Tomas Bata University in Zlín
Faculty of Management and Economics

Doctoral Thesis

Conceptual Framework of Circular Economy Adoption for Green Logistics and Sustainable Supply Chain

Koncepční rámec cirkulární ekonomiky pro zelenou logistiku a udržitelný dodavatelský řetězec

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Zlín, December 2023

Published by **Tomas Bata University in Zlín** in the Edition **Doctoral Thesis.**
The publication was issued in the year 2024.

Key words: c*ircular economy*, *logistics*, *partial least squares*, *structural equation modelling*, *supply chain*, *sustainability.*

Key words in Czech: *cirkulární ekonomika, logistika, metoda nejmenších čtverců, modelování strukturních rovnic, řízení dodavatelských řetězců, udržitelnost.*

Full text of the doctoral thesis is available in the Library of TBU in Zlín.

ACKNOWLEDGEMENT

I would like to express my heartfelt gratefulness to my consultant, prof. doc. Ing. Felicita Chromjaková, Ph.D. for invaluable instructions, consultations, and moral support during the fulfilment of the thesis. In addition, I would like to offer my sincere gratitude to my supervisor, doc. Ing. Roman Bobák, Ph.D., who encouraged me to complete the thesis.

Great acknowledgments are due to my Dean, prof. Ing. David Tuček, Ph.D., who listened and gave me deep support for my study, and Dr. Ing. Lubor Homolka, Ph.D., who gave me lectures in statistical analysis, an important foundation for my thesis.

I am grateful to Mrs. Martina Drábková, Mrs. Pavla Bartošová, Mrs. Lenka Kolenovská, and other members of FaME, for the tremendous assistance they have given me over my program, as well as my other projects in the European country.

It is indeed a special privilege for me to be able to thank the Czech Republic people for providing the scholarship that enabled me to follow the Ph.D. program at Tomas Bata University in Zlin.

Last, but certainly not least, thanks to all my family, in particular my mother and my wife for their love, and sacrifice. It is to them this thesis is dedicated.

Luu Van Thanh

Zlín, December 2023

ABSTRACT

There are many studies on circular economy adoption for logistics and supply chains that ensure economic, environmental, and social sustainability. The big gap is a lack of understanding about a conceptual framework development, validation, and optimization for the circular economy adoption for green logistics and sustainable supply chain under a high-technology context.

The main objective of the study is to investigate a conceptual framework of Circular Economy Adoption for Green Logistics and Sustainable supply chains and its hypotheses to fulfil the above-mentioned gap, as well as concerning its practical aspects. Data were collected from the authors' network of universities, companies, and government sectors. Partial Least Squares Structural Equation Modelling is used to validate the proposed framework and its hypotheses. Other optimization approaches such as Combinatorial Optimization and Muti-Criteria Decision Making are employed for optimizing the real case operations in light of green and sustainable thinking and practices.

The key findings of the research are:

a) the confirmation of a dominant direct relationship of high-tech application with the circular economy adoption for green logistics and sustainable supply chain that benefits Vietnam stakeholders to motivate strategic changes.

b) reflection on the status quo of strategic awareness and operations in Vietnam, such as the promulgation and implementation of policies in government sectors, as well as the development of modern logistics and supply chain programs in universities.

c) The real-world cases inform distribution supply chain network design and operations decisions, encompassing facility layout and location requirements for costs optimization (SME company), warehouse layout improvements for efficient picking and sustainability (ATP case), and enhancing business process management within the context of knowledge-based and circular economies to improve business performance in light of sustainable competitiveness (MVN Group). Green and sustainable practices are intrinsic corporate values in fostering a premium circular economy for contemporary enterprises.

The scope of the study is focused on logistics and supply chains; however, variables for other industries and areas such as manufacturing and agriculture as well as countries require further investigation.

ABSTRAKT

Existuje mnoho studií uplatnitelnosti cirkulární ekonomiky v logistice a řízení dodavatelských řetězců, které zajišťují ekonomickou, environmentální a sociální udržitelnost. Velkou mezerou je nedostatečné porozumění ohledně vývoje, ověřování a optimalizace koncepčního rámce pro přijetí oběhového hospodářství pro zelenou logistiku a udržitelný dodavatelský řetězec v kontextu špičkových technologií.

Hlavním cílem studie je prozkoumat koncepční rámec přijetí oběhového hospodářství pro zelenou logistiku a udržitelné dodavatelské řetězce a jeho hypotézy k naplnění výše uvedené mezery, jakož i jeho praktické aspekty. Sběr dat vychází z autorovy sítě univerzit, společností a institucí vládního sektoru. Pro validaci vymezeného koncepčního rámce a definovaných hypotéz je využita metoda nejmenších čtverců a modelování strukturních rovnic. S ohledem na zelené a udržitelné uvažování a praktiky jsou v práci použité i další optimalizační metody kombinační optimalizace a multikriteriálního rozhodování deklarované na reálných případových studiích.

Klíčovými výstupy realizovaného výzkumu jsou:

a) potvrzení dominantních přímých vazeb high-tech aplikací adaptace cirkulární ekonomiky a udržitelných dodavatelských řetězců pro zelenou logistiku a udržitelný dodavatelský řetězec, které motivují vietnamské stakeholdery ke strategickým změnám.

b) reflexe status-quo o strategickém povědomí a aktivitách ve Vietnamu zaměřených na vyhlášení a implementaci politik ve vládním sektoru a také rozvoj moderních studijních programů logistiky a udržitelného dodavatelského řetězce na univerzitách.

c) případové studie ze světa poukazují na příklady návrhů distribučního dodavatelského řetězce a operativních rozhodnutí, zahrnujících požadavky na rozmístění příležitostí a jejich uspořádání s ohledem na optimalizaci nákladů (SMEs), efektivní vychystávání ze skladů s ohledem na udržitelnost (ATP příklad) a zlepšení řízení obchodních procesů v kontextu znalostně orientované cirkulární ekonomiky v návaznosti na zvýšení výkonnosti a udržitelné konkurenceschopnosti (MVN Group). Zelené a udržitelné praktiky jsou klíčovými firemními hodnotami v podpoře prémiového oběhového hospodářství v stávajících firmách.

Rozsah této studie je zaměřen na logistiku a řízení dodavatelských řetězců, nicméně proměnné pro jiné oblasti a odvětví, např. zemědělství, výroba vyžadují další výzkum.

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ABBREVIATIONS

CDA: Class-based Dedicated Assignment
CE: Circular Economy
CEA: Circular Economy Adoption
CEF: Circular Economy Framework
CO: Combinatorial Optimization
COL: Supply Chain Collaboration
CON: Supply Chain Configuration
GDP: Gross Domestic Product
GLS: Green Logistics and Sustainable Supply Chain
GOP: Government Policy
ID4.0: Industry 4.0
KE: Knowledge Economy
KM: Knowledge Management
MCDM: Multiple-Criteria Decision-Making
MILP: Mixed-Integer Linear Programming
PLS-SEM: Partial Least Squares Structural Equation Modelling
SC: Supply Chain
SCM: Supply Chain Management
TSP: Traveling Salesman Problem

1 INTRODUCTION

1.1 Motivation

This section was detailed in the research papers Luu et al (2023), and Luu (2022, 2021a, 2021b). In terms of macro-economy strategy and government policy, this subsection discusses several economic factors such as GDP, public debt, inflation rate, the labor market, population, unemployment, and related strategies that affect the sustainable development of the logistics and supply chain field in Vietnam (Table 1). "*In 2019, Vietnam's economy continued to show fundamental strength and resilience, supported by robust domestic demand and export-oriented manufacturing*"[1]. Political and economic reforms since 1986 have promoted economic development, rapidly turning Vietnam from one of the poorest countries in the world into a low-middle-income country. From 2002 to 2020, GDP per capita increased by 3,6 times, reaching US$ 3,753 in 2021 and US$ 4,086 in 2022. GDP growth is at 7.4% in 2019, like the growth rate of 7.5% in 2018 (Table 1). The public debt is reduced over the year from 43.5% of GDP in 2018, this is a good sound (less than 60% of GDP)[2].

Table 1: Vietnam economy data

	2018	**2019**	**2020**	**2021**	**2022**
Population (million)	94.7	96.5	97.6	98.5	99.5
GDP per capita (USD)	3,216	3,439	3,548	3,753	4,086
GDP, annual variation in %	7.5	7.4	2.9	2.6	8.0
Unemployment Rate	2.2	2.2	2.5	3.1	2.3
Fiscal Balance (% of GDP)	-1.0	-0.4	-2.9	-3.4	-2.5
Public Debt (% of GDP)	43.5	40.8	41.3	39.3	-

Source: General Statistics Office[3]

Due to the extensive economic integration, the Vietnamese economy was heavily affected by the COVID-19 pandemic but also exhibited considerable resilience. The initial medical impact of the epidemic is not as serious as in many other countries, thanks to proactive countermeasures at both the central and local levels. Macroeconomy and fiscal framework are stable with total GDP growth for

[1] *https://www.worldbank.org/en/country/vietnam/overview*
[2] *https://www.focus-economics.com/countries/vietnam*
[3] *https://www.gso.gov.vn/en/data-and-statistics/2020/12/infographic-social-economic-situation-12-2020/*

2020 at 2.9%, the lowest outturn in at least two decades and far below the 6.76% average during 2015–2019, however, Vietnam is one of the few countries in the world that do not forecast an economic recession. Vietnam is witnessing rapid changes in its demographic and social structure. Vietnam's population has grown to about 99.5 million in 2022 and is expected to increase to 120 million by 2050. The economy began on a robust footing according to available data. Industrial production gained steam in a stronger manufacturing sector, while retail sales notably expanded, and exports surged, however, the tourism sector remained downtrodden due to the border closure. Overall, the unemployment rate is reduced over time to 2.2% in 2018-2019 and 2.3% in 2022 after an increase of 3.1% in 2021. According to the Vietnam Census in 2019, 55.5% of the population is under 35 years of age, with an average life expectancy of nearly 76 years, which is higher than in other similar-income countries in the region. This is the abundant human resource that contributes to the Vietnam labor market. But the population is aging rapidly. Vietnam also needs to improve the qualifications of its workforce to create more productive jobs on a large scale in the future (Luu, 2022).

According to WTO commitments, Vietnam opened the logistics market in 2014. Compared to the period before joining the WTO, Vietnam's logistics have significantly grown in the number of participating businesses as well as the professionalism of service providers. The Vietnam Logistics Research and Development Institute (VLI) shows that there are about 3,000 enterprises in Vietnam operating in the field of logistics in general and need more than 200,000 employees by the year 2030, meanwhile, the ability to meet the needs of logistics human resources is only about 10% of the market demand[4]. In Vietnam with a system of more than 30 seaports, and 6 international airports, the volume of cargo exploited through ports has increased on average by 10% per year since 2007. The total cost of logistics in Vietnam is estimated at 20.9% - 25% of GDP, which is about 3 times the rate of logistics in the USA, or Japan, and about 1,3 times compared with Thailand[5] (Figure 1) (Luu, 2022).

Figure 1: Logistics cost comparison

[4] *https://vli.edu.vn/495-2/*
[5] *https://logistics4vn.com/chi-phi-logistics-cua-viet-nam-chua-giam-ngay*

Source: Logistics4VN (2015)

This is also quite understandable, the US and Japan are both countries with large-scale developed economies with modern logistics infrastructure along with effective supply chain management, high labor efficiency, and high-tech applications. While Vietnam and Thailand have several common factors that impact their logistics costs, as both Vietnam and Thailand are developing countries located in Southeast Asia, with favorable geographical positions to access consumption markets in the region with seaports and several industrial parks in the development of logistics infrastructure. Besides, both have abundant labor and relatively low labor costs compared to other countries in the region. However, each country has its own characteristics and factors that logistics costs can still be different. For example, Thailand has a more favorable geographical position with a developed seaport system and modern logistics infrastructure, and proximity to international airports which can reduce transportation costs. In general, Vietnam still has a lot of room to reduce logistics costs competitive with Thailand as well as other developed countries, by developing logistics infrastructure in a synchronous transportation planning and development of skilled workforces to strengthen configuration and collaboration in the supply chain network to reduce transports costs which are account for the main part of logistics costs[6].

Table 2: Logistics performance index (1=low to 5=high)

Country	**2007**	**2010**	**2012**	**2014**	**2016**	**2018**
Japan	4.0	4.0	3.9	3.9	4.0	4.0
USA	3.8	3.9	3.9	3.9	4.0	3.9
Czech Republic	3.1	3.5	3.1	3.5	3.7	3.7
Thailand	3.3	3.3	3.2	3.4	3.3	3.4
Vietnam	2.9	3.0	3.0	3.2	3.0	3.3

Source: https://databank.worldbank.org/source/LPI

Additionally, the World Bank biennially constructs the logistics performance indicator (LPI) to gauge international logistics proficiency based on time, cost, and reliability dimensions. Table 2 also shows that Vietnam still has a low LPI (3.3) compared with Japan (4.0), the USA (3.9), and the Czech Republic (3.7) but gradually competes with Thailand (3.4) in 2018. According to the World Bank,[7] logistics plays a pivotal role in enhancing the competitive edge of nations and enterprises. Global logistics is propelled by three driven forces: Economic trends, Technological advancements, and Policy challenges. Hence, this thesis argues

[6] *https://logistics4vn.com/giai-phap-nao-cho-chi-phi-logistics-viet-nam*

[7] *https://www.worldbank.org/en/news/speech/2017/05/22/performance-and-prospects-of-global-logistics*

that logistics and supply chain is a high-tech industry with three distinct attributes: economics-technology-policy framework, as well as focuses on two independent constructs of its configuration, and collaboration in supply chain networks (Luu et al., 2023). Each company is confronted with sustainable logistics, green technologies are highly required. It has no model that has been taken as standard in the trend of globalization. Depending on the economic potential, the level of science and technology, and the national topography, each country determines its development strategy, as well as selects the suitable model to achieve high market efficiency and effectiveness, besides it brings convenience to the social and environmental sustainability. Therefore, the concept of green logistics and sustainable supply chain is developed along with the CE. According to Decision No., 175/QD/TTg of Vietnam's Prime Minister on "*Approving the overall strategy for developing service sector of Vietnam by 2020*", the logistics market growth rate reaches 20–25%, the total value of logistics service is forecast to account for 10% of GDP. Logistics is considered a key factor to promote the development of production and distribution systems of other services. This shows that the green logistics industry has become a national program (Luu, 2022). Along with industry, agriculture plays an important role in sustaining all human activities. Major challenges such as overpopulation, and competition for resources pose a threat to the food security of the planet. To tackle the ever-increasing complex problems in agricultural production systems, advancements in smart farming and precision agriculture offer important tools to address agricultural sustainability challenges. As a result of several land reform measures, Vietnam has become a major exporter of agricultural products. It is now the world's largest producer of cashew nuts and black pepper, accounting for one-third of the world's market;[8] and the second-largest exporter of coffee and rice in the world after Thailand since the 1990s. The country has the highest proportion of land use for permanent crops together with other nations in the Greater Mekong Subregion. However, Vietnam's agriculture still faces the above major challenges, coupled with the impacts of climate change, such as saline intrusion in the Mekong Delta.

In terms of modern economy business model, the government is working to effectively reduce the impact of growth on the environment and adapt to climate change. Policies and plans to promote green growth and sustainable resource exploitation have been adopted. The government also takes measures to mitigate and adapt to climate change, coping with extreme weather and natural disasters through the implementation of the Nationally Determined Contribution (NDC). According to the Minister of Natural Resources and Environment of Vietnam - Tran Hong Ha[9]: "*We have also identified that the model of a green economy, a low carbon economy such as a circular economy is a key task to contribute to a*

[8] *Voice of Vietnam (2018c). "Vietnam's pepper industry about to burst". Voice of Vietnam*

[9] *https://thanhnien.vn/tai-chinh-kinh-doanh/kinh-te-xanh/bo-truong-tran-hong-ha-kinh-te-xanh-se-la-tuong-lai-1343755.html*

sustainable economic restructuring. We are determined to change the economy from brown energy to green energy, unsustainable to sustainable development" (Luu, 2022).

