fadil, LUX A2.0, LUX SA2.0, President
  3 Electric cars: VF31, VF32, VF33

RESEARCH OBJECTIVES

01 Analysis the current state of the automotive market and green supply trends in the world in general and in Vietnam in particular

02 Overview of studies related to standards and evaluation models, and green supplier classification

03 General overview of fuzzy set theory and MCDM models, specifically FAHP, and FTOPSIS models

04 Develop specific MCDM models to classify a group of green suppliers

05 Apply the two proposed models to the assessment and grouping of green suppliers for Vinfast Company, thereby giving some suggestions and solutions

2.RESEARCH QUESTIONS

1

What set of criteria affects Vinfast's selection of green suppliers?

2

How is influence level of each criteria on green supplier selection?

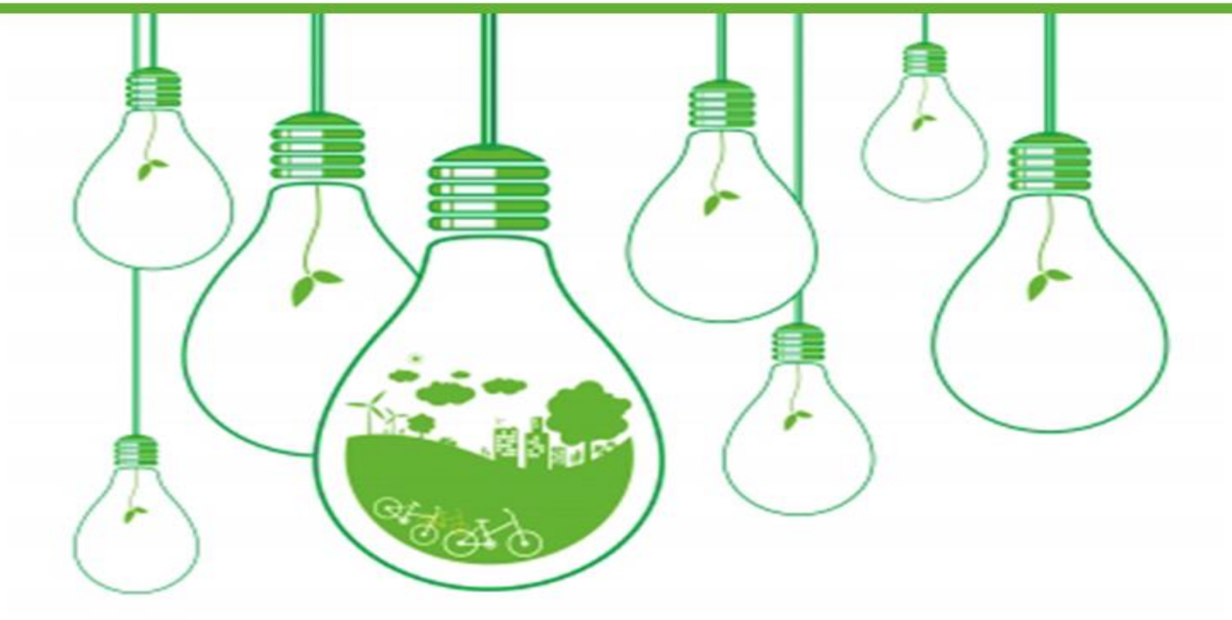
3. Research Scope

- Research method to collect data is direct interview, which focuses on a group of professionals, business and economic specialists, and Vinfast’s high-level staffs

4. Methodology and Data review

- **Methodology**: Use both quantitative and qualitative research.
- **Data**: Mainly use secondary data that conducted through online references (news, Vinfast's official website, research articles, books, etc), consultation with economic experts, and Vinfast's internal data.

CHAPTER II: LITERATURE REVIEW



1. AUTOMOTIVE INDUSTRY OVERVIEW

GLOBAL AUTOMOTIVE INDUSTRY

The automobile industry occupies a significant role in supporting the national economy and being an economic sector with huge profits through the manufacture of goods with outstanding value

01

In 1771 the first automobile was invented with a steam engine.

02

In 1886 the first automobile with gasoline-powered internal combustion engine was born and became a huge turning point for the automotive industry in the world

03

For many decades, the automotive industry has been growing continually, specifically after the Second World War.

04

- Nowadays, China leads the world in total automotive production with 27%.
- Toyota is the largest manufacturer by production volume.

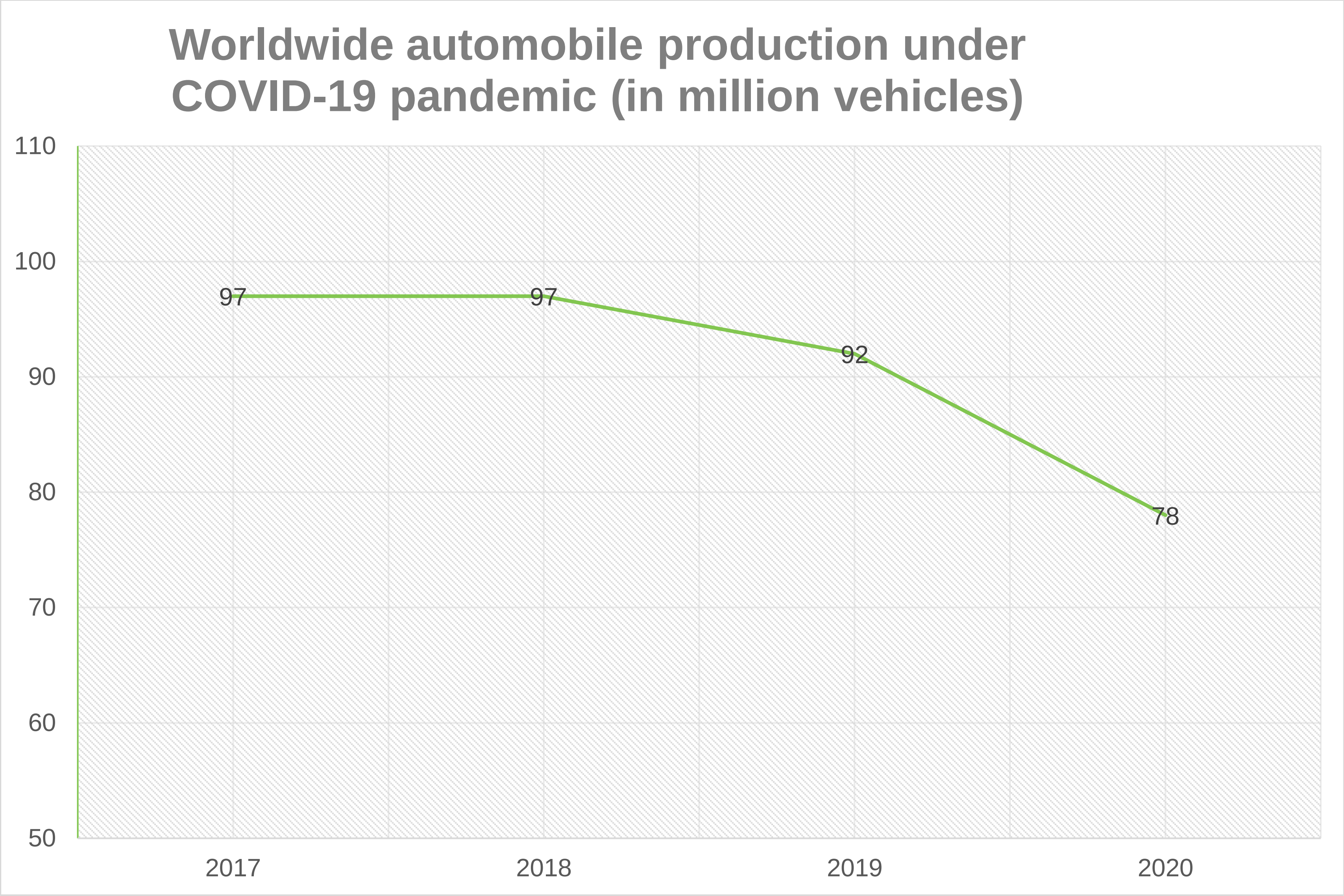


Chart 2.1 Worldwide automobile production under COVID-19 pandemic

Vietnamese Automobile Industry

01 GDP

Contributes 3% to country's gross domestic product

02 Classif... cation

- Fo... nvested ... ises
- St... wned en... es

03 Government policies

- C... imposed high ta... on the li... g... bject to special consumption tax
- Now, cars are subject to up to 15 taxes and fees