In terms of high-tech applications and human resources development, there are only a few universities in Vietnam that offered bachelor's degrees in logistics and supply chain. The program is relatively backward, teaching mainly traditional forwarding skills. Modern techniques, new concepts, and frameworks are rarely updated. At the seminar on "*Training program of Logistics and Supply Chain Management*" organized by the Department of Industrial Systems Engineering in the International University, Vietnam National University Ho Chi Minh City held on 06 November 2013[10], 14 enterprises were surveyed on the current situation and human resource needs in logistics and supply chain management. The results of the survey show that the human resource needs for this field are enormous, and it is necessary to develop a training program for this field in near future. The survey also shows that when dealing with difficulties in logistics and supply chain operations, enterprises rely mainly on their feeling and experience. The problems that cannot be solved by themselves rely on external experts or consulting firms. Thus, it can be affirmed that, at present, Vietnam enterprises are in shortage of trained human resources with specialized knowledge of logistics and supply chain, to solve problems arising in their operations along with the new trend of a '*green and sustainable mindset'* (Luu, 2022).

The motivation for this work is based on the existence of an increasing interest in a circular economy (CE) business model on green logistics and sustainable supply chain (GLS) areas that can be applied to Vietnam logistics industry (Luu, et al., 2023).

1.2 Research statement & gap

Human activities are destroying the earth more and more. The global ecosystem is under threat and becoming smaller. This can be illustrated by the shrinking of the earth due to falling land, rising sea levels, growing population, and increasing cattle numbers as well as per capita consumption, at once reducing biodiversity at a rapid rate. The IPBES (Fischer, et al., 2018) reported that "*The health of ecosystems on which we and all other species depend is deteriorating more rapidly than ever. We are eroding the very foundations of our economies, livelihoods, food security, health, and quality of life worldwide*". The circular economy concept is one of the most appropriate approaches to achieving sustainability in the future (Hazen et al., 2020). Humans tried to plan their resources as time, effort, costs, etc., for any necessary activities (Luu, 2022).

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[10] *Survey results on the human resources needs for Logistics and Supply Chain Management at ISE Department-IU-VNU, November 06, 2013*

The majority of academics have investigated either CEs or high-tech applications (ID4.0) separately (Birkel & Müller, 2021; Morseletto, 2020; Kirchherr, Reike, and Hekkert, 2017), while others examined connections between them in terms of a specific industries and businesses (Agrawal et al., 2022; Rajput & Singh, 2022; Kumar, Rehman Khan et al., 2022; Singh, and Kumar, 2021; Bag and Pretorius, 2020). For example, Shayganmehr et al. (2021) explored the impact of ID4.0 and CEs on sustainable production. Massaro et al. (2021) studied how ID4.0 enables CEs and affects businesses. Rajput & Singh (2019) identified key facilitators linking CE, ID4.0, and supply chains. Kumar et al. (2021) analyzed inhibitors in SC operations due to ID4.0 and CE. Dev et al. (2020) focused on operational excellence in reverse logistics with CE and ID4.0. Agrawal et al. (2022) and Rosa et al. (2020) propose integration of ID4.0 and CEs through literature review (Luu, et al., 2023; Luu, 2021a, 2021b). Obviously, previous studies have focused on production and manufacturing fields; or enablers and barriers analysis; or systematic literature reviews; or theoretical framework development and methodological validation without considering practical concerns, it is difficult for companies to adopt them into their operations. A notable gap exists in comprehending a conceptual framework for the adoption of a circular economy in green logistics and sustainable supply chains within a high-technology context. This study is one of the first attempts to further the development, validation, and optimization of a conceptual framework for CE adoption in GLS transitions and practices.

Coming from the motivation of the study, what exactly is a Circular Economy adoption for GLS? Attempts have been made to tackle issues triggered by an escalation in demand for natural resources. Regulatory bodies are pushing global supply chains to become sustainable across all operational activities to make them more environmentally friendly and financially feasible, forcing the adoption of advanced technologies (Luu, et al., 2023; Luu, 2021a). Prior research focused on CE and ID4.0 effects in logistics and supply chain (Agrawal et al., 2022), and explored organizational decision-making, external pressures, and internal resources (Dubey et al., 2019), yet no one has proposed a framework of a CE under high-tech applications for GLS. However, the impact of external pressures on internal resource development in the context of CE in high-tech context for enhancing green logistics and sustainable supply chains remains unclear. This study adopts Policy Feedback (Pierson, 1993) and Resource-Based View (RBV) (Barney, 1991) to analyze the relationship between external pressures (government policy) and internal resources, shaping CE and ID4.0 capabilities and framework for GLS especially in cooperation and configurations of supply chain networks with the aim of devising an economic mechanism to achieve corresponding social and environmental goals, especially that can be applied for Vietnam. RBV explains competitive advantage through strategic resource bundles, while government policies contribute resources and incentives (Luu, et al., 2023; Luu, 2021b, 2022).

Research realized in Vietnam is based on research cooperation with the HCM city Vietnam National University. Vietnam, where the logistics industry has been treated as a national program along with green and sustainable development, is chosen as the place for research data collection. The government policy and strategy motivate a circular economy adoption for green logistics competitive with Thailand and other developed countries which is defined in the motivation of the study. Moreover, HCM City is truly a diversified hub with highly skilled laborers from different industries and regions in the world. Evidently, although the research focuses on logistics and supply chain fields, even the questionnaires are also delivered to manufacturing enterprises that have strong logistics operations. Therefore, the crucial principles in the conceptual framework can be applied to Vietnam industries as well as to others.

On the side of the research approach, utilizing resources and optimizing costs are about smart and responsible business, those combinations will maximize economic, social, and environmental benefits. To do that, Partial Least Squares Structural Equation Modelling (PLS-SEM), Combinatorial Optimization (CO), and/or Multiple-Criteria Decisions-Making (MCDM) are used as the keys to examine research framework and optimize real-world problems. There is a need for a better understanding of a structured approach in identifying and modeling GLS in a CE context that aims to meet the three pillars of sustainability. Accordingly, supply chains that have the desire to improve their performance, do not only try to maximize their economic benefits but also bother about the environmental and social externalities of their operations (Luu, 2022).

Therefore, the main aim of this dissertation is to close the research gap by modeling a conceptual framework of CE adoption for GLSs, especially investigating the collaboration and configurations of supply chain networks in a circular economy framework integrated with high-tech applications such as ID4.0 under the impact of government policy, as well as using CO and MCDM approaches for optimizing operations of real case studies in light of green mindset and sustainable practices.

1.3 Research questions and objectives

1.3.1. Research questions

On the basis of the research statement and gap, the research should be deployed to fulfill the limitations of previous works toward the GLS transition by investigating the positive effects of high-tech applications, government policy, supply chain collaboration, and configurations in a CE context.

The research questions are specifically developed below.

RQ1. Do high-tech applications impact CE adoption and GLS?

RQ2. Do government policies influence CE adoption?

RQ3. Do supply chain collaboration and configurations play a role in a GLS network?

RQ4. How is a CE model adopted for GLS?

1.3.2 Research objectives

Coming from the main aim of the dissertation and to answer the research questions, the thesis forms the following objectives:

RO1. To explore Industry 4.0 technologies, directly and indirectly, impact CE adoption and GLS, respectively.

RO2. To examine the influence of government policies on CE adoption.

RO3. To capture the effects of supply chain collaboration and configurations on GLS network.

RO4. To use PLS-SEM and others for the proposed model validation and optimization.

1.4 Summary of research methodology

1.4.1 Conceptual design

The study is designed as a mixed approach consisting of three phases (Figure 2) in both qualitative and quantitative methods as well as primary and secondary data.

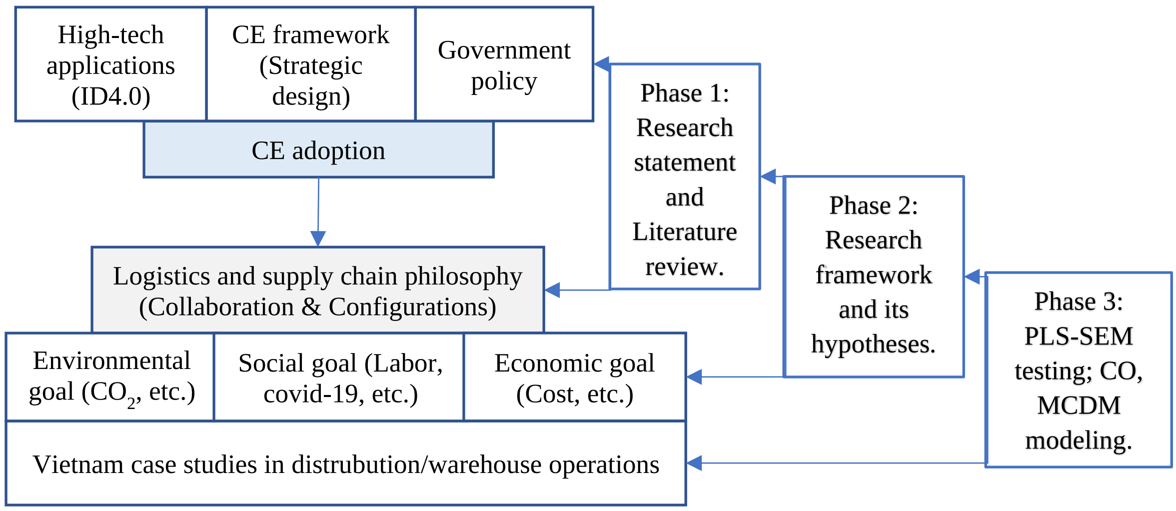


Figure 2: Research conceptual design
Source: own research

With qualitative approaches, the first phase of the study explores research forming and literacy on CE, logistics and supply chain fields. From these grounds, the research uses interview technique to deep understanding in adoption of CE on green logistics and sustainable supply chain transitions. In the second phase, a proposed framework of CE adoption for GLS, and its hypotheses are developed. In the third phase, quantitative methods with questionnaire techniques to collect primary data and statistical software such as ADANCO/SmartPLS-SEM are used to validate the proposed framework and its hypotheses. Other quantitative methods such as MCDM and Combinatorial Optimization models are also used for selected case studies in Vietnam with their secondary data to optimize distribution supply chain network design and order-picking warehouse operations in light of green and sustainable goals.

1.4.2 Summary of methodology

Details of the research approach are illustrated in Table 3, as follows.

Table 3: Research methodology summary

Research approaches	**Mixed methods**	
	Qualitative study	**Quantitative study**
Methods	- Thematic Analysis	- Survey/Case studies
Research techniques	- Interviews - Documentary review	- Questionnaires & PLS-SEM Model. - MCDM/MILP & CO of TSP/CDA
Object of analysis	- Professors/ lecturers/ civil servants/ managers.	- Employees/students. - Companies in Vietnam industry.
Research data	- 18 key involved persons	- 210 responders (primary data). - 3 companies (secondary data).
Data analysis	- The interviews were recorded and stored in MS Word & Excel.	- SmartPLS/ADANCO software. - IBM ILOG CPLEX software. - LINGO solver.
Research studies	**1. Study 1:** Framework, hypotheses & measurement development. **2. Study 2:** Verification of the 7 constructs & 32 variables.	**3. Study 3:** Framework validation and hypotheses testing. **4. Study 4:** Critical analysis on KCE model of the MVN. **5. Study 5:** MCDM solving for SCND in the SME. **6. Study 6:** CO solving for OPW in the ATP.
Research objectives/results	Satisfied all RQs/ROs of 1, 2, 3, and 4.	

Source: own research

1.5 Summary of three real-world case studies

The three companies in different Vietnam industries are known as SME, MVN, and ATP since its name and other information that would allow for the identification of companies have been made anonymous (Luu & Chromjaková, 2023a, 2023b; Luu, et al., 2023).

1.5.1 The MVN

MVN is the largest dairy company in Vietnam. The research aims to critically analyze the MVN outcomes realized in its business process management and the value chain in the knowledge-based and circular economics context constitutes a key element in ensuring sustainable competitiveness.

Figure 3 describes a modified CE framework as the 3R1O for MVN operations (Reduce, Reuse, Recycle, and Optimize) showed an important advance around resource consumption.

The MVN pledges to continue this momentum for a bright future, where growth and sustainable progress work together to advance its economic, social, and environmental values.

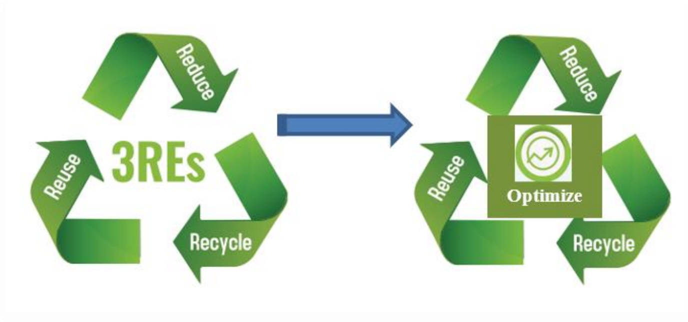


Figure 3: A modified 3R1O framework
Source: processing based on the MVN Sustainable Development Report, 2020

1.5.2 The SME

The SME operates in retail distribution with many points from North to South Vietnam. The old SME supply chain is the three-echelon network of factories-warehouses-retailers. Since 2020, under covid-19 pandemic impacts and the increasing demand, the company is testing a four-echelon network described in Figure 4. However, SME is coping with distribution problems such as high costs of transportation, inventory, and rental; as well as considering more distribution depots and warehouses.

Therefore, the main goal of the study is to develop an optimal distribution network for the SME with the best delivery routes to fulfill the demands of retailers while minimizing the total distribution costs. To achieve the goal, the following objectives are developed: *a*) Analyze the supply chain network design (SCND) in the SME retail distribution network; *b*) Develop a MILP mathematical model for the SCND and deploy the CPLEX software to find the optimal solutions (Luu & Chromjaková, 2023a).

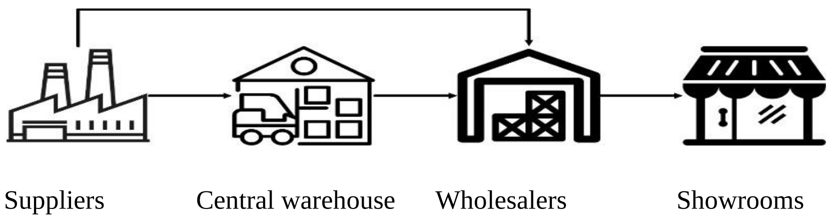


Figure 4: The current supply chain network of the SME
Source: processing based on the SME report

1.5.3 The ATP

ATP, the biggest network provider in Vietnam, plays an important duty in receiving goods, boosting sales in Vietnam, and whole logistic control from Hong Kong to Vietnam.

The main problems of this case are ineffective warehouse leads to weak performance in order picking operations. The study aims to re-layout the allocations of goods in a more scientific way regarding picking path optimization. Hybrid models of Class-based Dedicated Assignment and Travelling Salesman Problem are developed using LINGO solver to optimize the distance that pickers must travel to collect an uncertain number of products over proposed warehouse layouts.

1.6 Main findings of the research

The key findings and contributions of the research are: The vital role of high-tech applications in driving strategic shifts and decisions to adopt CE for GLS for sustainable growth (Luu, et al., 2023). It also reflects the current situation regarding the formulation and execution of policies within the country. Consequently, this discovery assists government sectors in recognizing the need to realign their activities in order to provide enhanced support to businesses and society as a whole.

The findings in the operations optimization for real-world cases are used for strategic, tactic, and operational decisions in supply chain network design and operations, such as determining the number of facilities needed, optimizing total distribution costs (the SME) (Luu & Chromjaková, 2023a); by respective decisions in the warehouse layouts to optimize the pick path along with sustainable development (the ATP) (Luu, et al., 2023); as well as improving business performance and business process management in the context of knowledge-based and circular economics (the MVN) (Luu & Chromjaková, 2023b). This is because green and sustainable practices are fundamental corporate values for a premium circular economy for modern companies.