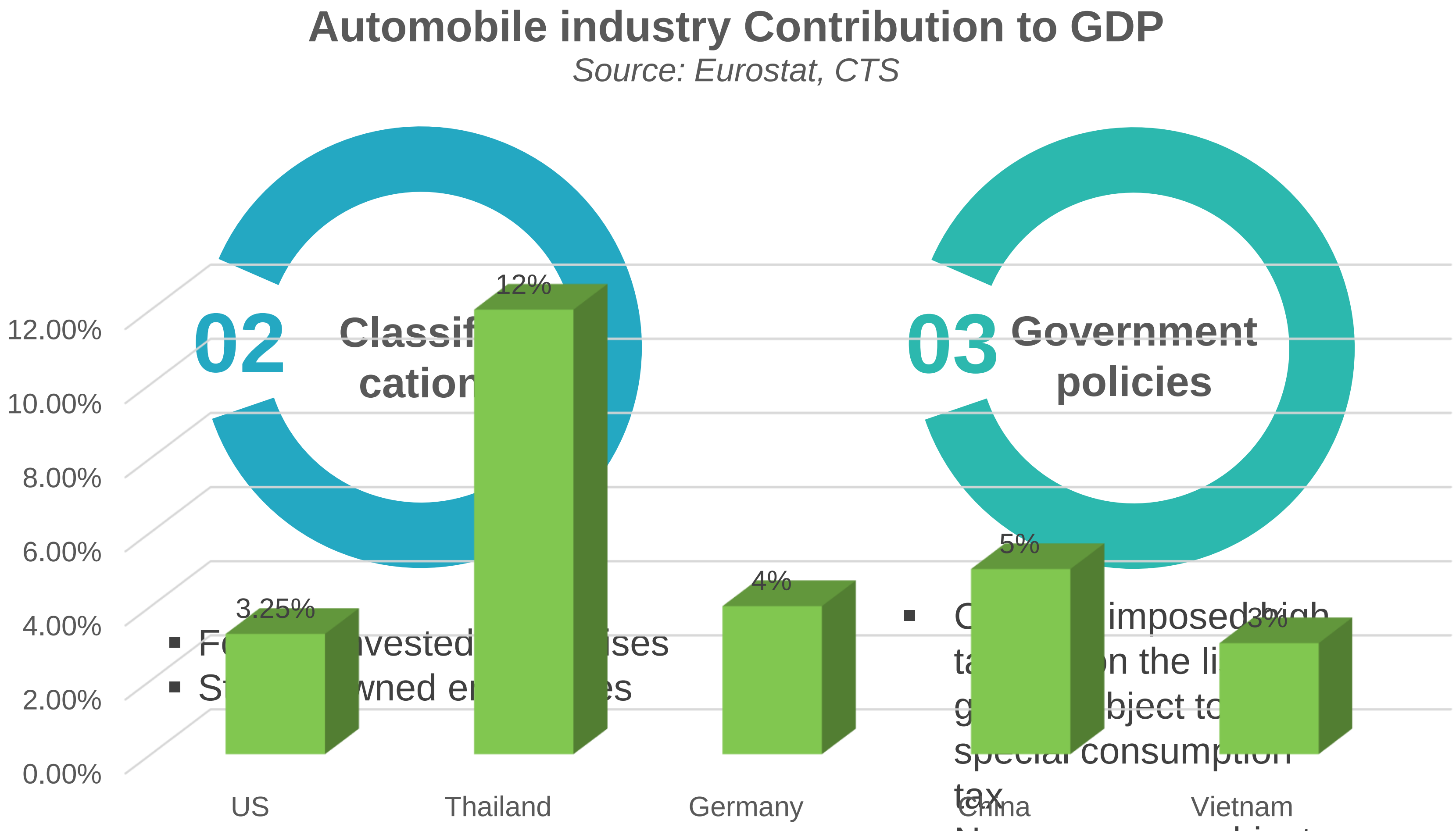


Chart 2.2 Auto Industry contribution to GDP

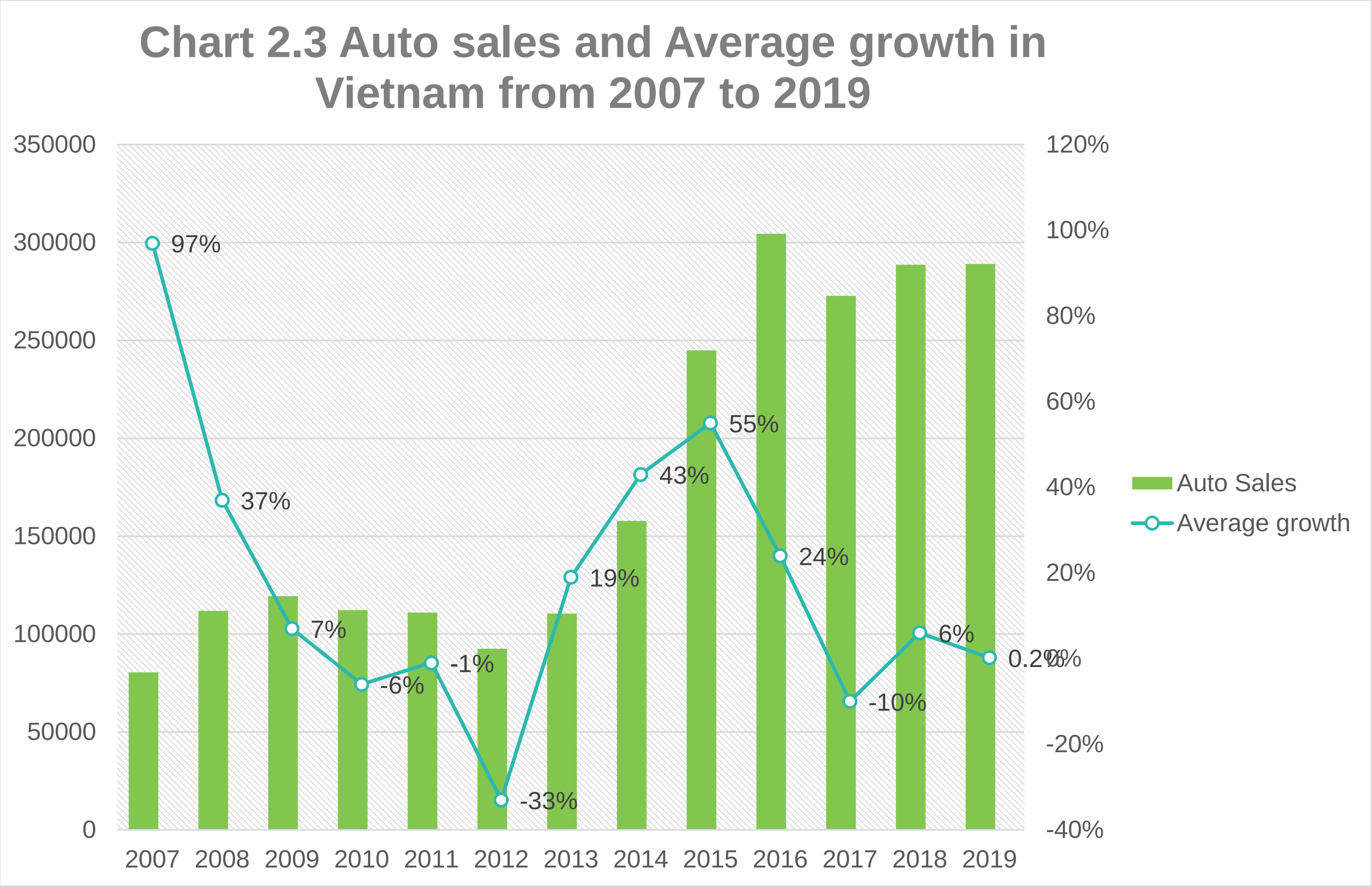


Chart 2.3 Auto sales and Average growth in Vietnam from 2007 to 2019
350000
300000
250000
200000
150000
100000
50000
0
120%
100%
80%
60%
40%
20%
0%
-20%
-40%
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
97%
37%
7%
-6%
-1%
-33%
19%
43%
55%
24%
-10%
6%
0.2%
Auto Sales
Average growth

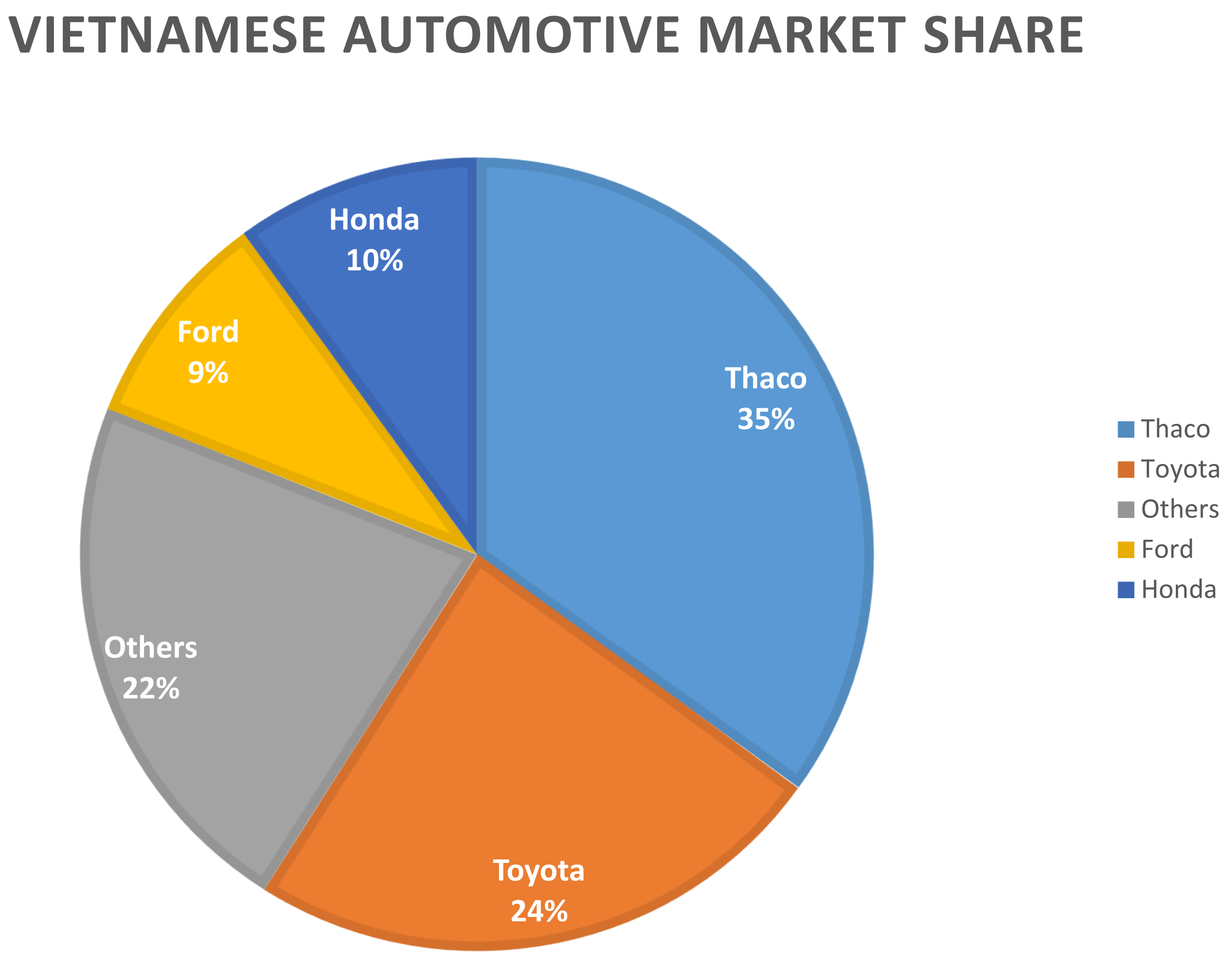


Chart 2.4. Vietnamese automotive marketshare

GREEN SUPPLY CHAIN MANAGEMENT THEORY

Green Supply Chain

Green Supply Chain

An innovative supply chain which complies with social development trends

GSCM is the effort of purchasing departments on activities such as reducing pollutants, recycling and materials substitution *(Narasimhan, 1998)*

Objectives

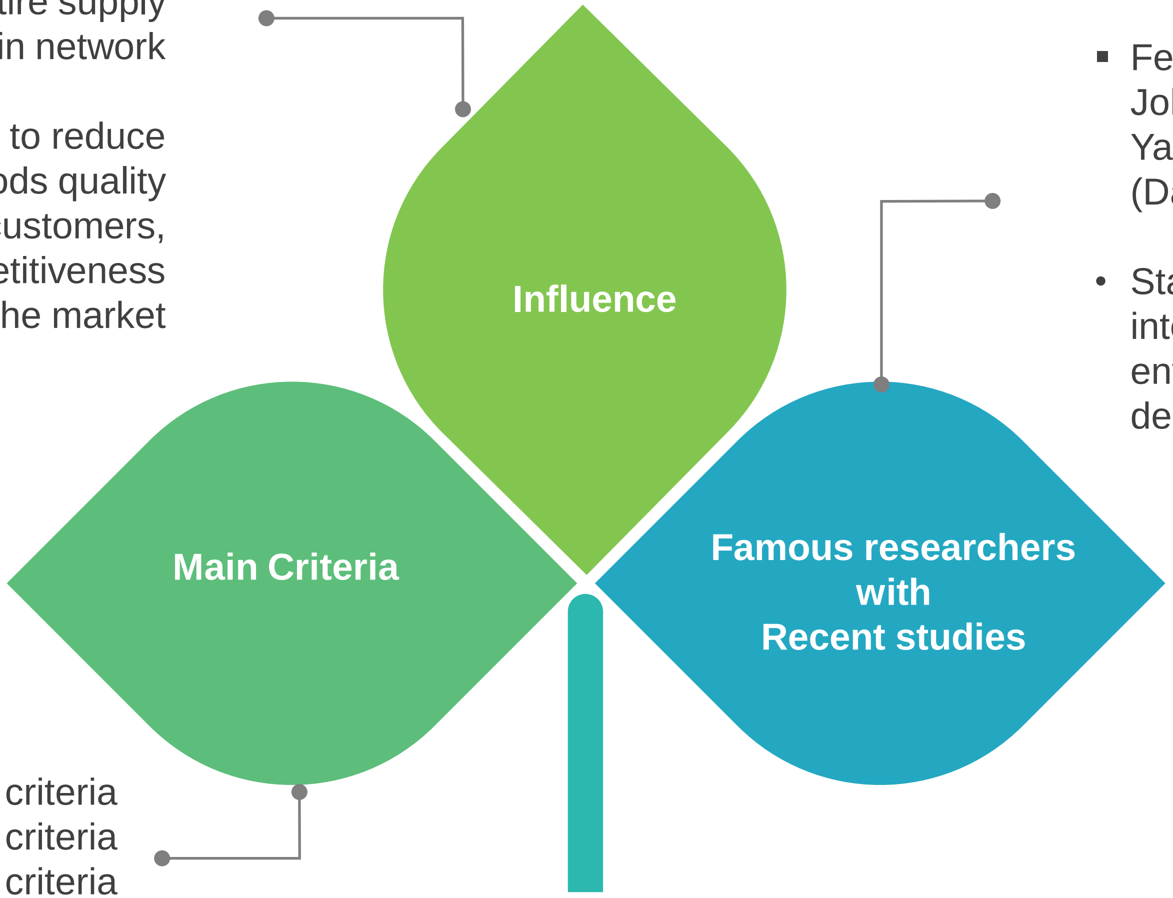
Objectives

Achieve optimal allocation of resources, increase economic benefits and improve environmental consistency in the whole product life cycle

GSCM enterprises cooperate with their downstream and upstream, optimizing the environmental benefits from product design, material selection and retailing to recycling, improving both economic and environmental performances *(Zhu, 2004)*

Green Supplier Selection

- Play critical role on the competitiveness of the entire supply chain network
- The basis for enterprises to reduce input costs, improve goods quality and services provided to customers, and improve their competitiveness in the market



- Feng et al. (2011). Dickson (1966), Johnson et al. (1995), Patton (1996) Yahya and Kingsman (1999), etc (Dawei et al., 2015), etc
- Statistical models and artificial intelligence based models, data envelopment analysis, multi-criteria decision models/approaches, etc

- Economic criteria
- Environmental criteria
- Social criteria

MULTI - CRITERIA DECISION-MAKING

*"MCDM methods provide a possibility to evaluate these and other conflicting factors and to decide which alternative is the most suitable according to different criteria" (*Siksnelyte-Butkiene *et al.*, 2020).

Definition

A technique that combines alternative's performance across numerous, contradicting, qualitative and/or quantitative criteria and results in a solution requiring a consensus

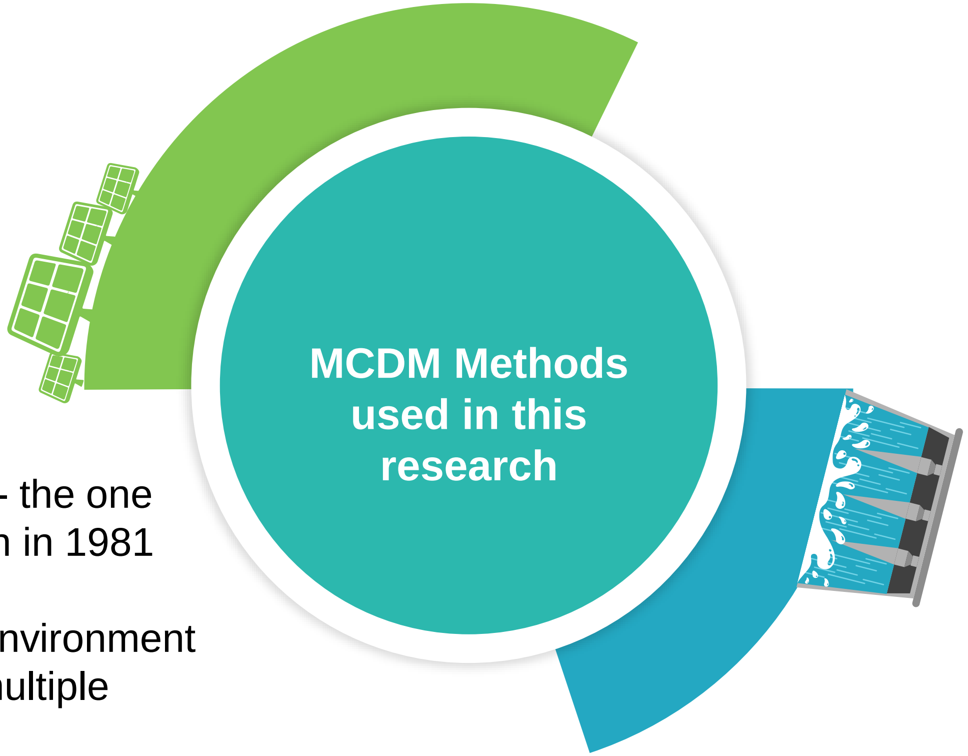
Popular methods in GSS

- Analytical hierarchal process (AHP)
- Analytical network process (ANP)
- TOPSIS
- Data envelopment analysis (DEA) and fuzzy decision-making
- etc

FUZZY AHP & TOPSIS

FAHP

- ❑ Proposed by Chang in 1996, a synthetic extension of the AHP method
- ❑ Overcome the limitation of AHP
- ❑ Determine the weights of factors through a pair comparison matrix and also based on expert opinions to make a reasonable decision



FTOPSIS

- ❑ Developed base on TOPSIS method- the one that was introduced by Hwang & Yoon in 1981
- ❑ Evaluates efficiency in an uncertain environment and allows accurate assessment of multiple criteria at the same time
- ❑ Principle relates to Positive and Negative Ideal Solution theory
- ❑ Used to rank and classify GS

Research Gap

01

Integrate the fuzzy set theory with AHP and TOPSIS method to opt for VinFast's green supplier in specific and in Vietnamese automobile industry in general

02

Give comprehensive research to explore the importance of factors in GSS for a company's development