1.7 Doctoral thesis outline

The thesis structure is presented in the ordinal chapters as follows:

Chapter 1 introduces the motivation, research statement, questions, and objectives, research design, summary of methodology, summary of research hypotheses and conceptual framework, and main findings.

Chapter 2 reviews previous related material and methods to conceptualize the study.

Chapter 3 develops the research approaches including qualitative and quantitative studies to propose the conceptual framework, hypotheses, and validate this model using PLS-SEM, as well as examine the impacts of the model in practical concerns in operations of 3 cases using CO and MCDM techniques.

Chapter 4 presents the discussion and contributions of the study on theoretical and practical implications.

Chapter 5 makes a conclusion, limitations, and future research.

2 LITERATURE REVIEW - CONCEPTS, DEFINITIONS, AND MATERIALS

2.1 Literature review process

To develop this part, I chose some keywords with search string as (“Circular Economy” OR “Closed-loop” OR “Circular Business Model” OR “Sustainability” OR “Knowledge-based Economy”) AND (“GLS” OR “Sustainable Supply Chain” OR “Green Logistics”) AND (“Combinatorial Optimization” OR “MCDM” OR “High-tech Application” OR “Industry 4.0”).

The Web of Science, Scopus and Google Scholar are used to select journals such as the Journal of Cleaner Production; International Journal of Production Research; International Journal of Production Economics; Computers and Operations Research; Computers and Industrial Engineering; Production and Operations Management; Annals of Operations Research; Journal of Business Research; Business Strategy and Development; European Journal of Operational Research; Journal of the Knowledge Economy; Resources, Conservation & Recycling; Ecological Economics, etc.

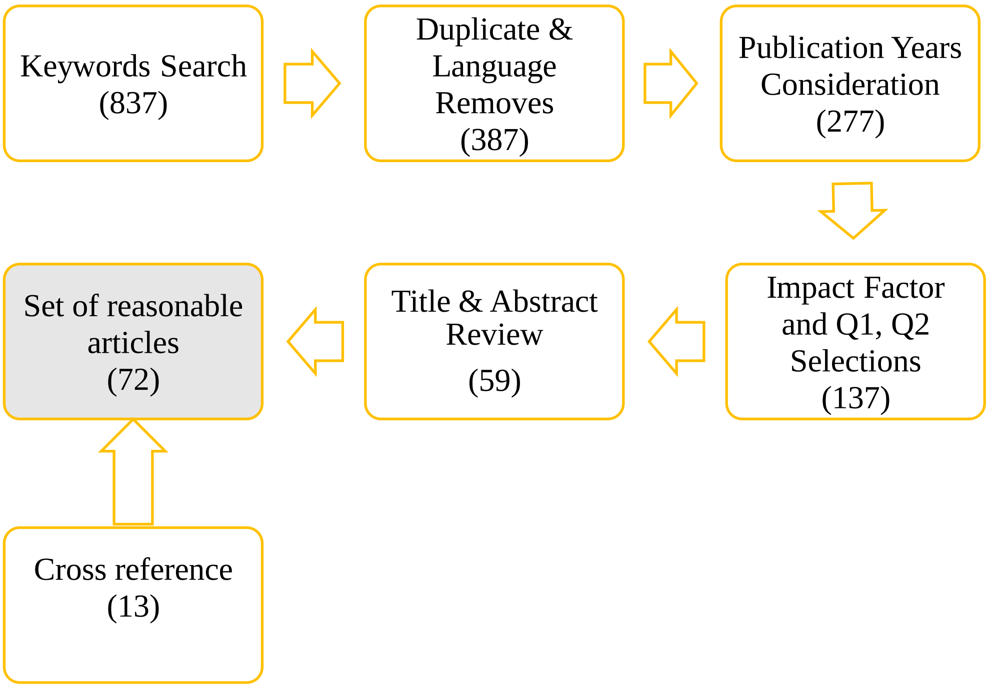


Figure 5: Systemic literature review process

Source: own research (Luu, 2022)

The keyword search led to a set of 837 articles, of which 450 were duplicated, and in other areas and languages, were removed. The screening process continued to be considered in publication years (2017-2023), its impact factor and belongs to the Q1 and Q2 journals that selected 137 papers out for a review on the title and abstract with 59 papers accepted. Besides, a set of 13 papers has been searched from cross-references. Finally, 72 papers have been selected and analyzed for this literature (Figure 5).

2.2 Theoretical background

Prior research focused on investigating the effects of CEs under high-tech applications on GLS, considering independent motives, external pressures, and internal resources (Agrawal et al., 2022; Dubey et al., 2019). However, the interplay between external pressures, internal resource development, and their adoption for enhancing environmentally friendly logistics and sustainable supply chain practices remains unclear in the context of CEs.

As defined in Figure 6, this study employs two primary theoretical perspectives: Policy Feedback theory (Pierson, 1993) and Resource-Based View (RBV) theory (Barney, 1991). The RBV elucidates how organizations attain a competitive advantage through strategic internal resources such as CEs and ID4.0

capabilities. Conversely, external pressure such as government policy (GOP) yields resources and incentives for organizational actors, operating in diverse ways that significantly impact government, enterprises, and communities (Luu, et al., 2023; Harland et al., 2019).

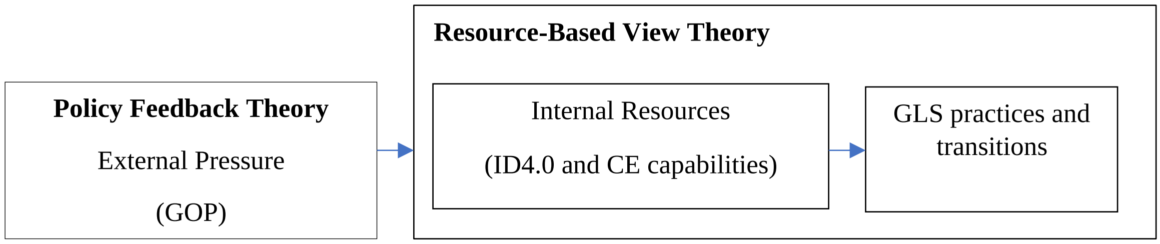


Figure 6: Theoretical framework
Source: adapted from Pierson (1993) and Barney (1991)

2.3 Related material

2.3.1 Industrial engineering & management

This section was detailed in the research papers Luu et al (2023), Luu (2022, 2021a, 2021b). In today's global economies incorporated with the industrial revolution 4.0, in which ID4.0 stems from technological advancements in production. The term 'ID4.0' has become a metaphor for tremendous change in the manufacturing sector and relates to the application of innovative technologies in enterprises.

According to Alkahtani et al. (2018), the current trends and advancements in industrial engineering include energy exhaustion minimization to reduce environmental impact by having a smarter design and techniques; cloud computing in smart products; robotics, and automation to lower cost without affecting quality. Furthermore, the subset of industrial engineering & management such as Production Management, Information Technology, Intelligent Systems, Optimization, Quality Management, Operations Research, Production Systems, and Supply Chain Management is getting a potential boost in the upcoming years. Those trends aim to create a greener living and reduce the environmental footprint to sustain not only manufacturing but also the global supply chain. In which, manufacturing and logistics are revolutionizing by providing the opportunity to utilize advanced technologies (Luu, 2022). Industrial engineering and logistics are key facilitators of global supply chain and production, which is highly associated with a nation's economic, industrial, and agricultural development (Luu, 2022). Supply chain management has become one of the primary key success factors in dealing with the increasing complexity of the current business environment.

2.3.2 Logistics and supply chain background

Logistics and Supply Chain was born nearly half a century and is gradually globalized. Logistics and supply chain management is a very broad field that many researchers had their eyes on with the unlimited definitions mentioned in many books and research, such as "*Supply chain management is primarily concerned with the efficient and effective integration of suppliers, manufacturers, distributors, and customers network by planning, organizing, directing, controlling, and managing flows of information, materials, and services so that merchandise is produced and distributed in the right quantities, to the right locations, at the right time, and to minimize total system costs subject to satisfying service requirements"* (Simchi-Levi et al., 2008).

Hugos (2018) mentioned the difference between the concept of logistics and supply chains, in which logistics typically refers to activities that occur within the boundaries of a single organization, and supply chains refer to networks of companies that work together and coordinate their actions to deliver a product to market.

Modern logistics and supply chain management is a demand for diversified and specialized industrial manufacturing, scattered global resources' availability, expanded consumer market, and sustainable requirements. From the first assembly lines to today's advanced robotic solutions, the supply chain process is constantly evolving, the newest trends in supply chain and logistics focus on a "green and sustainable" mindset by using smart, tech-based, and IT-based management to reduce operating cost, enhance efficiency and reduce environmental impact. The logistics and supply chain perspective are important for any business in terms of the supply of quality raw materials; efficient production process; and the reduce–reuse–recover finished goods (Luu, 2022).

Logistics and supply chain management is now one of the key success elements in dealing with the growing complexity of the present business environment in today's global economies merged with ID4.0 (Agrawal et al., 2022; Karaman et al., 2020; Khan & Zhang, 2021). The demand for varied and specialized industrial manufacturing, the accessibility of dispersed global resources, the increased consumer market, and sustainable criteria are all factors in the global logistics and supply chain (Luu, et al., 2023; Luu, 2022).

2.3.3 Distribution supply chain network, and warehouse management

The challenge of Supply Chain Network Design entails making a range of decisions aimed at efficiently delivering requested products to specific customers in a timely and cost-effective manner (Luu & Chromjaková, 2023a). These decisions include determining the optimal number, location, and capacity of facilities required within the network (Salehi Sadghiani et al., 2015). Effective control of supply and demand fluctuations in retail distribution supply chains is increasingly critical for the establishment of sustainable communities. Retailers play a pivotal role in determining the flow and pace of a distribution network, making them indispensable for community sustainability (Alikhani et al., 2019; Fernie and Sparks, 2014). Consequently, there is a growing need to comprehend the intricate process of designing a retail distribution supply chain network (Alikhani et al., 2021; Ning and You, 2018).

According to Hugos (2018), warehouses play a vital role in the supply chain alongside production, inventory, location, transportation, and information. Efficient warehouse management significantly impacts overall supply chain performance. While the primary purpose of a warehouse is to store goods until needed, it has evolved into a strategic asset that enhances competitiveness through value-added activities like packaging, labeling, and acting as distribution centers (Bottani et al., 2019). Therefore, optimizing warehouses is essential for effective logistics and supply chains, with researchers focusing on five key decision categories: warehouse size and layout design, equipment selection, operational strategy, storage assignment, and routing policies. Rouwenhorst et al (2000) further categorized warehouse perspectives into processes, resources, and organization, each with its own level of decision-making, making warehouse design, planning, and control complex tasks involving trade-offs and conflicting objectives.

2.3.4 Supply chain collaboration and configuration

The research argues that logistics and supply chain is a high-tech industry that influences the adoption of the circular economy, and examines more two independent variables such as supply chain configuration and collaboration within the supply chain network (Hussain & Malik, 2020). Depending on economic potential, the level of science and technology, and the national topography, each country determines its development strategy and selects the suitable model to achieve high market efficiency and effectiveness and provides convenience to social and environmental sustainability (Luu, 2022). Govindan & Hasanagic (2018) coined the term ‘industrial chains’ to emphasize the need for collaboration between several supply chains within a wider supply chain network that typically spans many industries (Luu, et al., 2023). Furthermore, while collaboration within the supply chain network aims to find potential for industrial symbioses, most existing supply chain configurations must be modified to facilitate sharing with the same supply chain. The inherent flexibility of existing supply chain structures to introduce and extend the reverse product flow to the larger supply chain network is a key component of supply chain design that allows the transition to GLS (Hussain & Malik, 2020; Tura et al., 2019; De Angelis et al., 2018; Govindan & Hasanagic, 2018).

2.3.5 Industry 4.0 and circular economy background

A CE was created because of social innovation that is focused on consumption, as opposed to technology innovation that was production-focused and led to ID4.0. Business models and strategies are cross-cutting and influential (Cagáňová, et al., 2020). It is also referred to as the fourth industrial revolution, industry digitalization and automation, and the use of cutting-edge technologies like IoT and smart things, which have an impact on every aspect of corporate operations.

The CE idea attracted a lot of attention in the 1960s. Preston (2012) claimed that industrial ecology, which was first developed in the 1970s, is the root of CE today (Luu, 2022). Since, numerous studies have attempted to define the concept of circular economy. For instance, Kirchherr et al (2017) defined CE as "*A circular economy describes an economic system that is based on business models which replace the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/ distribution and consumption processes, thus operating at the micro level (products, companies, consumers), meso level (eco-industrial parks) and macro level (city, region, nation and beyond), with the aim to accomplish sustainable development, which implies creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations*" (Kirchherr et al., 2017). Recently, Figge et al (2023) proposed good definition of the CE that included four conditions of (*a*) refer to closing resource loops, (*b*) mention optimizing rather than minimizing resource flows, (*c*) consider at least two levels, and (*d*) distinguish between the CE as a perfect ideal type and a realistic imperfect CE that delivers sustainability in combination with other approaches. The definition states that "*The circular economy is a multi-level resource use system that stipulates the complete closure of all resource loops. Recycling and other means that optimise the scale and direction of resource flows, contribute to the circular economy as supporting practices and activities. In its conceptual perfect form, all resource loops will be fully closed. In its realistic imperfect form, some use of virgin resources is inevitable*" (Figge et al., 2023).

The circular economy as an approach to face environmental challenges and secure sustainable development is gaining increasing attention after 2014 when the World Economic Forum (WEF) in Davos presented the report 'Toward a Circular Economy' prepared by WEF, Ellen MacArthur Foundation, and McKinsey & Company. The circular economy was presented as an industrial system with benefits operational as well as strategic, on both a micro and macroeconomic level. This is a trillion-dollar opportunity with great potential for innovation, job creation, and economic growth (WEF, Ellen McArthur Foundation, and McKinsey & Company, 2014). One of the key elements of the development of a CE is the ID4.0 program. Kumar *et al* (2021) identified the major criteria for sustainable operations and barriers that need to be overcome to achieve the objectives of sustainability. It develops an effective and integrated strategic approach that will foster sustainable operations through the utilization of improved knowledge of ID4.0 and CE. Technological and social advancements have always been closely related. There is no doubt that ID4.0 influences contemporary society.

2.3.6 Knowledge management, and knowledge economy

Dalkir (2017) identified more than 100 published definitions of knowledge. An acceptable description is that fundamental knowledge is human understanding acquired through perception, learning, and observation. Knowledge is intangible and more complex than data or information and constitutes an organizational resource among people such as information, reputation, intellectual capital, customer relationships, the diversity and talent of staff, the ability to work safely and sustainably, and, newly, knowledge (Milton & Lambe, 2020).

Knowledge management defined as the intentional and methodical coordination of an organization to generate value through reuse and innovation. This is achieved by encouraging the creation, sharing, and use of information, as well as the transmission of important lessons learned, and best practices into corporate memory to support ongoing organizational learning. There, four factors referred to as ‘knowledge enablers’ included *a*) peoples, *b*) processes, *c*) technologies, and *d*) governance (Dalkir, 2017).

Knowledge-based economy (KE) is more than just a novel theoretical notion since it also represents a new age that differs significantly from agrarian and industrial societies. Several definitions have been proposed and fine-tuned over the years by international organizations (APEC, 2000; World Bank, 1999). Typically, the Organization for Economic Cooperation and Development (OECD, 2001) stated that it succinctly as an economy based directly on the creation, distribution, and application of knowledge and information. It has already exerted an impact on and caused a change in all areas of economic and social life, and its influence is spreading

2.3.7 Sustainability, KE and CE for green logistics & sustainable supply chain

Sustainability has relationship with CE based on the dependence between economic, social, and environmental goals but may undertake by different approaches and methodologies (Geissdoerfer et al., 2017; Moreno et al., 2016). The main difference between CE and sustainability is that sustainability may focus more on integrating the economy, society, and environment presenting the three as an equal factor. While CE focuses more on economic priorities which bring economic benefits to society and the environment and can be seen as a more business-centric approach (Luu, 2022).