03

Give suggestions and references for other studies in the future

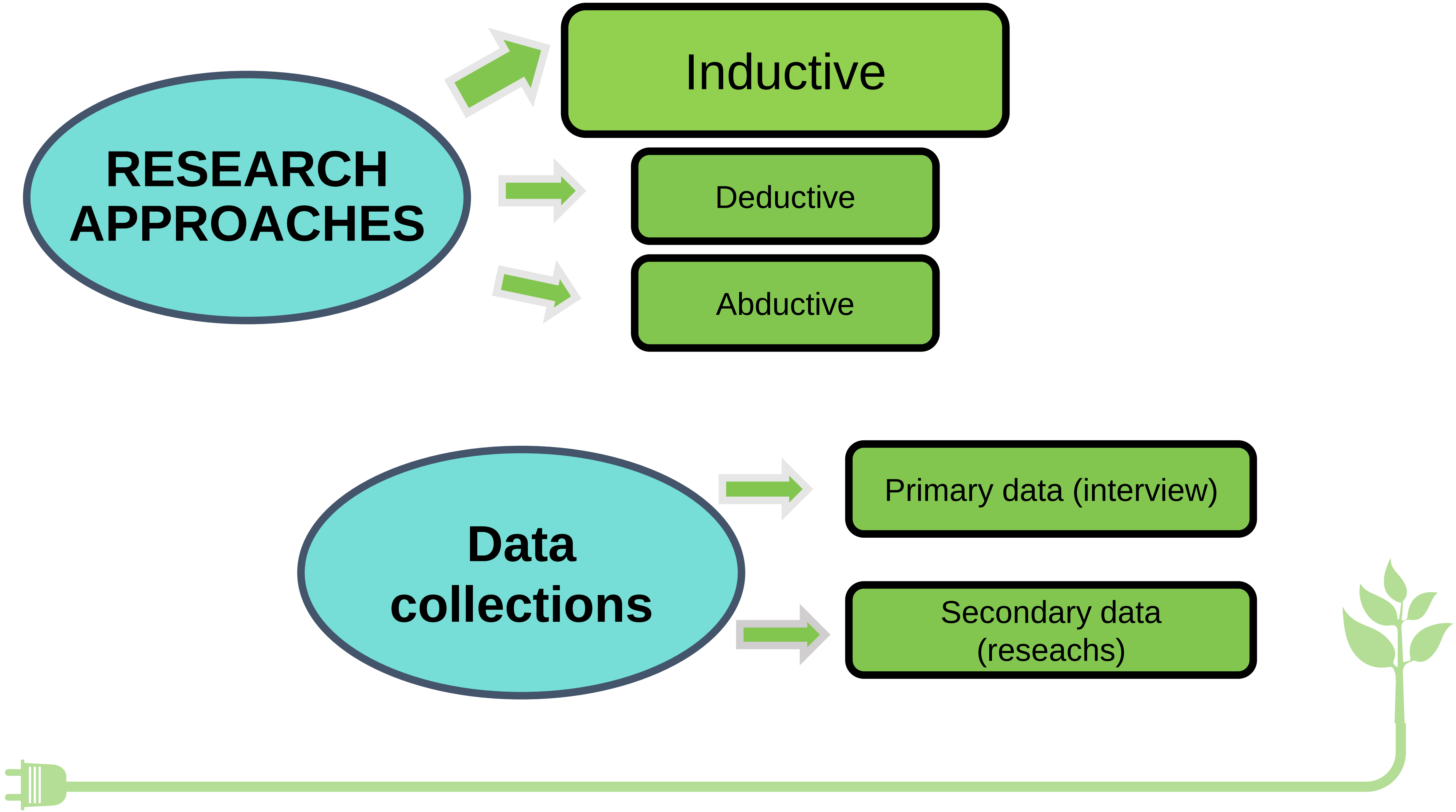
CHAPTER III: METHODOLOGY

Methods

- ✓Fuzzy AHP
- ✓Fuzy TOPSIS

RESEARCH APPROACHES

- ✓Inductive
- ✓Deductive
- ✓Abductive


RESEARCH APPROACHES
Inductive
Deductive
Abductive
Data collections
Primary data (interview)
Secondary data (reseachs)

DATA VARIABLES

Criteria		Papers
Economic (C1)	Cost (C11)	(Liao, Fu and Wu, 2016)
	Delivery (C12)	(Liao, Fu and Wu, 2016)
	Service level (C13)	(Bali, Kose and Gumus, 2013); (Lee et al., 2009)
	Quality (C14)	(Lee et al., 2009); (Guo et al., 2017)
	Staff training (C15)	(Sevkli et al., 2007)
	Technology (C16)	(Wang Chen et al., 2016)
	Flexibility (C17)	(Wang Chen et al., 2016)
	Financial capability(C18)	(Wang Chen et al., 2016)
	Culture (C19)	(Wang Chen et al., 2016)
	Innovativeness (C110)	(Wang Chen et al., 2016)
	Relationship (C111)	(Wang Chen et al., 2016)
Social (C3)	Human resource management (C31)	(Er and Firat, 2016)
	Corporate social responsibility (C32)	(Er and Firat, 2016)
	Health and safety (C33)	(Er and Firat, 2016)
	Human right issues (C34)	(Er and Firat, 2016)
	Relationship with stakeholders (C35)	(Er and Firat, 2016)

Table 3.1.1 Chosen sustainability criteria

DATA VARIABLES

Environmental (C2)	Green products (C21)	(Bali, Kose and Gumus, 2013);(Lee et al., 2009)
	Green image (C22)	(Bali, Kose and Gumus, 2013);(Lee et al., 2009)
	Eco-design(C23)	(Wang Chen et al., 2016)
	Management commitment(C24)	(Wang Chen et al., 2016)
	Green technology(C25)	(Wang Chen et al., 2016)s
	Pollution control(C26)	(Zhang, 2019) ; (Lee et al., 2009)
	Recycle(C27)	(Zhang, 2019);(King et al., 2006)
	Re-manufacturing(C28)	(Zhang, 2019); (King et al., 2006)
	Environmental management system (C29)	(Yildiz, 2019); (Lee et al., 2009); (Guo et al., 2017)
	Resource consumption(C210)	(Guo et al., 2017)

Table 3.1.2 Chosen sustainability criteria

FUZZY AHP METHOD

Pre-process

Figure 3.3 Pre-process steps

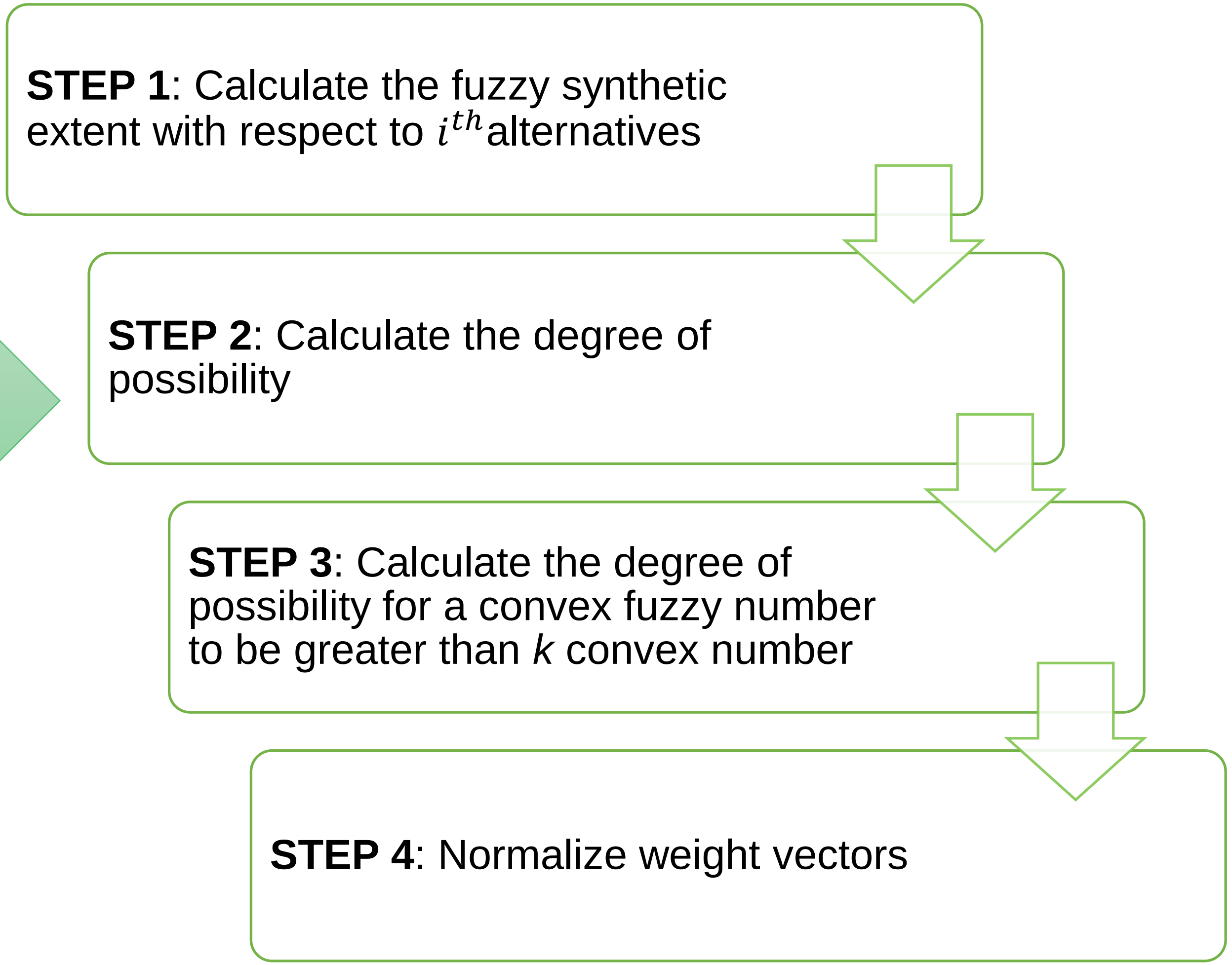


Figure 3.4 FAHP Process

❖ **STEP 1**: Calculate the fuzzy synthetic extent with respect to i^{th} alternative

The value of the fuzzy synthetic extent with respect to the i^{th} object is defined as:

$$S_i = \sum_{j=1}^{m} M_{gi}^{j} \times \left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right]^{-1} \qquad (1)$$

With

$$\sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j\right) \qquad (2)$$

$$\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{i=1}^{n} l_i, \sum_{i=1}^{n} m_i, \sum_{i=1}^{n} u_i\right) \qquad (3)$$

Then

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i}\right) \qquad (4)$$

❖ **STEP 2**: Calculate the degree of possibility

The values of S_i are compared and the degree of possibility of $S_j = (l_j, m_j, u_j) \geq S_i(l_i, m_i, u_i)$ is calculated as

$$V(S_j \geq S_i) = \begin{cases} 1, & \text{if } m_j \geq m_i \\ 0, & \text{if } l_i \geq u_j \\ \dfrac{l_i - u_j}{(m_j - u_j) - (m_i - l_i)}, & \text{otherwise} \end{cases} \quad (5)$$

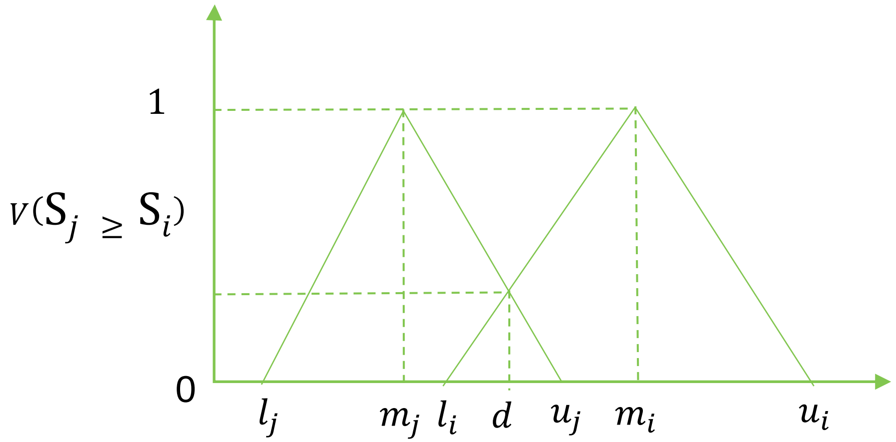


Figure 3.5 Intersection between S_j and S_i

Figure below indicates $V(S_j \geq S_i)$ for the case $m_j < l_i < u_j < m_i$ and "d" is the abscissa value of the highest intersection point between S_j and S_i

With the aim of comparison S_j and S_i, value $V(S_j \geq S_i)$ and $V(S_i \geq S_j)$ are both required.