There are many studies on CE, ID4.0, KE for green logistics and sustainable supply chains (Luu, et al., 2023; Luu, 2022; Patwa et al., 2021; Morseletto, 2020; Korhonen et al., 2018; Brandenburg et al., 2014). Moreover, Geissdoerfer et al (2017) provided conceptual clarity by distinguishing the terms and synthesizing the different types of relationships between CE and sustainability. Govindan and Hasanagic (2018) analyzed the drivers, barriers, and practices that influence the implementation of the CE in the context of supply chains. Seroka-Stolka and Ociepa-Kubicka (2019) presented CE development of green logistics practices on the example of sludge management. Hazen et al (2020) discussed how supply chain processes can support the successful implementation of CE. Yadav et al (2020) developed a framework to overcome sustainable SCM challenges through ID4.0 and CE-based solution measures. Bag and Pretorius (2020) proposed a research framework by integrating three contemporary concepts of ID4.0, sustainable manufacturing, and CE in the context of supply chain management. Del Giudice et al (2020) analyzed the effect of CE practices on firm performance for a circular supply chain and explores the moderating role that a big-data-driven supply chain plays within these relationships (Luu, 2022). Besides, Hussain and Malik (2020) identified the organizational enablers of circular supply chains and its process facilitators of collaboration and configurations, and their relationships with the environmental performance of supply chains.

Additional, numerous scholars (Širá et al., 2020; Sundać & Krmpotić, 2011) were involved in the creation of the KE for sustainable development. The document subsequently published details the modification of four indices of the KE such as economic incentives (regulatory quality, tariff/nontariff barriers), education & human resources (secondary/tertiary levels), innovation (number of patents, innovative solutions), and investment indices (R&D expenditure). Furthermore, Song et al (2022) found that technological innovation, a crucial notion of knowledge, is a buffer between high-tech applications and green and sustainable transformation. Summarizing the above analysis, it seeks KE prerequisites that enhance the transformative potential of CE adoption in mindset and practices for sustainable development (Zwiers et al., 2020).

2.3.8 Government policy, CE business model and framework

This part investigates the adoption of CE principles in terms of government policy, CE framework and business model (Luu, et al., 2023).

In terms of government policy, adoption of CE is heavily influenced by policies and legislations as noted by Kazancoglu et al (2021), Patwa et al (2021), and Govindan and Hasanagic (2018). These policies can take the form of regulations or initiatives aimed at promoting new approaches. Many countries have implemented legislation that encourages cleaner production and consumption systems, particularly in developing nations where such measures are mandatory. There is a need to enable and influence the growth of CE in emerging economies (Luu, 2022; Patwa et al., 2021). According to Govindan & Hasanagic (2018), stakeholders' awareness of political policies plays a significant role in driving CE adoption in supply chains. Kazancoglu et al (2021) identified various obstacles to implementation, including legal gaps in CE frameworks, inadequate regulation of circular economy suppliers, and a lack of governmental support for environmentally friendly initiatives (Luu, et al., 2023). Therefore, GOP plays a crucial role in facilitating the transition to a circular economy.

In terms of CE framework, many prior studies investigated on that based on the number of strategies used (Luu, 2021a; Patwa et al., 2021; Morseletto, 2020; Jabbour et al., 2019; Lopes de Sousa Jabbour et al., 2018; Kirchherr et al., 2017; Lewandowski, 2016; Moreno et al., 2016). Such as 3R (i.e., reduce, reuse, and recycle), 4R, 5R, 6R, 10R, ReSOLVE, and especially a modified 3R1O (Vinamilk, 2020), etc. For instance, Morseletto (2020) investigated what targets may facilitate the transition toward a CE, based on the 10R framework, specifically including recover, recycle, repurpose, remanufacture, refurbish, repair, reuse, reduce, rethink, and refuse strategies.

In terms of business model, even though CE business models are still in their infancy (Lüdeke-Freund et al., 2019), their practical and academic importance has prompted a surge in the number of research published on them recently. Models and typologies of circular business models (Lüdeke-Freund et al., 2019; Nußholz, 2017; Urbinati et al., 2017; Lewandowski, 2016; Rizos et al., 2016) are examples of conceptual advancements. Ferasso et al (2020) investigated how the circular economy and business models are related in the current business and management literature. The major findings highlighted the networks of current issues including business models, the circular economy, circular business models, value, supply chain, transition, resource, waste, and reuse, as well as the most common linkages between them. Centobelli et al (2020) presented a comprehensive survey of the literature on business model design in the context of the circular economy. The first findings of the research give a conceptual framework for strategic management researchers, emphasizing the importance of issues in business models for the transition to a circular economy. In addition, allows for the understanding of developing trends, and the provision of elements to inspire future academic studies, managerial actions, and policymaker activities.

2.4 Related methods – models and algorithms

This part glans over some research methods that were developed for the CE adoption in GLS operations. Most supply chain management research has focused on the assumption of linear relationships between node buyers and suppliers.

However, these supply chains are no longer linear systems but are characterized by network structures with autonomous and heterogeneous members. The following section speaks of the development of advanced mathematical modelling approaches to tackle complex global supply chain network challenges. Mathematical modeling approaches that are usually considered in supply chain problems include linear programming, mixed-integer/ integer linear programming, nonlinear programming, multi-objective programming, fuzzy mathematical programming, stochastic programming, heuristic/metaheuristic algorithms, and hybrid models in several key research areas as supply chain network design, strategic alliance, logistics management, warehouse management, supply chain contracts, production planning and scheduling.

Since combinatorial and multi-objective optimization were introduced, both mathematical programming and heuristic approach were proposed to deal with this kind of problem. An application of multi-objective mixed-integer programming is in a multi-section Operating Theatre Facility Layout (Chraibi et al., 2014), while Alperen Bal & Badurdeen (2020) also presented an MCDM framework for the facility location problem integrating the proposed CE business models. Recently years, Khan et al (2021) investigated the present and emerging trends in the field of sustainable supply chain management that are dominated by MCDM-based research methods (Luu, 2022). Yamchi et al (2020) developed a multi-objective linear mathematical model for a sustainable closed-loop agricultural supply chain with a deteriorating product to determine the optimal flow to every echelon and the optimal location of some facilities to achieve three objectives: reducing costs and carbon dioxide emissions throughout the proposed supply chain network and increasing the responsiveness.

But if the business needs a reasonably good solution in a short amount of time, which is often the case in real-time operational settings, then a heuristic solution may be the better choice. Feizollahi et al (2021) developed a new mathematical model for closed-loop supply chain networks. According to the NP-hard, an efficient algorithm was suggested based on the genetic meta-heuristic algorithm. Kazancoglu et al (2021) proposed a framework highlighting policy-related barriers for a supply chain in the transition to CE and finally discuss potential implications for enhancing the corporate environmental performance of a business.

Concerning high-tech applications, Sharma et al (2020) presented a systematic review of machine learning applications in agricultural supply chains. Blockchain technology is also widely used. For example, Kouhizadeh et al (2020) examined how blockchain technology is likely to transform and advance CE realization. Using grounded theory building from multiple case studies, the research presents early evidence linking the blockchain application to circular economy dimensions of ReSOLVE model, while Saberi et al (2019) argued that blockchain technology and smart contracts are critically examined with potential application to supply chain management. Local and global government, community, and consumer pressures to meet sustainability goals prompt us to further investigate how blockchain can address and aid supply chain sustainability. Jabbour et al (2019) made the case for the integration of the CE and large-scale data, also known as big data (Luu, 2022).

3 RESEARCH APPROACHES

3.1 QUALITATIVE STUDY 1 – Framework, and hypotheses development

3.1.1 Research design

Research overview

As per the light of real-world cases and previous studies in the Literature Review, the conceptual framework in Figure 3*b* is developed, the research focuses on 7 constructs of high-tech applications (ID4.0), government policy, SC collaboration, SC configuration, GLS, CE framework, and CE adoption. This qualitative study aims to use grounded documentary to investigate these 7 constructs and associated indicators for hypotheses development and its measurement. Based on the conclusions on the relevant hypotheses and associated variables, research questionnaires were drafted, and formulated the scientific conclusions.

ID4.0 and CEA

This section was detailed in the research papers Luu et al (2023) and Luu (2021a, 2021b) . CEs and ID4.0 are emerging concepts of interest to academics and practitioners (Kirchherr et al., 2017). While ID4.0 stems from technological advancements in production, CEs originate from social innovations pertaining to consumption. Various approaches exist that influence business models and strategies (Cagáňová, Chromjaková, & Sujanová, 2020).

The ID 4.0 concept was introduced in 2011 by the German government as a high-tech application and strategy for 2020. It can be defined as ‘real-time, intelligent and digital networking of people, equipment, and objects for the management of business processes and value-creating networks’ (Agrawal et al., 2022; Dombrowski et al., 2017). The ID4.0, the fourth industrial revolution, has become a metaphor for tremendous change in the manufacturing sector using Information and Communication Technologies (ICT), and relates to the application of innovative technologies, e.g., smart objects, IoT, AI, etc., in commercial enterprises (Luu, et al., 2023; Culot et al., 2020).

Preston (2012) claimed that contemporary CEs originated from industrial ecology, a concept devised in the 1970s. The topic was discussed at the 2014 World Economic Forum (WEF), where a report entitled ‘Toward a Circular

Economy' was presented by the WEF, Ellen MacArthur Foundation, and McKinsey & Company. It was described as an industrial system with operational and strategic benefits at micro- and macro-economic levels, constituting a trillion-dollar opportunity with great potential for innovation, job creation, and economic growth (WEF, Elle MacArthur Foundation, and Mckinsey & Co, 2014). ID4.0 has clearly altered modern society, influencing it through inextricable links that exist between social and technological advances. Performing CE practices by cutting-edge, digital technologies is a core, beneficial aspect of ID4.0 (Shayganmehr et al., 2021). The latter affords numerous opportunities for businesses; it enhances their circular performance, and is defined as a powerful strategic instrument for CEA that optimizes the utilization of resources (Rosa et al., 2020). The initiative of ID4.0 constitutes a major component of CEA for GLS transitions, as confirmed by statistical analysis of the following hypothesis:

Hypothesis 1a. High-tech Application positively impacts the Circular Economy Adoption.

The ID4.0 construct is measured herein by three observed variables, as follows (Luu, et al., 2023):

- ID401: The number of high-tech applications at the organization. Analysis of big data, IoT, AI, and blockchains are widely applied to boost business performance and sustainability (Rajput & Singh, 2022; Choi, 2021; Kouhizadeh, Zhu, and Sarkis, 2020; Dubey et al., 2019; Manavalan and Jayakrishna, 2019). Saberi et al. (2019) investigated how implementing a blockchain could address and aid SC sustainability, while Del Giudice et al. (2020) discovered that a big-data-driven SC would moderate interconnections between CE-HR management and company performance (Luu, et al., 2023).
- ID402: The number of digital processes applied in operations, such as MRPII/ERP, EOQ, and machine learning. For example, Sharma et al. (2020) reported on machine learning within an agricultural SC, Angolia and Pagliari (2018) wrote about using a commercial software application like SAP ERP for SC management (Luu, et al., 2023).
- ID403: The model and its algorithms -the number of relevant variables integrated into the given model. Optimization models, heuristic algorithms, and other components enhance business performance within such an arrangement. Mathematical techniques, e.g., linear, nonlinear, integer linear, and fuzzy programming, tackle complex, global, SC-management-related matters; indeed, MCDM was introduced for this express purpose (Khan et al., 2021). In this respect, heuristic algorithms represent good options for enterprises, e.g., a genetic algorithm, ANN, or the fuzzy method (Luu, et al., 2023; Feizollahi et al., 2021; Kazancoglu et al., 2021).

CEA and GLS

Several researchers have investigated CEs, such as Morseletto (2020), who examined which targets facilitated a transition toward its implementation. Patwa et al. (2021) presented an empirically validated CEA model in emerging economies (Luu, 2022).

Numerous studies have been published on CEA with a view to logistics and SCs (Luu, et al., 2023). Govindan & Hasanagic (2018) analyzed drivers, barriers, and practices that influenced CE implementation in the context of SCs. Hussain & Malik (2020) found that a proposed framework emphasized the joint effects of organizational actors and process facilitators, including SC collaboration and configuration which enabled circular SCs. Hazen et al. (2020) discussed how SC processes aided successful implementation of CEs. Kumar et al. (2021) discerned that insufficient funding for ID4.0 initiatives and inefficient strategies for integrating ID4.0 with environmental measures formed two principal barriers to achieving sustainability objectives. Incorporating ID4.0 and CEA, logistics and SC management has proven decisive in successfully navigating the highly complex contemporary business environment. Global logistics and SC are essential in diverse and specialized sectors, where a balance must be struck between the availability of resources world-wide, the growing consumer market, and the requirement to be green and sustainable. This has led to a rise in the extent of GLS transition that are developed in tandem with CEA (Luu, et al., 2023). Hypotheses below was derived from these findings:

Hypothesis 1b. Circular Economy Adoption mediates the relationship between Hight-tech Application and Green Logistics and Sustainable Supply Chain transitions.

Hypothesis 2. Circular Economy Adoption positively affects Green Logistics and Sustainable Supply Chain transitions.

Research indicates that CEA reflects the understanding and attitude of management and staff at an organization to a CE during a transition to GLS, through the variables observed below (Luu, et al., 2023):

- CEA1: CE insights. A better understanding of CE concepts is gained when transitioning to GLS by employees mutually knowledgeable about CE concepts and insights (Luu, et al., 2023; Hussain & Malik, 2020; Batista et al., 2018).
- CEA2: Awareness of sustainability. A shift to GLS is made possible when staff have a good understanding of what constitutes sustainability (Luu, et al., 2023; Tura et al., 2019).
- CEA3: Awareness of the economic possibilities of CE. Implementing GLS is enabled by comprehension of the potential of a CE to bring about gain in revenue and cut costs (Luu, et al., 2023; Rehman Khan et al., 2022; Bressanelli et al., 2019; Tura et al., 2019).

- CEA4: Capacity of CE to improve environmental conditions. A transition to GLS is facilitated if staff are aware of the capacity of a CE to reduce CO2 and the utilization of hazardous materials (Luu, et al., 2023; Rehman Khan et al., 2022; Hussain & Malik, 2020).
- CEA5: Benefits of CE to society. Employees should be aware of the potential of a CE to cut unemployment rates and diminish the impact of COVID-19, which aid a transition to GLS (Luu, et al., 2023; Hussain & Malik, 2020).

There is a need to encourage the spread of CEs (Luu, et al., 2023; Luu, 2021a; Patwa et al., 2021). Besides high-tech applications, Luu et al (2023) investigated the adoption of CE principles that could be applied in Vietnam in governmental policies (GOP), and CE frameworks (CEF). The article summarized several CEFs, arranged according to the number of R strategies involved. Kirchherr et al. (2017) found that a CE was typically considered a combination of the 3Rs, yet a systemic transformation was actually required. Morseletto (2020) stated, in the context of the 10Rs, that widespread strategies for recovery and recycling did not always lend themselves to CE support, with others promoting more potent CE frameworks instead. Various CEF and GOP were studied herein to discern the level of understanding and practices in a strategic CEA design. As a result of these exchanges, the following hypotheses were established:

Hypothesis 3. Circular Economy Framework positively impacts the Circular Economy Adoption.

Hypothesis 4. Government policy positively affects the Circular Economy Adoption.

Research thoroughly investigated indicators of CEF-related factors, as follows (Luu, et al., 2023):

- CEF1: Design strategies. Designs should encompass a ‘system change’ if a circular design policy is being considered, e.g., an ‘R’ strategy (Luu, et al., 2023; Patwa et al., 2021; Kirchherr et al., 2017; Ellen MacArthur Foundation, 2013).
- CEF2: Design principles. Basic principles shape the design: utilization of waste, construction allows for reuse, sustainability enabled by diversity, energy drawn from renewable sources, etc., (Luu, et al., 2023; Ellen MacArthur Foundation, 2013).
- CEF3: A systematic concept. Comprehension is required of how components mutually interact, in addition to relationships between the whole and its parts. A systematic approach emphasizes flow and connections over time, and has the potential to deal with regenerative situations (Luu, et al., 2023; Ellen MacArthur Foundation, 2013).

- CEF4: Various participants. Different participants should be considered in the value chain, in consideration of the needs and opinions of internal and external customers (Luu, et al., 2023; Ellen MacArthur Foundation, 2013).
- CEF5: Construction of design by experienced people (Luu, et al., 2023; Ellen MacArthur Foundation, 2013).

CEA is greatly influenced by GOP (Kazancoglu et al., 2021; Patwa et al., 2021; Govindan & Hasanagic, 2018). It is sometimes aided by enforcing regulations or promoting new approaches. Several countries have enacted legislation that encourages cleaner methods of production and consumption systems, serving as mandatory drivers in developing nations. Govindan & Hasanagic (2018) found that awareness of political policies by stakeholders highly encouraged CEA in SCs. Kazancoglu et al. (2021) discovered obstacles to implementation comprised gaps in law on CEs, insufficient regulation of CE suppliers and obligation on their part, and a lack of governmental support for environmentally friendly initiatives (Luu, et al., 2023). Hence, GOP plays a crucial role in the transition to a CE in relation to the variables outlined below (Patwa et al., 2021).

- GOP1: Legislation, i.e., appropriate regulations, laws, and policy-related barriers for GLS operations in a CE context. A strong regulatory framework and such strategies help create an ecosystem in which businesses cooperate, form partnerships, and promote sustainability (Luu, et al., 2023; Harland et al., 2019; Zhang et al., 2019).
- GOP2: Capacity building. In relation to CEs, GOPs reinforce the development of GLS capacity. Governments initiate capacity-building programs that encourage communities to join forces and engage in activities to engender a sustainable society. Capacity building is required for proper educational outreach (Luu, et al., 2023; Patwa et al., 2021; Gupta & Koontz, 2019).
- GOP3: Educational strategy, i.e., education and training to develop thinking, and reinforce green and sustainable practices. Such endeavor relates to knowledge, and informs attitudes toward sustainability and compliance with regulations (Luu, et al., 2023; Patwa et al., 2021).
- GOP4: Urban planning, i.e., a synchronous infrastructure for GLS in a CE context. Urban planning is critical to addressing the problems faced by emerging countries of rapid economic and demographic growth, and the desire to live sustainably (Luu, et al., 2023; Ahluwalia, 2019).

SC Configuration and Collaboration

GLS-orientated operations constitute key factors for enhancing performance in green and sustainable development (Chhabra & Kr Singh, 2022; Ghadimi et al., 2019; Tseng et al., 2019; Antheaume et al., 2018). Depending on the given economic potential and level of advancement in science and technology, each nation determines its own strategy for such improvement. Selection is made of a model deemed suitable for superior market-related efficiency and effectiveness; one which expedites social and environmental sustainability. Govindan & Hasanagic (2018) coined the phrase 'industrial chain' to emphasize the need for collaboration between SCs (COL) within a primary SC network that typically spans multiple business sectors. While COL seeks out potential means for industrial symbiosis, most pre-existing SC configurations (CON) have to be modified to enable sharing with the overarching SC (Antheaume et al., 2018; Swami & Shah, 2013). The inherent flexibility of lesser SC structures already in place for introducing and extending reverse product flow into the primary SC network represents a core component of design that facilitates a transition to GLS. Investigation consequently encompassed another two independent GLS variables, specifically COL and CON (Luu, et al., 2023; Hussain & Malik, 2020; Tseng et al., 2019). Hypotheses were constructed as follows:

Hypothesis 5. Collaboration of supply chain segments positive impact on Green Logistics and Sustainable Supply Chain networks.

Hypothesis 6. Configuration of supply chain segments positively impact on Green Logistics and Sustainable Supply Chain networks.

In order to elucidate corresponding relationships in the framework, research was conducted on several variables of COL and CON, respectively (Luu, et al., 2023; Hussain and Malik, 2020).

- COL1: Collaboration with SC partners. Such cooperation inside and beyond industrial boundaries facilitates GLS (Luu, et al., 2023; Govindan and Hasanagic, 2018).
- COL2: SC responsibility. GLS is made possible by an SC-wide responsibility for implementing CE guidelines (Luu, et al., 2023; Hussain and Malik, 2020).
- COL3: Data sharing. GLS is enabled through superior data sharing and the presence of supportive technology (Luu, et al., 2023; Bressanelli et al., 2019; Tura et al., 2019).
- CON1: Similarity in operational practices. Commonality in operational and logistic procedures in an SC aids implementation of GLS (Luu, et al., 2023; Hussain & Malik, 2020).
- CON2: SC restructuring. Restructuring SCs eases the transition to GLS, including managing end-of-life returns or waste generated during manufacture (Luu, et al., 2023; Howard et al., 2019; Tura et al., 2019).
- CON3: SC structural flexibility. Heightening the structural flexibility of an SC, eliminating 'linear lock-in', and lifting geographical restrictions all contribute to accomplishing GLS (Luu, et al., 2023; De Angelis et al., 2018).

Finally, analysis covered nine variables for GLS operations influenced by CE practices (Luu, et al., 2023).

- GLS1: Compliance with environmental regulations. GLS operations are conducted under applicable environmental laws and regulations, as a consequence of CE implementation (Luu, et al., 2023; Hussain & Malik, 2020).
- GLS2: Reduction in energy consumption. GLS cuts energy consumption through the actions of CE practices (Luu, et al., 2023; Hussain & Malik, 2020).
- GLS3: Reduction in hazardous materials. Efforts to achieve GLS by adopting CE strategies lead to reduction in the use of hazardous materials (Luu, et al., 2023; Hussain & Malik, 2020).
- GLS4: Green IT. GLS operations enhance green IT and communication, enabled by implemented CE practices (Luu, et al., 2023; Mardani et al., 2020).
- GLS5: Green transportation. GLS operations bolster green forms of transportation via adopted CE practices (Luu, et al., 2023; Mardani et al., 2020).
- GLS6: Green manufacturing. GLS operations reinforce environmentally-friendly manufacturing techniques, through the adoption of CE methods (Luu, et al., 2023; Mardani et al., 2020).
- GLS7: Green storage. GLS operations underline efforts to use eco-friendly storage and packaging solutions through the adoption of CE practices (Luu, et al., 2023; Mardani et al., 2020).
- GLS8: Green procurement. GLS operations aid green procurement, enabled by CE practices (Luu, et al., 2023; Mardani et al., 2020).
- GLS9: Reverse logistics. GLS operations improve reverse logistics, as facilitated by CE strategies (Luu, et al., 2023; Rajput & Singh, 2022; Mardani et al., 2020).

3.1.2 Research framework and hypotheses development

Based on the theoretical framework in Figure 6 and the above discussion, the conceptual frameworks are depicted in Figure 7.

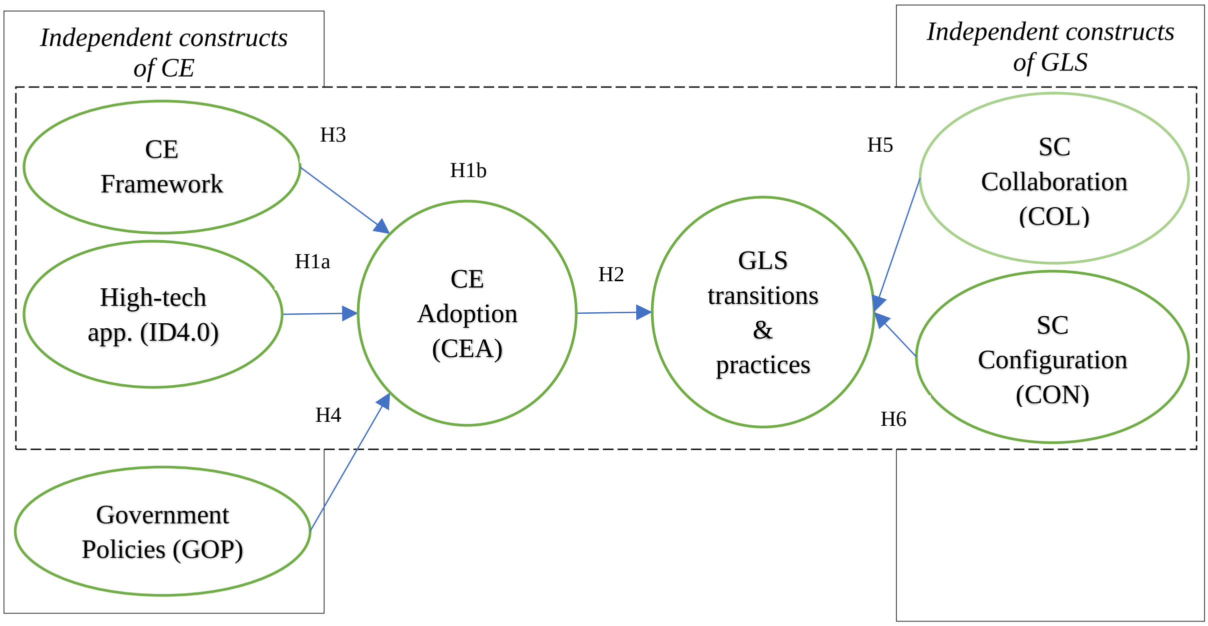


Figure 7: Proposed conceptual research framework
Source: own research

Summary of the associated hypotheses

Table 4 summarizes the proposed hypotheses both indirect and direct forming from the investigation.

Table 4: Summary of proposed hypotheses

Hypotheses		
H1	*a. Direct effect*	*ID4.0 positively impacts CEA.*
	b. Indirect effect	*CEA mediates the relationship between ID4.0 and GLS.*
H2	*Direct effects*	*CEA positively affects GLS.*
H3		*CEF positively impacts the CEA.*
H4		*GOP positively affects the CEA.*
H5		*SC collaboration (COL) positive impact on GLS networks.*
H6		*SC configuration (CON) positively impact on GLS networks.*

Source: own research

3.1.3 Measurement development

In the light of previous sections, the study examines 7 constructs with 32 observed indicators. Detailed constructs and variables are explained in Table 5 that are used to design the draft questionnaire and in-depth interview protocol for the next qualitative study. All indicators are measured on a five-point Likert scale.

Table 5: Measurement of the constructs

Constructs	**Variables Measurement**	**Source**
1. Supply chain Collaboration (COL) measures the role of collaboration within the supply chain network in the adoption of CE.	(COL1) GLS are enabled by collaboration with supply chain partners within and beyond the immediate industrial boundaries. (COL2) GLS is enabled by a supply chain-wide responsibility for implementing CE principles. (COL3) GLS is enabled by enhanced information sharing and technological support within the value chain.	Luu, et al., 2023; Hussain & Malik, 2020; Govindan and Hasanagic 2018; De Angelis et al. 2018; Hasanagic 2018; Herczeg et al., 2018; Tura et al. 2019; Bressanelli et al. 2018
2. Supply chain Configuration (CON) measures the role of supply chain configuration in the SC networks in the adoption of CE.	(CON1) GLS are enabled by the application of similar operational and logistical practices across the supply chain network. (CON2) GLS are enabled by supply chain restructuring to include processes for end-of-life returns, managing the byproducts and waste produced during the production process. (CON3) GLS is enabled by a greater supply chain structural flexibility that breaks the 'linear lock-in' and geographical barriers.	Luu, et al., 2023; Hussain & Malik, 2020; Ritzen and Sandstrom 2017; Bressanelli et al. 2018; Batista et al. 2018; Mohamed Sultan and Mativenga 2019; De Angelis et al. 2018; Prendeville et al. 2016; Srai et al. 2016
3. Green Logistics and Sustainable Supply Chain (GLS) measure representing the effect of the adoption of circular economy on the operations of GLS	(GLS1) The operations of the GLS in compliance with the applicable environmental laws and regulations by the adoption of circular economy practices. (GLS2) The operations of the GLS in reducing energy consumption by the adoption of circular economy practices. (GLS3) The operations of the GLS in reducing the usage of hazardous/ toxic material by the adoption of circular economy practices.	Luu, et al., 2023; Hussain & Malik, 2020; Torasa & Mekhum, 2020; Mardani et al., 2020

	(GLS4) The operations of the GLS in enhancing green information technology and communication by the adoption of circular economy practices. (GLS5) The operations of the GLS in enhancing green transportation by the adoption of circular economy practices. (GLS6) The operations of the GLS in enhancing green manufacturing by the adoption of circular economy practices. (GLS7) The operations of the GLS in enhancing green storage and packaging by the adoption of circular economy practices. (GLS8) The operations of the GLS in enhancing green procurement by the adoption of circular economy practices. (GLS9) The operations of the GLS in enhancing the reverse logistics and renewable material by the adoption of circular economy practices.	
4. Circular Economy Adoption (CEA) measures the understanding and attitude of organizational actors towards CE for GLS transitions.	(CEA1) Understanding of circular economy insights. 'A mutual understanding of CE principles and insights by management and employees enables a transition to GLS'. (CEA2) Sustainability awareness. 'A general awareness of sustainability by management and employees enables a transition to GLS. (CEA3) Awareness of CE's potential for economic performance such as revenue gains and cost saving. 'An awareness of CE's potential for revenue gains and cost saving by management and employees enables a transition to GLS'.	Luu, et al., 2023; Hussain & Malik, 2020; Hazen et al., 2020; Geissdoerfer et al., 2017; Govindan & Hasanagic, 2018; Feizollahi et al., 2021

	(CEA4) Awareness of CE's potential for environmental performance such as reduction of CO_2 emission and hazardous materials. 'An awareness of CE's potential for a reduction on CO_2 and hazardous materials by the management and employees enables a transition to GLS'. (CEA5) Awareness of CE's potential for social performance such as reduction in the unemployment rate and covid-19 effects. 'An awareness of CE's potential for a reduction on the unemployment rate and covid-19 effects by the management and employees enables a transition to GLS'.	
5. Circular Economy Frameworks (CEF) measure the understanding and practices of CE strategic designs.	(CEF1) Design for 'systems change' when considering any circular design strategy such as the framework of various Rs strategies, for example, the 3R (reduce-reuse-recycle)/ 4R/ 10R/ ReSOLVE/ other CE strategies. (CEF2) Design follows the basic principles, such as Designing out waste (reduce)/Designing for reuse (reuse)/Building resilience through diversity (recycle)/Relying on energy from renewable sources (recovery)/ Think in systems. (CEF3) Design by systematic thinking for optimization. (CEF4) Design with different participants in the value chain. (CEF5) Design with 'hands-on' experiences.	Luu, et al., 2023; Macarthur, 2020; Moreno et al., 2016; Lewandowski, 2016; Kirchherr et al., 2017; Patwa et al., 2021; Morseletto, 2020; Lopes de Sousa Jabbour et al., 2018; Jabbour et al., 2019; Vinamilk, 2019
6. High-tech application measures the awareness and level of industry 4.0 technologies	(ID401) High-tech application is one of the fundamental values in the organization. a. Big data and information flow: The Internet of Things (IoT), Cloud computing, Data-driven	Lopes de Sousa Jabbour et al., 2018; Jabbour et al., 2019; Dubey et al., 2019; Manavalan and

(ID4.0) in the organization.	analytics, Artificial Intelligence (AI), and robot applications. b. Blockchain technologies (ID402) Level of modern systems applied in the operations, such as MRP/MRPII/ERP, machine learning, etc. (ID403) Level of model and algorithms applied in the systems: optimization models/ heuristic/ meta-heuristic algorithms, and/or continuous improvement projects deployment, etc.	Jayakrishna, 2019; Saberi et al., 2019; Bag and Pretorius, 2020; Del Giudice et al., 2020; Kouhizadeh, Zhu, and Sarkis, 2020; Patwa et al., 2021; Tan et al., 2020; Kumar, Singh, and Kumar, 2021; Sharma et al., 2020;
7. Government policies (GOP).	(GOP1) Appropriate level of legislation, regulation, and standards development as well as policy-related barriers for GLS in the CE context. (GOP2) Government policies promote capacity building for GLS in the context of CE. (GOP3) Plan of education and training to support and facilitate thinking, behaviour, and operations of organizations in a green and sustainable mindset. (GOP4) Urban planning: construction of synchronous infrastructure for GLS in the context of CE.	Luu, et al., 2023; Kazancoglu et al., 2021; Nguyen & Pham, 2020; Patwa et al., 2021

Source: own processing

3.2 QUALITATIVE STUDY 2 – Verification for the circular economy model in green logistics and sustainable supply chains

3.2.1 Research design for data collection and analysis

Research overview

In this thesis, another qualitative technique such as an interview is employed due to its potential for efficient theory development. The previous study has identified the transitions of Green Logistics and Sustainable Supply Chains in the Circular Economy context under the impacts of 7 constructs and their 32 variables. But in the beginning stage, it has no data to provide comprehensive insights into the specific CE and GLS practices. Furthermore, given the limitations of GLS studies in both industry and academia, particularly in developing countries, a qualitative study is adopted to gain a deeper understanding of the complexities (Saunders *et al*., 2019; Saunders et al., 2009) associated with adopting CE for GLS transitions.