❖ **STEP 3: Calculate the degree of possibility for a convex fuzzy number to be greater than *k* convex number**

The minimum degree of possibility $d(i)$ of $V(S_j \geq S_i)$ for $i, j = 1, 2, \dots, k$ can be calculated as:

$$V(S \geq S_1, S_2, S_3, \dots, S_k) = V\,[(S \geq S_1)\ and\ (S \geq S_2)\ and \dots (S \geq S_k)] \qquad (6)$$
$$= \min V(S \geq S_i) = W'(S_i)$$

Assume that

$$d'(A_i) = \min V(S \geq S_i), \text{ for } i = 1, 2, \dots, k\ ;\ i \neq k$$

The weight vector

$$W' = (d'(A_1), d'(A_2), \dots d'(A_n))^T \qquad (7)$$

where $A_i (i = 1, 2, 3, \dots, n)$ contains the set of n elements

❖ **STEP 4: Normalization reduces the weight vector to**

$$W = (d'(A_1), d'(A_2), \dots d'(A_n))^T = (W_1, W_2, \dots, W_n)^T \qquad (8)$$

where W is a non-fuzzy number

FUZZY TOPSIS METHOD

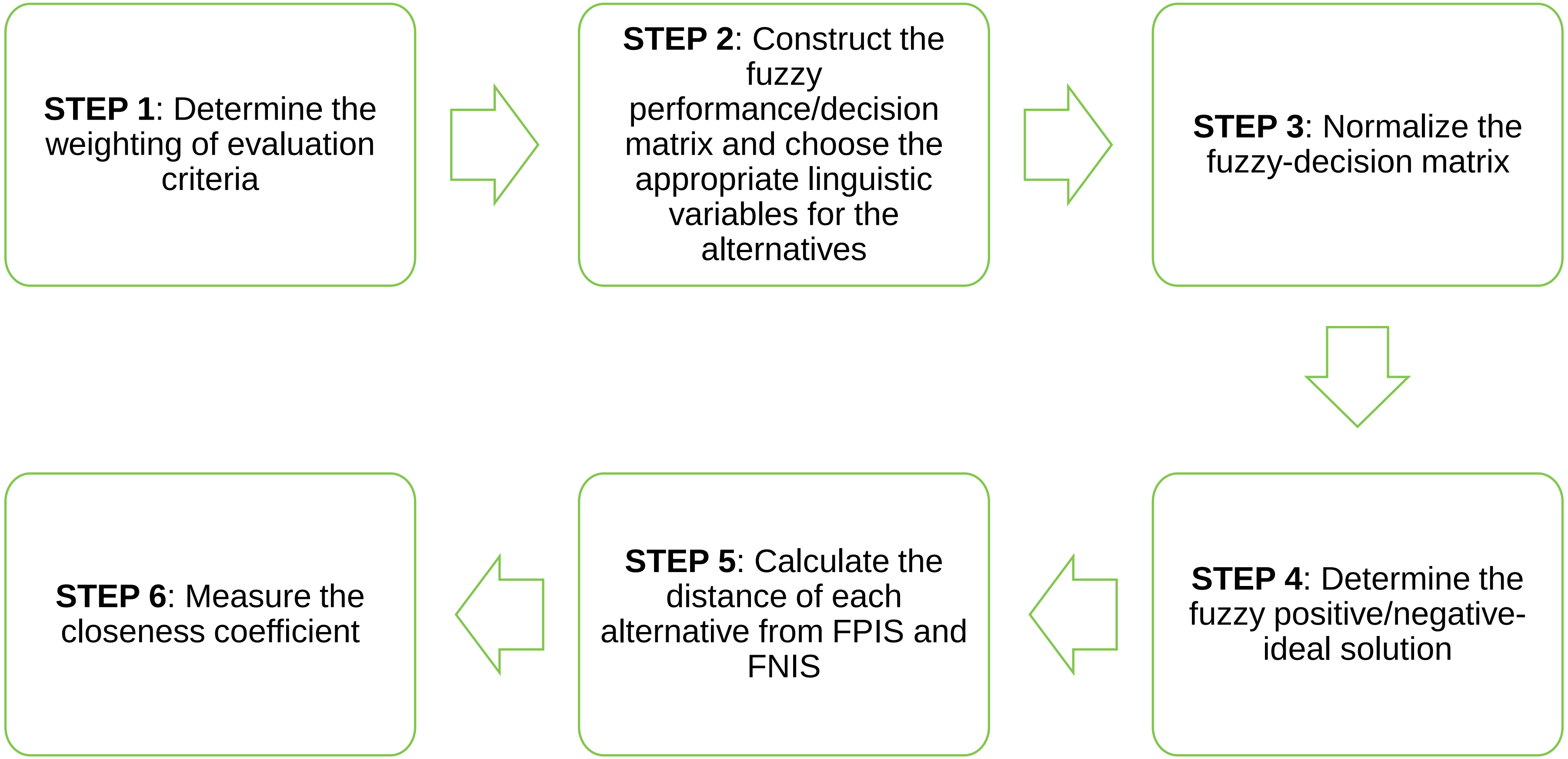


Figure 3.6 FTOPSIS Process

❖ **STEP 1: Determine the weighting of evaluation criteria**

This research employs fuzzy AHP to find the fuzzy preference weights

❖ **STEP 2: Construct the fuzzy performance/decision matrix and choose the appropriate linguistic variables for the alternatives with respect to criteria**

$$\tilde{D} = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_i \\ \vdots \\ A_m \end{array} \begin{array}{c} \begin{array}{cccccc} C_1 & C_2 & \cdots & C_j & \cdots & C_n \end{array} \\ \begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \cdots & \tilde{x}_{1j} & \cdots & \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{22} & \cdots & \tilde{x}_{2j} & \cdots & \tilde{x}_{2n} \\ \vdots & \vdots & \ddots & & \vdots & \\ \tilde{x}_{i1} & \tilde{x}_{i2} & & \tilde{x}_{ij} & \cdots & \tilde{x}_{in} \\ \vdots & \vdots & \cdots & \vdots & \vdots & \vdots \\ \tilde{x}_{m1} & \tilde{x}_{m2} & & \tilde{x}_{mj} & \vdots & \tilde{x}_{mn} \end{bmatrix} \end{array} \quad (9)$$

$$\tilde{x}_{ij} = \frac{1}{K}\left(\tilde{x}_{ij}^{1} \oplus \cdots \oplus \tilde{x}_{ij}^{2} \oplus \cdots \oplus \tilde{x}_{ij}^{K}\right) \quad (10)$$

$$\tilde{W} = [\tilde{w}_1, \tilde{w}_2, \ldots, \tilde{w}_n] \quad (11)$$

$$\tilde{x}_{ij}^{K} = (\tilde{l}_{ij}^{K}, \tilde{m}_{ij}^{K}, \tilde{u}_{ij}^{K}) \quad (12)$$

Where $\boldsymbol{i} = 1, 2, \ldots, m$
$\boldsymbol{j} = 1,2, \ldots, n$

- $\mathbf{A_m}$: m^{th}alternative
- $\boldsymbol{C_n}$: n^{th} $criteria$
- $\boldsymbol{k}$: Number of expert assessments
- $\boldsymbol{\tilde{W}_j}$: weight of j^{th}criteria

- $\boldsymbol{\tilde{x}_{ij}^{K}}$: is the performance rating of alternative A_m with respect to criterion C_n.

❖ STEP 3: Normalize the fuzzy-decision matrix.

The normalized fuzzy-decision matrix denoted by $\tilde{R}$

$$\tilde{\boldsymbol{R}} = [\tilde{r}_{ij}]_{m \times n}, \quad (13)$$

$$i = 1, 2, \ldots, m$$

$$j = 1, 2, \ldots, n$$

Then, the normalization process can be performed

$$\tilde{r}_{ij} = \left(\frac{l_{ij}}{u_j^+}, \frac{m_{ij}}{u_j^+}, \frac{u_{ij}}{u_j^+}\right), \quad (14)$$

$$u_j^+ = max_i\{u_{ij} | i = 1, 2, \ldots, m\}$$

The weighted fuzzy normalized decision matrix is calculated by matrix $\tilde{\boldsymbol{V}}$

$$\tilde{\boldsymbol{V}} = [\tilde{v}_{ij}]_{m \times n}, \quad (15)$$

Where $\tilde{v}_{ij} = \tilde{r}_{ij} \oplus \tilde{w}_j$

$$i = 1, 2, \ldots, m$$

$$j = 1,2, \ldots, n$$

❖ STEP 4: Determine the fuzzy positive-ideal solution (FPIS) and fuzzy negative-ideal solution (FNIS)

Then the two solution FPIS (A^{+}) and FNIS (A^{-}) sets are determined

$$A^{+} = (\tilde{v}_1^{+}, \tilde{v}_2^{+}, \ldots, \tilde{v}_j^{+}, \ldots, \tilde{v}_n^{+}) \qquad (16)$$

$$A^{-} = (\tilde{v}_1^{-}, \tilde{v}_2^{-}, \ldots, \tilde{v}_j^{-}, \ldots, \tilde{v}_n^{-}) \qquad (17)$$

Where $\tilde{v}_j^{*} = (1, 1, 1) \oplus \tilde{w}_j = (lw_j, mw_j, uw_j)$ and $\tilde{v}_j^{-} = (0, 0, 0)$; $j = 1,2, \ldots, n$