The qualitative method is also employed to comprehend the process (Corley and Gioia, 2004) and establish causal relationships (Eisenhardt & Graebner, 2007), for example the connection between GLS practices and CE, etc., as well as offer an original stepwise approach for the research analysis (Batista et al., 2021). According to Saunders et al (2009), researchers should conduct semi-structured and in-depth interviews to compare data from published studies with principles guiding the research herein and real-world circumstances (Luu, et al., 2023). By understanding the adoption CE in GLS, it becomes possible to assess appropriate variables and constructs in the conceptual model as well as finalize questionnaires for data collection in a subsequent quantitative study. The goal of our findings is to verify the assumptions of CE and green logistics relevant to the model proposal based on our research. Appendix 1*a* provides a semi-structured interview protocol as an outline.

The author selected a network consisting of companies and universities in Vietnam as the study context for conducting both qualitative and quantitative investigations. As mentioned in the Introduction, Vietnam's industrial sector is undergoing a shift from a brown economy to a green economy. The Vietnamese government has oriented strategies to promote the circular economy and foster the development of environmentally friendly industries. The logistics industry has emerged as a national program expected to play a crucial role in achieving a balance among the triple objectives of economics, environment, and society.

Furthermore, Vietnamese universities have been actively expanding their offerings in modern economics, logistics, and supply chain programs to cater to the growing demand for skilled professionals in these areas. According to Saunders et al (2019), there are no definitive rules for determining the appropriate sample size in non-probability sampling. Therefore, in this qualitative approach, a total of 18 key individuals (Appendix 1*b*) were selected from a network consisting of 30 universities, public sectors, and companies. Appendix 1*c* outlines several key companies in that network, wherein approximately 33.4% of the companies operate within the distribution sector, 16.7% are engaged in the network equipment business, and 49.9% are enterprises involved in the production of paints, textiles, dairy & nutrition, with robust logistics operations. This sample size was deemed appropriate for conducting both qualitative and quantitative investigations pertaining to the transition of Green Logistics and Supply Chain practices in the context of the Circular Economy. Their contributions helped identify important matters aiding clarification of links between the 7 constructs and 32 variables in the proposed model that subsequently finalize the questionnaire (Luu, et al., 2023).

Research procedure for data collection and analysis

Participants for this study were purposefully selected (Yin, 2014) to ensure their in-depth knowledge and understanding of CE and GLS practices. A total of 18 individuals were approached, consisting of 5 professors, 4 lecturers, 5 CEO/managers, and 4 civil servants specializing in industry, economics, and public sectors as outlined in Appendix 1*b*. Data collection proceeded in three phases.

In the first phase, the author leveraged their network to compile a list of potential participants and subsequently contacted them to extend interview invitations. Ultimately, 18 participants were finalized, who either engaged in one-to-one or a group interview and review processes or consultants conducted via MSTEAMS, email, Facebook, Zalo, or face-to-face meeting.

The second phase involved providing interviewees with the questionnaire and interview procedure in advance, enabling them to familiarize themselves with the structure and prepare for the interview aims to create a comfortable environment for the interviewees. The interviews were conducted flexibly based on the schedule of participants and consisted of three main stages: *warm-up*, *development*, and *closing*. The warm-up involved greetings and providing an overview of the study. In the development stage, participants' personal information was reviewed before delving into the main content of the interviews. A diverse set of questions was posed to comprehensively explore the nature of CE adoption in GLS practices. The closing stage focused on confirming and gathering additional relevant information.

In the final phase, after the completion of the interviews, the authors summarized and analyzed the collected data thoroughly, then securely stored using Microsoft Word and Excel files.

3.2.2 Research results

In light of the purpose of the qualitative study of validating the significant importance of constructs and associated indicators to be employed in the subsequent quantitative approach. Specifically, indicators that did not achieve an agreement rate of at least 75% were deemed unsuitable for inclusion and further development in the survey questionnaire.

The comprehensive findings, along with the determination of suitable indicators, were synthesized and succinctly presented in Table 6, which serves as the conclusive report encapsulating the outcomes of this research endeavor.

Overall, most participants expressed agreement with the seven proposed constructs and their 32 indicators. Table 6 illustrates that a minimum of 78% of the interviewees concurred with the constructs and their associated variables, with agreement rates ranging from 78% to 100%. Although participants provided diverse definitions and explanations, these were considered for further consideration.

Table 6: Interview results on agreeing responses

Const.	Indicator	Agreeing responses				Total (%)
		Professor (5)	Lecturer (4)	Manager (5)	Servant (4)	
1. ID40	1. ID401	5	4	5	3	94%
	2. ID402	5	4	5	4	100%
	3. ID403	5	4	5	3	94%
2. CEA	4. CEA1	4	4	5	3	89%
	5. CEA2	5	4	5	4	100%
	6. CEA3	4	4	4	3	83%
	7. CEA4	5	4	4	4	94%
	8. CEA5	5	4	5	4	100%
3. CEF	9. CEF1	5	4	5	4	100%
	10. CEF2	5	4	4	3	89%
	11. CEF3	4	3	4	3	78%
	12. CEF4	5	3	5	4	94%
	13. CEF5	5	4	5	4	100%
4. GOP	14. GOP1	5	3	4	4	89%
	15. GOP2	5	4	5	3	94%
	16. GOP3	5	3	5	4	94%
	17. GOP4	4	4	4	3	83%
5. GLS	18. GLS1	5	4	4	3	89%
	19. GLS2	5	3	5	4	94%
	20. GLS3	5	4	3	3	83%
	21. GLS4	5	3	5	3	89%
	22. GLS5	5	4	5	4	100%
	23. GLS6	5	4	4	4	94%
	24. GLS7	4	4	5	4	94%
	25. GLS8	5	3	4	4	89%
	26. GLS9	5	4	5	4	100%
6. COL	27. COL1	5	4	5	4	100%
	28. COL2	5	4	5	4	100%

	29. COL3	5	4	5	3	94%
7. CON	30. CON1	5	4	5	4	100%
	31. CON2	5	4	5	3	94%
	32. CON3	5	4	4	4	94%

Source: own research

3.2.3 Discussion

In general, the discussions exhibited a positive tone, as 18 respondents acknowledged the importance of adopting circular economy practices, particularly in logistics and supply chains, for achieving economic, environmental, and social sustainability. Surprisingly, over 75% of the respondents demonstrated a clear understanding of the concept of economic, environmental, and social sustainability, as well as the role of green logistics within business processes, considering the context of Industry 4.0. This indicates that the pursuit of a greener and circular economy transition aligns with their interests and is supported by government policies.

For example, a CEO suggested that corporate culture and human factors play a crucial role in the transition toward green logistics and sustainable supply chains. However, this research primarily focuses on the impacts of modern tech-economic models, rather than cultural and human influences. As a result, these suggestions were deemed outside the scope of the research, and the agreement rate fell below the accepted threshold of 75%. Nevertheless, these suggestions could be intriguing for future research directions.

On the other hand, other lecturers emphasized the importance of applying systems thinking in developing a circular economic ecosystem model within the context of Industry 4.0 to optimize organization operations, as well as the roles of government in addressing strategic issues.

However, these opinions appear to overlap with aspects already covered in the strategic design of the circular economy framework (i.e., CEF3) and government policies (GOP). Consequently, these contributions were not further developed within the scope of this thesis.

In summary, the qualitative research yielded important insights into the adoption of Circular Economy practices for Green Logistics and Sustainable Supply Chain transitions (Luu, et al., 2023). These findings provide valuable perspectives from researchers and practitioners in logistics and supply chains, encompassing universities, enterprises, and government. Then the results will be returned to finalize the questionnaires which are used to collect primary data for further quantitative study for the proposed research framework validating and hypotheses testing.

3.3 QUANTITATIVE STUDY 3 – Validation for research model and hypotheses testing

3.3.1 Research design for data collection and statistical analysis

The detailed research procedure is summarized in Figure 8 in which this third study uses Partial Least Squares Structural Equation Model (PLS-SEM) by SmartPLS-SEM and ADANCO software for data analysis to evaluate and validate the proposed framework and hypotheses (Luu, et al., 2023).

In the selection of techniques, such as Covariance-based Structural Equation Modeling (CB-SEM) and Artificial Neural Networks (ANN), PLS-SEM is chosen as the preferred method.

Dash and Paul (2021) have indicated that CB-SEM and PLS-SEM yield highly similar outcomes. However, CB-SEM requires substantial data requirements, whereas PLS-SEM performs well when working with limited sample sizes and non-normally distributed data (Hair et al., 2017; Goodhue et al., 2012).

On the other hand, ANN lacks the capability to assess causal relationships, while PLS-SEM provides an explanation of such relationships among multiple variables without imposing rigid preconditions and assumptions (Hair et al., 2017). Consequently, PLS-SEM is considered the inferential technique of choice (Luu, et al., 2023).

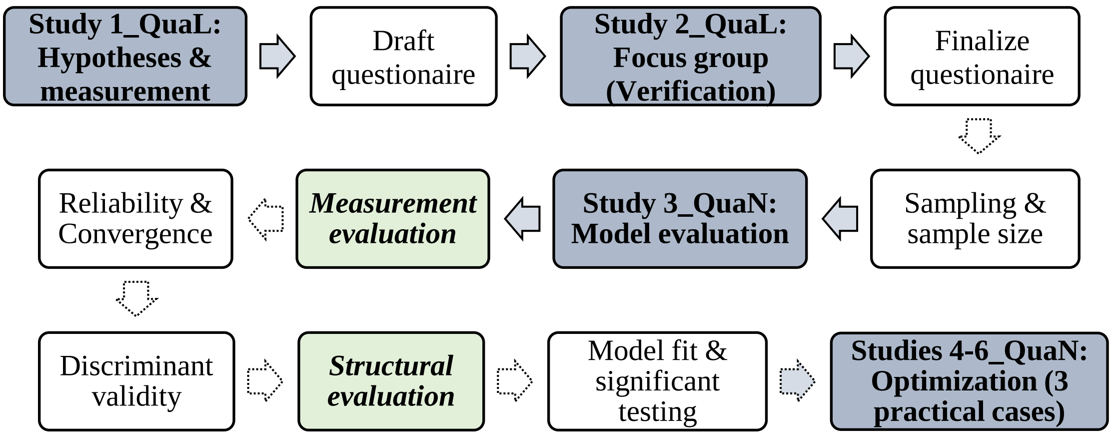


Figure 8: Research procedure
Source: own processing

Sampling and sample size for data collection.

The author chose Ho Chi Minh City in Vietnam as the main survey site since it is the largest commercial hub that attracts skilled laborers from different regions and industries from the world and Vietnam. The recipients surveyed had knowledge and experience of CEs, ID4.0, and logistics, and worked in junior, executive, or senior management in the network of the author and 18 key involved persons.

Finalized bilingual questionnaires (Appendices 2*a* & 2*b*), utilizing a five-point Likert scale, were administered to subjects. The survey was conducted mainly in Ho Chi Minh City, a prominent global commercial center and skilled labor destination. It targeted experienced individuals (75% with ≥ 5 years of experience) in CEs, and logistics. These participants held roles including professors/lecturers (30.5%), managers (25.2%), and CEOs (17.6%), representing a balanced mix across universities (36%), companies (33%), and public & other sectors (31%). For detailed sample distribution, refer to Appendix 2*c* (Luu, et al., 2023).

This study required a high volume of samples for reasons of associated distribution theory (Raykov and Widaman, 1995). Hair et al (1998) stated that three different sample sizes exist for SEM: small ≤ 100; medium = 100÷200; and large ≥ 200 (Luu, et al., 2023). Moreover, Hair et al (2017) proposed that the sample size should exceed 10 times the maximum number of structural paths directed toward a specific construct within the structural model. Based on Figures 3*b*, the 210 sufficient responders collected from the survey, concluded that this sample size aligns with Hair et al (2017; 2014) assertion.

Evaluation of the reflective measurement model

Because the model is built with reflective, a reflective measurement model evaluated by several critical metrics such as reliability of indicators and constructs through the outer loading and Cronbach's alpha; convergent validity by the average variance extracted (AVE); and discriminant validity by Heterotrait-Monotrait ratios (HTMT). According to the findings of Hair et al (2019) and Henseler et al (2014), when a significant concentration of HTMT is observed, it raises potential concerns regarding the discriminant validity of the measurement model. Therefore, this research recommends the HTMT over the Fornell-Larcker criterion.

Table 7 summarizes the evaluation of the reflective measurement model with the relevant metrics and its thresholds. According to Hair et al (2017; 2014), with values of greater than 0.7, outer loadings indicate thus that the reliability of the indicators is satisfied. Construct reliability of the reflective measurement models is evaluated by Dijkstra-Henseler's rho (ρA), Jöreskog's rho (ρc), and Cronbach's Alpha (CA). If their values are greater than 0.7, it can be suggested that the sample is free of biases, or even, if the answers, in their group, are reliable (Hair et al., 2019; 2014). Convergent validity is examined with AVE. The AVE value is higher than 0.5, which indicates that the construct explains an average of 50% or more of the variance of its indicators, so the convergent validities are guaranteed.

Table 7: The measurement model assessment

Metrics		Indicators	Thresholds
Reliability	Indicators	Outer loadings	> 0.70
	Constructs	Dijkstra-Henseler's rho (ρA)	> 0.70
		Jöreskog's rho (ρc)	> 0.70
		Cronbach's alpha (CA)	> 0.70
Convergent validity		Average variance extracted (AVE)	> 0.50
Discriminant validity		Heterotrait-monotrai (HTMT)	< 0.85
		HTMT values by bootstrapping process	< 1.00

Source: Luu, et al., 2023; Hair et al., 2017

The last metric in the process of evaluating the reflective measurement model is called the discriminant validity observed by the HTMT. If HTMT's confidence interval does not include 1. It proposes the values for HTMT should be less than 0.85 that can be understood the constructs or latent variables are independent of one another (Hair et al., 2017, 2014).

Evaluation of the structural model and hypotheses testing

The research continues to analyze the inner structural model to test whether the theoretical structural relationships between the constructs are significant (Luu, et al., 2023). The coefficients of Pearson's determination (R^2), the cross-validated redundancy (Q^2), the standardized root mean square residual (SRMR), the *t*-value, and the *p*-value are illustrated in Table 8 (Hair et al., 2017; Henseler et al., 2009).