❖ STEP 5: Calculate the distance of each alternative from FPIS and FNIS

$$\tilde{d}_i^{+} = \sum_{j=1}^{n} d\left(\tilde{v}_{ij}, \tilde{v}_j^{+}\right), i = 1, 2, \ldots, m \qquad (18)$$

$$\tilde{d}_i^{-} = \sum_{j=1}^{n} d\left(\tilde{v}_{ij}, \tilde{v}_j^{-}\right), j = 1,2, \ldots, n \qquad (19)$$

❖ STEP 6: Measure the closeness coefficient

$$CC_i = \frac{\tilde{d}_i^{-}}{\tilde{d}_i^{+}+\tilde{d}_i^{-}} = 1 - \frac{\tilde{d}_i^{+}}{\tilde{d}_i^{+}+\tilde{d}_i^{-}}, \qquad (20)$$

$i = 1, 2, \ldots, m$

$\frac{\tilde{d}_i^{-}}{\tilde{d}_i^{+}+\tilde{d}_i^{-}}$: fuzzy satisfaction degree in i^{th} alternative

$\frac{\tilde{d}_i^{+}}{\tilde{d}_i^{+}+\tilde{d}_i^{-}}$: fuzzy gap degree in i^{th} alternative

CHAPTER IV
EMPIRICAL CASE ANALYSIS OF VINFAST

CASE STUDY

- VinFast is known as one of the leading company in automobile industry
- VinFast stated theirs position and approach as a green supplier, they must assess its core competences and recognize the difference in consumer requirements.
- VinFast maintains good relationships with vendors that would profit from the purchase of goods if necessary

VinFast focuses on launching innovative and environmental-friendly products

Trend Approach

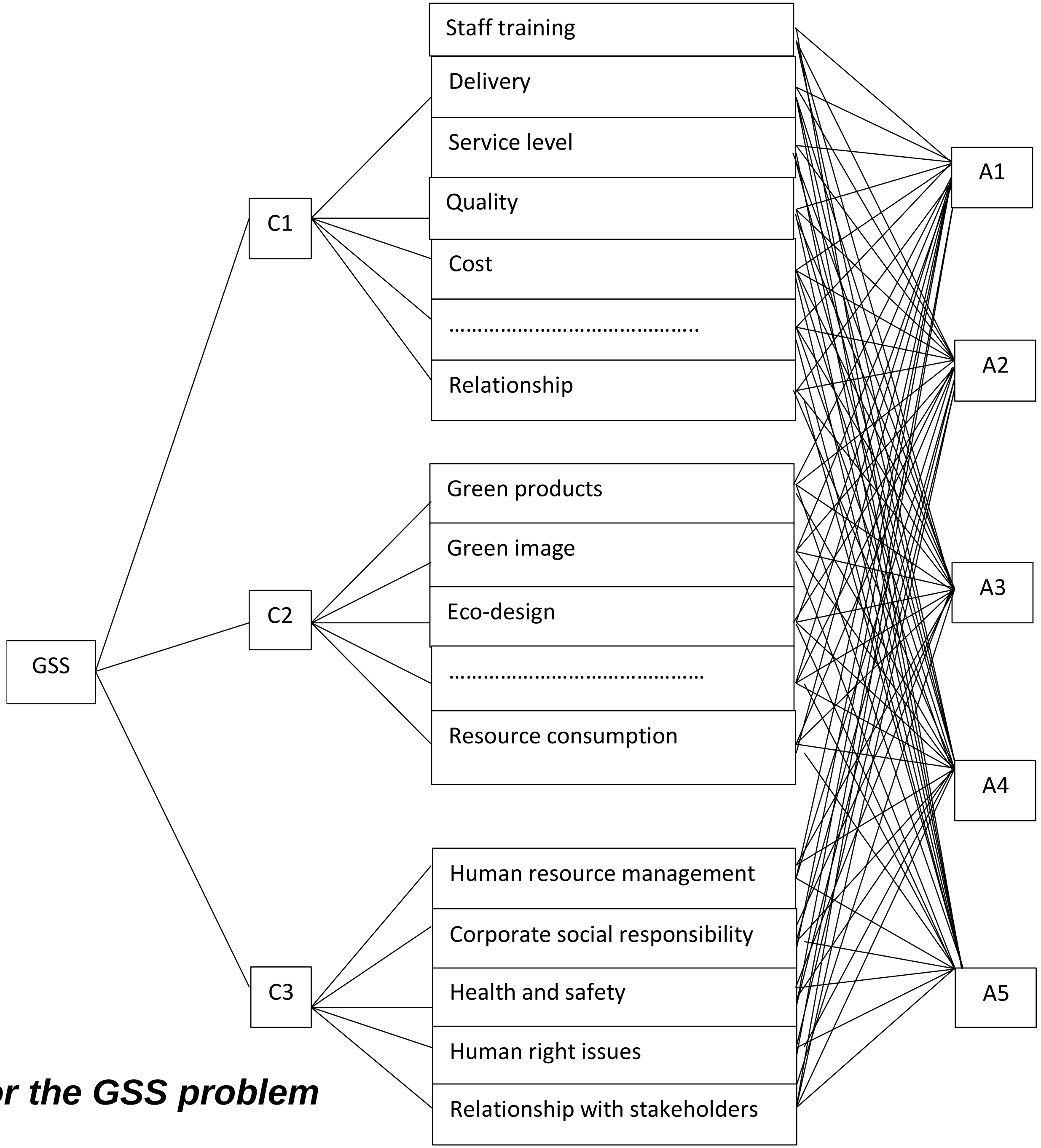


Figure 4.1 AHP hierarchy for the GSS problem

Expert	Organization	Duties	Seniority
1	VinFast Commercial and services trading limited liability company	Specialist	10
2	VinFast Commercial and services trading limited liability company	Development Engineer	15
3	VinFast Commercial and services trading limited liability company	Engineer	10
4	VinFast Commercial and services trading limited liability company	Senior Manager	8
5	VinFast Commercial and services trading limited liability company	Project Manager	10
6	VinFast Commercial and services trading limited liability company	Parts Quality Group Manager	15
7	Manufacturing department, Kia Motors Vietnam	Purchasing Manager	8
8	Parts Quality Control Section, Porsche Vietnam	Section Manager	8
9	Body Development Division Engineering Development Engineer, Mercedes-Benz Vietnam Ltd	Team Leader	
10	Automotive Asia Limited (Audi Vietnam)	Engineer	9
11	THACO passenger Car Distribution Co., Ltd (BMW Distributor in Vietnam)	Purchasing Manager	15
12	Production Control Management Division, Isuzu Viet Nam Co., Ltd.	Team Leader	15

Table 4.1 Professional backgrounds of the selected twelve experts in this research

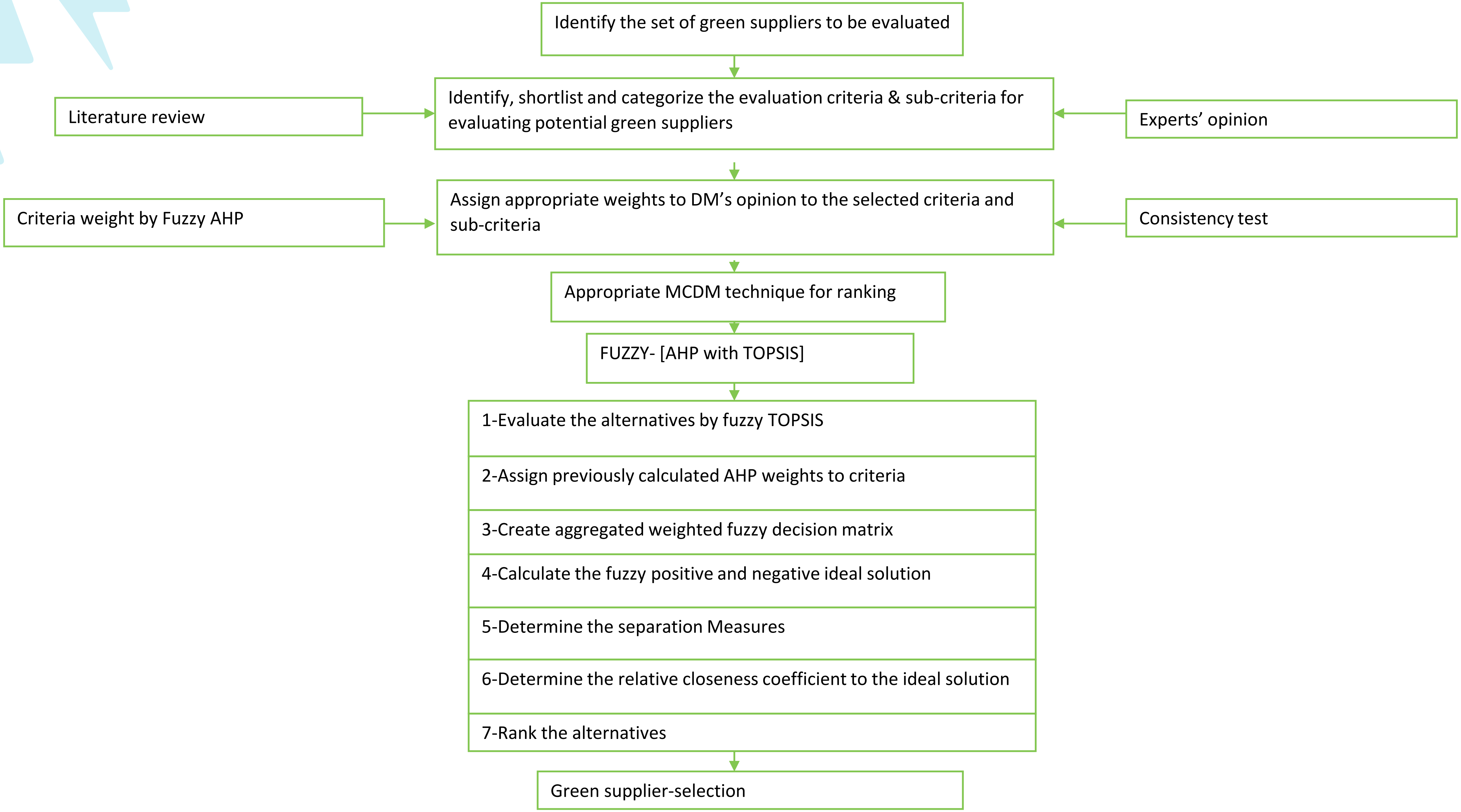


Figure 4.2: Proposed Framework of GSS Process

FUZZY AHP FOR WEIGHTING CALCULATION

1. Weighting Results for Main Criteria
2. Weighting Results for Sub-Criteria of Economic
3. Weighting Results for Sub-Criteria of Environmental
4. Weighting Results for Sub-Criteria of Social