Table 8: The structural model assessment

Metrics	Thresholds	References
The coefficients of Pearson's determination (R^2)	✓ 0.25: small effect ✓ 0.50: median effect ✓ 0.75: large effect	Hair et al., 2019, 2017
Predictive relevance (Q^2)	✓ > 0.00: small predictive relevance. ✓ > 0.25: medium predictive relevance. ✓ > 0.50: large predictive relevance.	Hair et al., 2014, 2012

	✓ ≤ 0.00: lacks predictive relevance.	
The standardized root means square residual (SRMR)	✓ = 0.00: perfect fitting model ✓ < 0.08: good fit	Henseler et al., 2014 Hu & Bentler, 1998
Significant test	✓ *p* - value ≤ 0.05 or 5%	Hair et al., 2019, 2017, 2014
	✓ *t* – value ≥ 1.96	

Source: Luu, et al., 2023; Hair et al., 2019, 2017

The process of evaluation of the structural model begins with an assessment of the portion of the variance of the endogenous variables and indicates the quality of the adjusted model with Pearson's coefficients (R^2). Hair et al (2019; 2017) suggested that R^2 values of 0.25, 0.50, and 0.75 presented a small, medium, and large effects of the constructs in the model, respectively. Whereas R^2 values larger than 0.9 are considered to be overfitted.

Next step, the study uses the blindfolding technique to calculate the cross-validated redundancy (Q^2), it should be greater than 0. Detailly, Q^2 values larger than 0.00, 0.25, and 0.50, respectively, indicate the small, medium, and large predictive importance of the inner model (Hair et al., 2014). Otherwise, Q^2 values equal to or less than 0 can be determined that the model lacks predictive relevance (Hair et al., 2012).

Besides the steps mentioned above, Henseler et al., (2014) proposed the efficacy of the standardized root mean square residual (SRMR) to assess the model fit. Theoretically, an SRMR value of zero can be indicated that the model fits perfectly, however, in practice, a value less than 0.08 (Hu & Bentler, 1998) is generally considered a good fit.

Finally, the significance and relevance of the structural correlations and linear regressions can be checked with *p*-values or *t*-values. The hypotheses formulated in the model are supported when the *p*-values are less than 0.05 or *t*-values greater than 1.96 (Hair et al., 2019, 2017).

Mediating Effect Analysis

According to Nitzl et al (2016), the presence of a mediating effect necessitates the inclusion of an intermediate variable that acts as a mediator in the relationship between the independent and dependent variables. One of the calculations of the mediating effect, also known as the indirect effect, can be expressed as follows: "*Indirect effect = Total effect - Direct effect*".

Once all the measurement models' quality requirements have been met, the mediation model is examined (Hair Jr. et al., 2021). And the significance of the indirect impact can also be assessed using a bootstrapping process (Cohen, 1996). In this study, the hypothesis posits that CEA serves as a mediator between ID4.0 and GLS. The investigation of this mediating effect will involve inferring its presence and examining its nature if it is indeed established.

3.3.2 Research results

Conceptual framework and hypotheses

Figure 9 illustrates the conceptual framework exported from ADANCO software. The 7 constructs of ID4.0, CEA, GLS, COL, CON, CEF, and GOP with 32 associated indicators are results from previous studies and are considered in the Vietnam case studies context.

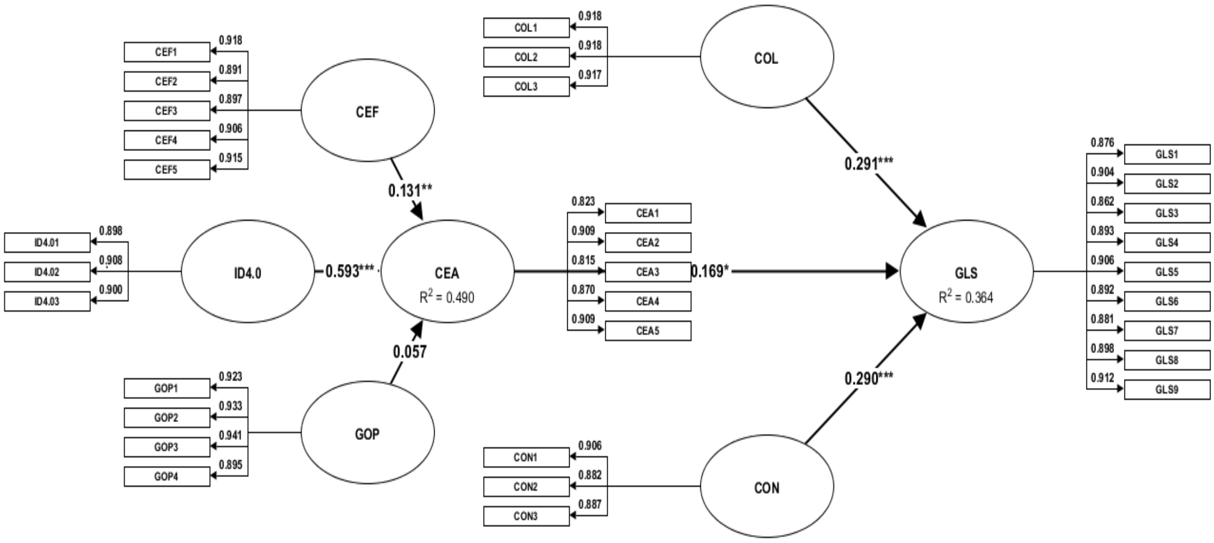


Figure 9: The solved research framework
Source: own processing exported from ADANCO (Luu, et al., 2023)

Results for the measurement model

Based on the research procedure of this quantitative study, the first step for the reflective measurement evaluation of the outer model is to examine the indicator loadings; construct reliability through criteria of Dijkstra-Henseler's rho (ρA), Jöreskog's rho (ρc), as well as Cronbach's alpha (α) (Hair et al., 2017; 2014). The next step is to determine the convergent validity of the models using Average variance extracted (AVE).

This section was detailed in the research paper Luu et al (2023). According to Table 9, the outer loading values of 32 observed variables are in the range of 0.8147 (CEA3) to 0.9407 (GOP3), exceeding the threshold of 0.7 indicates thus that the reliability of the indicators is satisfied (Hair et al., 2017; 2014).

In this table, all values of the construct reliabilities measured by Dijkstra-Henseler's rho (ρA), Jöreskog's rho (ρc), and Cronbach's alpha (α) are greater than the 0.7 thresholds, for example, their values of the COL construct are 0.9101, 0.9415 and 0.9069, respectively. Therefore, all model items are related to their respective constructs in a meaningful and satisfactory manner (Hair et al., 2019; Henseler, et al., 2009).

Convergent validity obtained by the observations of the Average Variance Extracted is easy to find in this Table, the AVE of all constructs is higher than the threshold of 0.5, this level or higher indicates that the construct explains an average of 50% or more of the variance of its indicators, so the convergent validities of the model are guaranteed (Hair et al., 2019; 2017).

Table 9: Summary of the measurement model

Factors	**Indicators**	**Outer loading**	**Construct Reliability**			**Convergent Validity**
			Dijkstra-Henseler's rho (ρA)	**Jöreskog's rho (ρc)**	**Cronbach's alpha (α)**	**AVE**
COL	COL1	0.9183	0.9101	0.9415	0.9069	0.8428
	COL2	0.9183				
	COL3	0.9175				
CON	CON1	0.9057	0.8775	0.9209	0.8715	0.7952
	CON2	0.8822				
	CON3	0.8872				
GLS	GLS1	0.8761	0.9683	0.9722	0.9678	0.7952
	GLS2	0.9043				
	GLS3	0.8621				
	GLS4	0.8933				
	GLS5	0.9057				
	GLS6	0.8919				
	GLS7	0.8814				
	GLS8	0.8982				
	GLS9	0.9117				
CEA	CEA1	0.8233	0.9164	0.9374	0.9160	0.7502
	CEA2	0.9088				
	CEA3	0.8147				
	CEA4	0.8699				
	CEA5	0.9093				
CEF	CEF1	0.9182	0.9587	0.9580	0.9457	0.8204
	CEF2	0.8913				
	CEF3	0.8974				

	CEF4	0.9065				
	CEF5	0.9151				
ID4.0	ID4.01	0.8982	0.8882	0.9289	0.8854	0.813
	ID4.02	0.9077				
	ID4.03	0.8997				
GOP	GOP1	0.9232	0.9453	0.9585	0.9423	0.852
	GOP2	0.9335				
	GOP3	0.9407				
	GOP4	0.8954				

Source: own processing

Table 10: Discriminant validity

a. HTMT

Factors	**COL**	**CON**	**GLS**	**CEA**	**CEF**	**ID4.0**	**GOP**
COL							
CON	0.587						
GLS	0.539	0.554					
CEA	0.420	0.460	0.425				
CEF	0.358	0.360	0.294	0.433			
ID4.0	0.436	0.528	0.494	0.762	0.471		
GOP	0.416	0.400	0.420	0.534	0.429	0.715	

b. B_HTMT

Factors	**COL**	**CON**	**GLS**	**CEA**	**CEF**	**ID4.0**	**GOP**
COL							
CON	0.691						
GLS	0.637	0.651					
CEA	0.542	0.572	0.538				
CEF	0.470	0.477	0.413	0.533			
ID4.0	0.555	0.634	0.612	0.846	0.576		
GOP	0.539	0.523	0.537	0.635	0.535	0.804	

95% bootstrap quantiles

Source: own processing from ADANCO (Luu, et al., 2023)

The last step in the measurement model is to evaluate the discriminant validity, which is understood as an indicator that the constructs are independent of one another (Hair et al., 2017; 2014). With PLS-SEM, the discriminant evaluation method recommended by the Heterotrait-Monotrait ratio (HTMT) of the correlations.

Table 10*a* shows that HTMT values less than the threshold of 0.85 indicate that there is a valid discriminant between the constructs (Luu, et al., 2023; Hair et al., 2017). In addition to examining the size of the HTMT values, the research uses a bootstrapping procedure to determine whether the HTMT value is statistically significantly lower than 1, and it is done (see Table 10*b*).

Results for the structural model and hypotheses testing.

The research continues to investigate the inner structural model after ensuring discriminant validity. The evaluation of Pearson coefficients (R^2) is the first analysis at this point. As in Table 11*a*, with the R^2 values of 0.36 and 0.49, the GLS and CEA constructs, respectively have medium effects based on the thresholds of Hair et al (2019, 2017). Additionally, the endogenous constructs of GLS and CEA have Q^2 values of 0.28 and 0.36, respectively, greater than the threshold of 0.25 indicating the medium predictive relevance of the path model for these endogenous constructs (Table 11*b*) (Luu, et al., 2023).

Table 11: Effects and predictive relevance testing

a. Coefficients of R^2

Factors	**Coefficient of determination (R^2)**	**Adjusted R^2**
GLS	0.36	0.35
CEA	0.49	0.48

b. Construct cross-validated redundancy, Q^2

Factors	**SSO**	**SSE**	**Q^2 (=1-SSE/SSO)**
GLS	1890.000	1356.392	0.28
CEA	1050.000	671.988	0.36
CEF	1050.000	1050.000	
COL	630.000	630.000	
CON	630.000	630.000	
GOP	840.000	840.000	
ID4.0	630.000	630.000	

Source: own processing from ADANCO and SmartPLS (Luu, et al., 2023)

To measure the goodness of model fit, Henseler et al (2014) assessed the efficacy of the standardized root mean square residual (SRMR). The SRMR is defined as the root mean square discrepancy between the observed correlations and the model-implied correlations. Table 12 shows that the SRMR of the research model is only 0.048 and 0.058 in the saturated and estimated models, respectively, indicating the goodness of model fit (Luu, et al., 2023; Hu & Bentler, 1998).

Table 12: SRMR

Saturated model	Value	HI95	HI99		Estimated model	Value	HI95	HI99
SRMR	0.048	0.043	0.047		SRMR	0.058	0.053	0.058
dULS	1.216	0.991	1.165		dULS	1.797	1.472	1.744
dG	2.590	8.254	13.17		dG	2.604	8.268	13.180

Source: own processing from ADANCO (Luu, et al., 2023)

The structural equation model is used to evaluate construct relationships. When the *t*-value is greater than 1.96, it indicates that the significant threshold is less than 0.05 (Hair et al., 2014). As in Table 13, industry 4.0 with the *t*-values of 8.15 and 2.37 has a dominantly direct effect on circular economy adoption, as well as an indirect effect inference to green logistics and sustainable supply chain, respectively. (H1*a*, & *b* are accepted). Additionally, the adoption of the circular economy directly affects green logistics and sustainable supply chain transitions (H2 is accepted) (Luu, et al., 2023). The circular economy framework also affects circular economy adoption (H3 is accepted). The supply-chain collaboration and configuration have a positive effect on green logistics and sustainable supply-chain networks because the *t*-values are 4.04 and 4.10, respectively (H5 and H6 are accepted). Although government policy has no evidence to affect circular economy adoption (H4 is rejected) because its *t*-value is 0.81 lower than the threshold of 1.96.

Table 13: The significance

Hypotheses		Mean value	t-value	p-value (2-sided)	Decision
H1a	ID4.0 ⇒ CEA	0.59	8.15	0.00	Accepted
H1b	ID4.0 ⇒ CEA ⇒ GLS	0.10	2.37	0.02	Accepted
H2	CEA ⇒ GLS	0.17	2.62	0.01	Accepted
H3	CEF ⇒ CEA	0.13	2.63	0.01	Accepted
H4	GOP ⇒ CEA	0.06	0.81	0.42	Not accepted
H5	COL ⇒ GLS	0.29	4.04	0.00	Accepted
H6	CON ⇒ GLS	0.29	4.10	0.00	Accepted

Source: own processing from ADANCO (Luu, et al., 2023)

3.3.3 Discussion

This thesis aims to fill the research gap by developing a conceptual framework of a circular economy adoption for green logistics and sustainable supply chains. The proposed framework and hypotheses were validated using PLS-SEM in this study and addressed the first part of the *RQ4* "*How does a CE model adoption for GLS?*" by providing insights into the proposed model. Additionally, the findings discussed with respect to the other three research questions are as follows: *RQ1. "Do high-tech applications impact CE adoption and GLS transition?". RQ2. "Do government policies influence CE adoption?" RQ3. "Do supply chain collaboration and configurations play a role in a GLS network?".*

In summary, the above-analyzed results confirm ***the prominent impact of ID4.0 on CE adoption***. ***CE adoption inferred acts as a mediator between ID4.0 and GLS*** and ***has a positive effect on GLS***, as well as the ***CE framework's positive impact on CEA***. ***SC collaboration and configurations play positive roles in a GLS network***. The author acknowledges and comprehends this situation of ***government policy, which lacks empirical evidence to influence the adoption of the circular economy***. Most of the respondents come from the network of universities, government sectors, and enterprises that are aware of the inadequacy of Vietnam policies (Luu, et al., 2023). Although the government also oriented strategies for the adoption of CE and ID4.0 in the field of GLS; executive authorities have not issued timely laws, regulations, and directions to guide the implementation; even in the government sector, and ministries have issued overlapping regulations, causing many difficulties for businesses (Nguyen & Pham, 2020). In other words, the fourth hypothesis (H4) also reflects the status quo of Vietnam government policy in issuing legislation and regulations; encouraging capability building in GLS; promoting education plans; and building synchronous urban planning infrastructure. Therefore, this finding indirectly helps the government sectors recognize and reorient their activities to better support businesses and society.

3.4 QUANTITATIVE STUDY 4 – Critical analysis for sustainable competitiveness under impacts of knowledge-based circular economics (KCE)

3.4.1 Research design for the KCE framework in the MVN company

Research overview

Due to the numerous changes in global consumption and production models that have occurred in recent years, the purpose of this study is to make a critical analysis of the real-world case, the MVN company, to investigate the impacts exerted on sustainable competitiveness by the knowledge-based and circular economics adoption for a business performance management.