WEIGHTING RESULTS FOR MAIN CRITERIA

	Initial Comparison Matrices																			
	Left Criteria is Greater									Right Criteria Is Greater										Total Number of Experts
	Perfect	Absolute	Very good	Fairly good	Good	Preferable	Not bad	Weak advantage	Equal	Weak advantage	Not bad	Preferable	Good	Fairly good	Very good	Absolute	Perfect			
C1							4	3	3	2								**C2**		**12**
C2							1	4	4	3	1							**C3**		**12**
C3						2	2	3	3	3								**C3**		**12**

Table 4.2: Initial Comparison Matrices

WEIGHTING RESULTS FOR MAIN CRITERIA *(CONT.)*

	Integrated Fuzzy Comparison Matrix								
	C1			**C2**			**C3**		
C1	1	1	1	1.0491	1.5280	2.0891	0.7172	1.0595	1.5280
C2	0.4787	0.6544	0.9532	1	1	1	1.0243	1.5131	2.1683
C3	0.6544	0.9439	1.3943	0.4612	0.6609	0.9763	1	1	1

Table 4.3: Integrated Fuzzy Comparison Matrix

	Fuzzy Sum of Each Row			**Fuzzy Synthetic Extent**			**Degree of Possibility of Mi > Mj**			**Degree of Possibility (Mi)**	**normalization**	**weights of criteria**	**Ranking**
C1	2.7663	3.5875	4.6171	0.2284	0.3833	0.6252		1.000	1.000	1.000	0.390	**0.390**	**1**
C2	2.5029	3.1675	4.1215	0.2067	0.3384	0.5581	0.880		1.000	0.880	0.343	**0.343**	**2**
C3	2.1156	2.6048	3.3706	0.1747	0.2783	0.4564	0.685	0.806		0.685	0.267	**0.267**	**3**
Sum	**7.3849**	**9.3598**	**12.1093**							**2.565**	**1.0000**		
										Sum			

Consistency Ratio (CRm)	0.0696	Compare with 0.1, They should be less than 0.1
Consistency Ratio (CRg)	0.1729	

Table 4.4: Results Of Fuzzy Weighting Value Of Main Criteria (Economical, Environmental, Social)

WEIGHTING RESULTS FOR MAIN CRITERIA *(CONT.)*

Step 1: The value of the fuzzy synthetic extent with respect to the i^{th} object is defined as in Eq. (3), (4), (5), (6) and presented in **Table 4.3** and **Table 4.4:**

$$S_i = \sum_{j=1}^{m} M_{gi}^{j} \times \left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right]^{-1}$$

$$\sum M_1 = (1 + 1.0491 + 0.7172;\ 1 + 1.5280 + 1.0595;\ 1 + 2.0891 + 1.5280)$$

$$= (2.7663;\ 3.5875;\ 4.171) \text{ etc.,}$$

Next, $$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i}\right)$$

$$S_1 = (2.7663;\ 3.5875;\ 4.171) \times \left(\frac{1}{12.1093}, \frac{1}{9.3598}, \frac{1}{7.3849}\right) = (0.2284;\ 0.3833;\ 0.6252)$$

$$S_2 = (0.2067;\ 0.3384;\ 0.5581)$$

$$S_3 = (0.1747;\ 0.2783;\ 0.4564)$$

WEIGHTING RESULTS FOR MAIN CRITERIA *(CONT.)*

Step 2: The values of S_i are compared and the degree of possibility of $S_j = (l_j, m_j, u_j) \geq S_i(l_i, m_i, u_i)$ is calculated as in Eq. (7) and the results are shown in **Table 4.4:**

$$V(S_j \geq S_i) = \begin{cases} 1, & if\ m_j \geq m_i \\ 0, & if\ l_i \geq u_j \\ \dfrac{l_i - u_j}{(m_j - u_j) - (m_i - l_i)}, & otherwise, \end{cases} \quad (7)$$

$$V_2\ (S_2 \geq S_1) = \left(\frac{0.2067 - 0.6252}{(0.3384 - 0.5581) - (0.3833 - 0.2284)}\right) = 0.880$$

$V_{11}\ (S_1 > S_2) = 1;$

$V_{12}\ (S_1 > S_3) = 1;$

$V_{21}\ (S_2 > S_1) = 0.880;$

$V_{23}\ (S_2 > S_3) = 1;$

$V_{31}\ (S_3 > S_1) = 0.685;$

$V_{32}\ (S_3 > S_2) = 0.806.$

WEIGHTING RESULTS FOR MAIN CRITERIA *(CONT.)*

Step 3: The minimum degree of possibility $d(i)$ of $V(S_j \geq S_i)$ for $i, j = 1, 2, \ldots, k$ can be calculated as in Eq. (8):

$$V(S \geq S_1, S_2, S_3, \ldots, S_k) = V\,[(S \geq S_1)\ and\ (S \geq S_2)\ and \ldots (S \geq S_k)] \qquad (8)$$
$$= \min V(S \geq S_i) = W'(S_i)$$

- The weights priority is with Consistency Ratio (CRm) = 0.0696 (less than 0.1) in **Table 4.4**:

$\text{Min } V_1 \ (V_{11}, V_{12}) = 1;$

$\text{Min } V_2 \ (V_{21}, V_{23}) = 0.880;$

$\text{Min } V_3 \ (V_{31}, V_{32}) = 0.685;$

W= (1, 0.880, 0.685)

$\text{W\_normalize} = (0.390, 0.343, 0.267)^T$

WEIGHTING RESULTS FOR SUB-CRITERIA OF ECONOMIC *(CONT.)*

	Fuzzy Sum of Each Row			Fuzzy Synthetic Extent			Degree of Possibility of Mi > Mj											Degree of Possibility (Mi)	Normalization Weights	Ranking
C11	9.1916	12.7321	17.3066	0.0512	0.0955	0.1775		0.983	0.870	0.982	0.803	1.000	1.000	1.000	1.000	1.000	1.000	0.803	0.0984	5
C12	9.3827	13.0161	17.5220	0.0522	0.0977	0.1797	1.000		0.885	0.998	0.819	1.000	1.000	1.000	1.000	1.000	1.000	0.819	0.1004	4
C13	10.7455	15.0829	20.3769	0.0598	0.1132	0.2090	1.000	1.000		1.000	0.938	1.000	1.000	1.000	1.000	1.000	1.000	0.938	0.1150	2
C14	9.3994	13.0433	17.6255	0.0523	0.0979	0.1807	1.000	1.000	0.888		0.821	1.000	1.000	1.000	1.000	1.000	1.000	0.821	0.1007	3
C15	12.0749	16.3349	21.3081	0.0672	0.1226	0.2185	1.000	1.000	1.000	1.000		1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.1226	1
C16	6.9449	9.2891	12.7089	0.0387	0.0697	0.1303	0.754	0.736	0.619	0.735	0.544		0.988	0.517	0.784	0.910	1.000	0.517	0.0634	11
C17	7.0141	9.4312	12.9111	0.0390	0.0708	0.1324	0.766	0.749	0.631	0.747	0.557	1.000		0.527	0.796	0.922	1.000	0.527	0.0647	10
C18	9.0995	12.4400	16.5770	0.0507	0.0933	0.1700	0.982	0.965	0.847	0.963	0.779	1.000	1.000		1.000	1.000	1.000	0.779	0.0954	6
C19	9.0705	12.2204	16.0155	0.0505	0.0917	0.1642	0.967	0.949	0.829	0.948	0.759	1.000	1.000	0.986		1.000	1.000	0.759	0.0930	7
C110	7.6817	10.4460	14.4468	0.0428	0.0784	0.1481	0.850	0.833	0.717	0.831	0.647	1.000	1.000	0.867	0.880		1.000	0.647	0.0793	8
C111	6.9112	9.2467	12.8345	0.0385	0.0694	0.1316	0.755	0.737	0.621	0.736	0.548	0.997	0.696	0.772	0.784	0.908		0.548	0.0671	9
Sum	**97.5161**	**133.2827**	**179.6330**															**8.158**	**1.0000**	
																		Sum		

Consistency Ratio (CRm)	**0.0539**	**Compare with 0.1, They should be less than 0.1**
Consistency Ratio (CRg)	**0.1470**	

Table 4.7: Results of Fuzzy Weighting Value Of Economic

WEIGHTING RESULTS FOR SUB-CRITERIA OF ENVIRONMENT C2 *(CONT.)*

	Fuzzy Sum of Each Row			Fuzzy Synthetic Extent			Degree of Possibility of Mi > Mj										Degree of Possibility (Mi)	Normalization weights of criteria	Ranking
C21	8.6642	11.9902	16.2367	0.0561	0.1035	0.1909		1.000	0.834	1.000	0.698	1.000	1.000	1.000	0.967	1.000	0.698	0.1088	4
C22	7.9374	10.9429	14.8106	0.0514	0.0945	0.1742	0.929		0.759	0.945	0.620	1.000	1.000	0.686	0.894	1.000	0.620	0.0967	7
C23	10.6368	14.8101	19.5575	0.0689	0.1278	0.2300	1.000	1.000		1.000	0.868	1.000	1.000	1.000	1.000	1.000	0.868	0.1353	2
C24	8.4868	11.7400	15.8358	0.0550	0.1013	0.1862	0.984	1.000	0.816		0.678	1.000	1.000	1.000	0.950	1.000	0.678	0.1058	5
C25	12.8414	17.4040	22.5743	0.0831	0.1502	0.2655	1.000	1.000	1.000	1.000		1.000	1.000	1.000	1.000	1.000	1.000	0.1560	1
C26	6.0324	7.9595	10.8594	0.0391	0.0687	0.1277	0.673	0.748	0.499	0.690	0.353		0.974	0.479	0.634	0.895	0.353	0.0551	10
C27	6.2128	8.2266	11.2219	0.0402	0.0710	0.1320	0.700	0.775	0.526	0.717	0.381	1.000		0.500	0.662	0.921	0.381	0.0595	9
C28	8.2384	11.1600	14.6617	0.0533	0.0963	0.1724	0.942	1.000	0.767	0.959	0.624	1.000	1.000		0.906	1.000	0.624	0.0973	6
C29	9.2063	12.5145	16.1692	0.0596	0.1080	0.1901	1.000	1.000	0.860	1.000	0.717	1.000	1.000	1.000		1.000	0.717	0.1119	3
C210	6.7774	9.1004	12.5165	0.0439	0.0786	0.1472	0.785	0.858	0.614	0.802	0.472	1.000	1.000	0.841	0.748		0.472	0.0736	8
Sum	**85.0340**	**115.8484**	**154.4436**													**Sum**	**6.411**	**1.0000**	

Consistency Ratio (CRm)	**0.0902**	**Compare with 0.1, They should be less than 0.1**
Consistency Ratio (CRg)	**0.3253**	

Table 4.10 Results of Fuzzy Weighting Value of Environmental

WEIGHTING RESULTS FOR SUB-CRITERIA OF SOCIAL C3 *(CONT.)*

	Fuzzy Sum of Each Row			Fuzzy Synthetic Extent			Degree of Possibility of Mi > Mj					Degree of Possibility (Mi)	normalization	Ranking
C31	4.2742	5.6477	7.4750	0.1227	0.2139	0.3727		1.000	0.977	0.993	1.000	0.977	0.2153	3
C32	4.0757	5.4292	7.1818	0.1170	0.2056	0.3581	0.966		0.943	0.959	1.000	0.943	0.2078	4
C33	4.3697	5.7991	7.5513	0.1255	0.2196	0.3765	1.000	1.000		1.000	1.000	1.000	0.2203	1
C34	4.2703	5.6958	7.5202	0.1226	0.2157	0.3749	1.000	1.000	0.985		1.000	0.985	0.2169	2
C35	3.0670	3.8365	5.1008	0.0881	0.1453	0.2543	0.657	0.695	0.634	0.652		0.634	0.1397	5
Sum	**20.0570**	**26.4084**	**34.8291**									**4.539**	**1.0000**	
												Sum		

Consistency Ratio (CRm)	**0.0388**
Consistency Ratio (CRg)	**0.0976**

Compare with 0.1, They should be less than 0.1

Table 4.13: Results of Fuzzy Weighting Value of Social

WEIGHTING AND RANKING RESULTS OF FAHP

Criteria	W_Concept	Sub-criteria	W_Local	Rank_Local	W_Global	Rank_ Global
Economical (C1)	0.390	Staff training (C11)	0.098	5	0.0384	12
		Delivery (C12)	0.100	4	0.0391	10
		Service level (C13)	0.115	2	0.0448	8
		Quality (C14)	0.101	3	0.0393	9
		Cost (C15)	0.123	1	0.0478	6
		Technology (C16)	0.063	11	0.0247	24
		Flexibility (C17)	0.065	10	0.0252	23
		Financial capability(C18)	0.095	6	0.0372	15
		Culture (C19)	0.093	7	0.0363	17
		Innovativeness (C110)	0.079	8	0.0309	20
		Relationship (C111)	0.067	9	0.0262	21
Environmental (C2)	0.343	Green products (C21)	0.109	4	0.0373	13
		Green image (C22)	0.097	7	0.0332	19
		Eco-design(C23)	0.135	2	0.0464	7
		Management commitment(C24)	0.106	5	0.0363	16
		Green technology(C25)	0.156	1	0.0535	5
		Pollution control(C26)	0.055	10	0.0189	26
		Recycle(C27)	0.060	9	0.0204	25
		Re-manufacturing(C28)	0.097	6	0.0334	18
		Environmental management system (C29)	0.112	3	0.0384	11
		Resource consumption(C210)	0.074	8	0.0253	22
Social (C3)	0.267	Human resource management (C31)	0.215	3	0.0575	3
		Corporate social responsibility (C32)	0.208	4	0.0555	4
		Health and safety (C33)	0.220	1	0.0588	1
		Human right issues (C34)	0.217	2	0.0579	2
		Relationship with stakeholders (C35)	0.140	5	0.0373	14

Table 4.14: Weighting and Ranking Results of FAHP

FUZZY TOPSIS FOR RANKING

Fuzzy number	Linguistic	Triangular fuzzy scale $M = (l, m, u)$
1	Equal	(1,1,1)
2	Weak advantage	(1,2,3)
3	Not bad	(2,3,4)
4	Preferable	(3,4,5)
5	Good	(4,5,6)
6	Fairly good	(5,6,7)
7	Very good	(6,7,8)
8	Absolute	(7,8,9)
9	Perfect	(8,9,10)

Table 4.15: Linguistic Variables for The Ratings

A linguistic rating set of S was used to express the opinions of the managers, where S = (E, WA, NB, PR, G, FG, VG, A, PE)

FUZZY TOPSIS FOR RANKING *(CONT.)*

Step 4 and 5 :(calculate A+, A−, Di+, and Di−). As shown in Table 4. , the distance of each green supplier from A+ and A− can be calculated by Eq. (20)~(21).

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23	C24	C25	C26
A1	0.981	0.927	0.958	0.944	0.978	0.975	0.952	0.968	0.949	0.935	0.976	0.960	0.923	0.917	0.940	0.858	0.979	0.976	0.937	0.964	0.971	0.799	0.935	0.883	0.925	0.909
A2	0.940	0.980	0.892	0.914	0.930	0.935	0.971	0.931	0.969	0.966	0.930	0.966	0.960	0.958	0.907	0.931	0.948	0.929	0.962	0.922	0.924	0.911	0.807	0.946	0.805	0.860
A3	0.966	0.976	0.927	0.938	0.963	0.956	0.933	0.931	0.933	0.951	0.960	0.929	0.942	0.941	0.903	0.943	0.986	0.959	0.911	0.931	0.948	0.869	0.889	0.806	0.868	0.938
A4	0.925	0.988	0.889	0.901	0.983	0.928	0.955	0.906	0.908	0.920	0.981	0.903	0.905	0.876	0.935	0.878	0.991	0.981	0.941	0.894	0.921	0.799	0.948	0.796	0.798	0.862
A5	0.980	0.970	0.950	0.964	0.910	0.974	0.930	0.966	0.966	0.968	0.933	0.957	0.962	0.926	0.900	0.892	0.954	0.932	0.908	0.939	0.965	0.911	0.816	0.931	0.910	0.954

S1+	24.4196
S2+	24.0922
S3+	24.2005
S4+	23.7138
S5+	24.3683

Table 4.19: D+

FUZZY TOPSIS FOR RANKING *(CONT.)*

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23	C24	C25	C26
A1	0.023	0.106	0.056	0.071	0.026	0.034	0.061	0.043	0.065	0.081	0.033	0.054	0.095	0.105	0.027	0.171	0.027	0.033	0.079	0.049	0.040	0.243	0.090	0.151	0.102	0.114
A2	0.084	0.025	0.130	0.105	0.096	0.078	0.039	0.085	0.042	0.045	0.084	0.047	0.053	0.056	0.049	0.091	0.075	0.085	0.051	0.095	0.092	0.120	0.233	0.077	0.237	0.166
A3	0.044	0.030	0.093	0.078	0.047	0.055	0.082	0.085	0.082	0.062	0.052	0.092	0.073	0.077	0.051	0.077	0.018	0.052	0.107	0.086	0.065	0.167	0.143	0.236	0.168	0.082
A4	0.106	0.014	0.134	0.117	0.020	0.085	0.057	0.111	0.108	0.095	0.027	0.120	0.113	0.149	0.031	0.152	0.010	0.027	0.075	0.125	0.095	0.243	0.073	0.246	0.245	0.164
A5	0.024	0.038	0.067	0.049	0.130	0.035	0.084	0.046	0.045	0.042	0.081	0.058	0.050	0.095	0.053	0.136	0.065	0.081	0.111	0.077	0.047	0.120	0.224	0.095	0.121	0.063

S1-	1.9787
S2-	2.3390
S3-	2.2040
S4-	2.7405
S5-	2.0369

Table 4.20: D-

FUZZY TOPSIS FOR RANKING *(CONT.)*

Step 6 :(obtain the closeness coefficient). The closeness coefficients of green suppliers can be calculated by Eq. (22), as shown in Table 4.21. Therefore, the ranking order of the five green suppliers is $A4 > A2 > A3 > A5 >$ A1. Consequently**, the best green supplier is *A4***

Rank of Alternatives			
A1	0.0750	**0.0750**	**5**
A2	0.0885	**0.0885**	**2**
A3	0.0835	**0.0835**	**3**
A4	0.1036	**0.1036**	**1**
A5	0.0771	**0.0771**	**4**

Table 4.21: Closeness coefficient of alternatives

CHAPTER V
CONCLUSIONS AND IMPLICATIONS

CONCLUSIONS

Green-oriented cooperation has become a leading component as global awareness of environmental sustainability

This thesis suggests a novel approach for managers to select suppliers based on the MCDM model

A4 was rated as the top supplier

Future research and different models will be needed to determine how to assign orders to the model's prospective green suppliers

MANGERIAL IMPLICATIONS

Theoretical implications

1. Heterogeneous knowledge is used to handle the evaluation values on various criteria for different features
2. A maximizing consensus approach based on an optimization model is proposed
3. The suggested green supplier selection methods do not necessitate extensive computations but still provides a fair and reliable solution result

Administrative implications

1. Assisting managers in properly allocating green marketing behavior
2. Realize the importance of motivating SC partners to notice GSCM practices and drive performance
3. Corporate social responsibility (CSR) could be essential
4. Improve their firm's green brand profile in the short-medium term
5. Adjust their green marketing policy in response to external and internal environmental changes

THESIS LIMITATIONS

- **Weight elicitation may be complicated in some cases, and imprecise data, such as weight intervals, fuzzy weights, or ordinal data, may be involved in the GSS challenge**
- **Failed to consider the scope for interactions and relationships between the sub-criteria**
- **Could not arrange meeting with more than 12 high-level executives of automotive manufacturing companies**

Thank You For Listening