On the business side, companies through different stages of the life cycle in an environment with a KE must contend with numerous additional requirements and challenges (Robert-Jan Van Ogtrop et al., 2021). Even more so if such establishments are concurrently adopting a CE to promote elements of sustainable development and competitiveness through strengthening the association between environment, society, and governance (ESG) disclosure and firm competitiveness, as well as avoiding CE rebound resulted from companies thinking about low-cost and recyclable production inputs and technologies (Rabaya & Saleh, 2022). The CEO of Vinamilk Group, Madam Mai Kieu Lien, has awarded "*Sustainable development is no longer a choice, but a mandatory way for all businesses to survive and develop"* (Vinamilk, 2020). Several researchers determined what factors are crucial to the perspectives of techno-optimism and ecomodernism (Lowe & Genovese, 2022).

Hybrid framework of KCE in the MVN

This study was detailed in the research paper Luu & Chromjaková (2023b). This study examines the value chain of business process management under the impacts of CE and KE indicators to evaluate their significance for sustainable competitiveness from practice-oriented CE proponents in MVN business performance, hence a hybrid framework of KCE is investigated to understand on how their integration impacts business operations and performance.

Figure 10 describes the value chain of the MVN under the impacts of four KE indicators of people, process, technology, and governance with the 3R1O framework in the CE context as outlined in Figure 3, as well as includes the involvement of their stakeholders such as research & development (R&D), farming, production, supply, and distribution.

Most companies discussed basic assumptions about social and economic structures as they pertain to CEs, with strong connections to system-conditioned prerequisites. CE is often mentioned along with the issue of global entrepreneurship, corresponding to the limited number of resources available for production. The paradigm is related to the need to achieve optimal performance of a company while also raising the standard of life. Knowledge management, in the context of CEs, should have the ability to react to environmental, economic, and social sustainability (Temesgen et al., 2021). The efforts made by a company to devise a relevant system-oriented concept within a project to implement CEs demand that particular attention is paid to barriers such as technology, consumption of resources, product definitions, and the needs of customers (Grafstrom & Aasma, 2021).

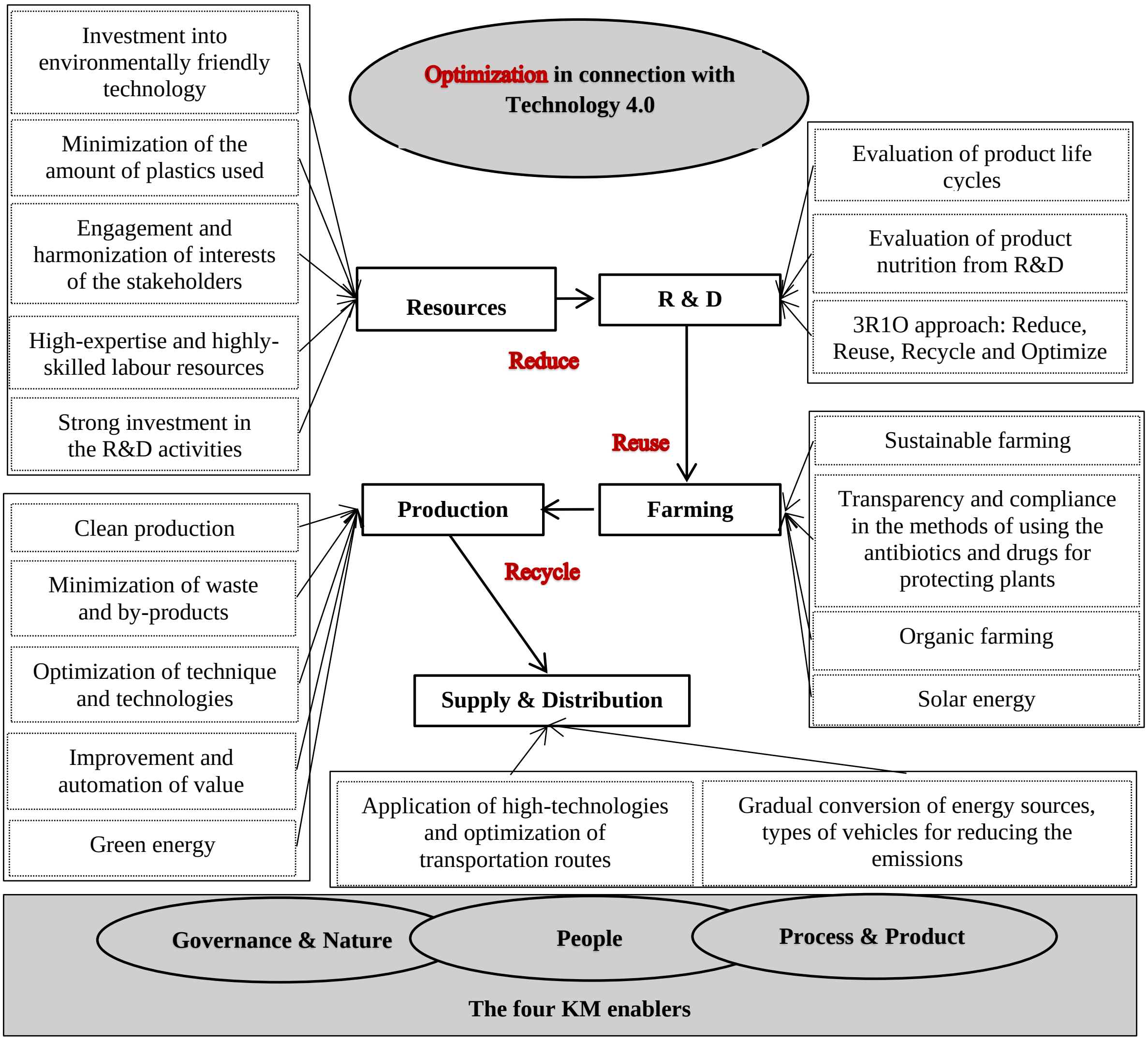


Figure 10: The KCE model for the MVN value chain
Source: own processing based on Sustainable Development Reports (2020, 2019)

3.4.2 Critical analysis

Results of the MVN performance

The MVN has the potential for greater success and competitiveness. In this sense, the given hybrid framework constitutes a key element in ensuring a sustainable position is reached in the competitive business environment of a country and globally.

For example, the MVN integrates the CE framework of 3R1O into four pillars of KE such as people, technology, product, and governance through their value chain (Figure 10). It has certainly achieved impressive results through the adoption of the CE founded on a knowledge-based economy. The MVN commits to a sustainable future, where growth and progress align to advance its economic, social, and environmental values.

On the side of the economic dimension, the MVN is the largest dairy company in Vietnam with a charter capital of approximately VND 20,900 billion in 2020 and has seen a rise in other financial performance over the years mentioned in Table 14.

On the side of society, in 2020, the MVN was ranked first among the top ten enterprises to adopt sustainable development in Vietnam in the manufacturing sector and was even rated among the top 100 best places to work in the country, additionally, the receipt of 93 solution initiatives, with a breakout rate of 258% compared to 2019, as well as an increased percentage of 117% in savings.

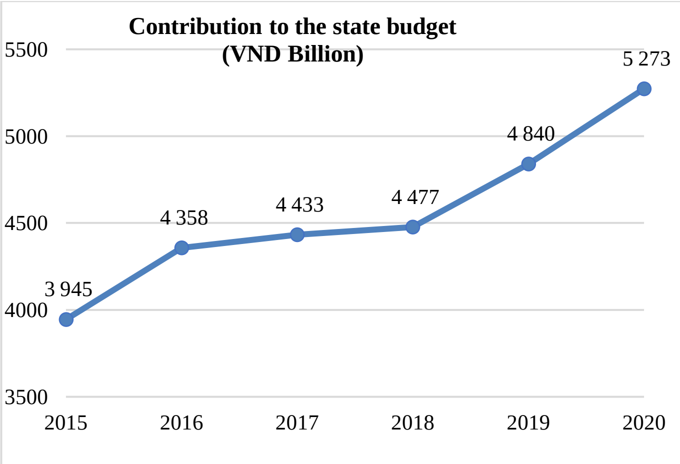
On the side of the environmental impacts, there are greater reduction, reuse, and recycling of their resources. Indeed, the 3R1O framework showed an important advance around resource consumption in production planning and scheduling.

Table 14: Highlights of the MVN performance

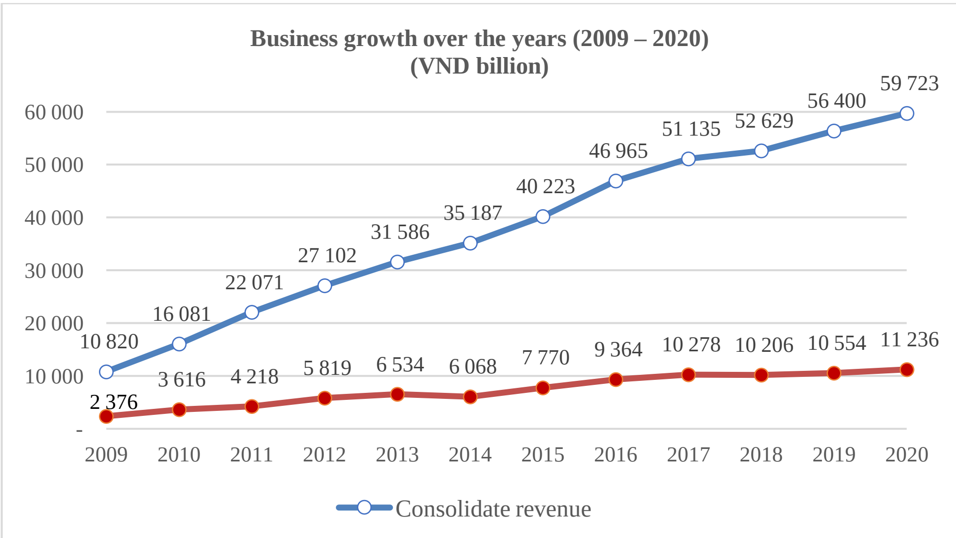
No.	Values	Highlights	2019	2020	Units	%
1	Financial matters	Charter capital	17,417	20,900	VND billion	20
2		Total revenue	56,400	59,723	VND billion	06
3		Profit after taxes	10,554	11,236	VND billion	06
4	Society	Contribute to state budget	4,840	5,273	VND billion	09
5		Saving	3.0	6.5	VND billion	117
6		Number of successful initiatives	26	93	No. of initiatives	258
7	Environment	Reduction in electricity	1,122,807	1,445,592	kWh	29
8		Reduction in CO2 emission	NA	17.3	million kg	
9		Reduction in plastic use	230,865	214,885	Kg	-7

Source: own processing based on the Sustainable Development Reports

Moreover, the impact of governmental policy is illustrated in Figures 11*a* & *b*, the MVN contributed to the state budget, as well as the increase in the gross domestic product. Vice versa, state bodies invest in building infrastructure and renovating economic institutions through a series of policies and laws and enforce rules, regulations, and sanctions to help the growth of the MVN.



a)



b)

Figure 11: Impacts of government policy and MVN business
Source: own processing based on SD Reports, 2019, 2020

3.4.3 Discussion

This study is also an attempt to answer a part of the *RQ*4 of the "how" question, by examining a practical CE adoption for business operations under KE context. The findings of the MVN performance illustrate the impact of the circular economy adoption in the knowledge economy context to boost sustainable competitiveness to contribute to the growth of the company and country in general. The author believes that other aspects of knowledge (e.g., creation/innovation) should be more widely applied to reinforce the sustainable competitive edges of a country or business development, the MVN case is a shred of evidence. From a business perspective, the author is very impressed with the benefits of economics, society, and environment that the knowledge-based circular economics model brings to the MVN (see Table 14), and thereby clearly interested in the importance of knowledge management and the impact of the knowledge economy in the circular economy adoption in light of sustainable practices on their people, process, technology, and governance in an organization, as well as strengthening the competitive position of businesses. In summary, KE and CE play an essential role in the creation of sustainable and competitive value reflected in organizational performance that strengthens business process management.

In conclusion, utilization of knowledge and competitiveness in the CE context are the priorities of every country today that ensure sustainable development. This is since, for modern companies, the issue of sustainable competitiveness is a fundamental corporate value for a premium circular economy.

3.5 QUANTITATIVE STUDY 5 – An optimization model for a distribution supply chain network design (SCND)

3.5.1 Research design for SCND in the SME company

Research overview

The quantitative study investigates the impact of ID4.0, especially the ID403 variable of model and algorithm (MCDM approach) to strengthen the retail distribution network of the real SME case and act as an examination of supply chain configuration and collaboration in a supply chain network in general. SCND decisions affect operational levels, such as inventory control policies, the choice of transportation modes and capacities, warehouse layout and management, vehicle routing, etc. This quantitative study uses the MCDM approach formulating mixed integer linear programming (MILP) as well as using secondary data of the SME company to suggest optimal solutions. The proposed model will be solved using the CPLEX tool. A great advantage of MILP is that there are a lot of solvers available (e.g., IBM Ilog CPLEX, GUROBI, XPRESS, SCIP). Especially, for small-to-medium-size problems, these solvers are surprisingly good at solving MILP problems without further knowledge from the user, making a combination of MILP and CPLEX a preferred choice (Luu & Chromjaková, 2023a; Ning & You, 2018).

The SME description

This study was detailed in the research paper Luu & Chromjaková (2023a). The old SME supply chain is the three-echelon network of factories-warehouses-retailers. Due to the demand increasing, the company is testing a four-echelon network described in Figure 4 in Introduction, which includes 2 factories located in the Central and the South of Vietnam, 2 current depots located in the North and the South, and 1 new depot opened in Central Vietnam, 20 warehouses (wholesalers), and 209 retailers (customers) in the country with 3 types of products which have the same dimensions. All the North-Central-South depots and wholesalers are rented from third parties logistics (3PLs). However, the company cannot control the costs, they coped with the increasing costs that negatively affect its profits. Therefore, this study aims to develop a mathematical model to test the SME network to find the most effective retail distribution supply chain network in considering which depots and warehouses should be rented to minimize total costs including transportation, inventory, and renting. Other objects including demands, capacities, and safety stocks are also considered in the model.

The SME has a transportation system (Table 15) with the capacities of small and medium-sized trucks from 05 to 15 tons per truck, in diversified load per trip from 500 to 16,800 sets of products. The motorbike is also used for trips from warehouses (WHs) to retailers with about 10 sets per trip (Luu & Chromjaková, 2023a).

Table 15: Transportation system description

Transportation	**Vehicle**	**Capacity load/trip**
Supplier (factory) ⇒ Central warehouse (depot)	Truck 15 tons	~ 16,800 sets of products
Supplier (factory) ⇒ Wholesale point (warehouse)	Truck 5 tons	~ 500 sets
Depot ⇒ Wholesale point (warehouse)	Truck 5 tons	~ 500 sets
Warehouse ⇒ Showroom (customer)	Motorcycles	≤ 10 sets

Source: SME database (Luu & Chromjaková, 2023a)

Research model: The study uses the MCDM of MILP model described below. Some texts in the previous work (Luu & Chromjaková, 2023a):

a. Indices, parameters, and decision variables

F, Set of factories, *f*: 1÷2.

D, Set of depots, $d = 1 \div 3$.

W, Set of warehouses, $w = 1 \div 20$.

C, Set of customers, $c = 1 \div 209$.

P, Set of products, $p = 1 \div 3$.

T, Set of months, $t = 1 \div 12$.

d_{pct}, Demand of product p from customer c, at time t.

cf_{pf}, Maximum capacity of factory f for product p.

cd_d, Maximum capacity of depots d.

cw_w, Maximum capacity of warehouse w.

$ctrs1_{fd}$, Transportation costs from factory f to depot d.

$ctrs2_{fw}$, Transportation cost from factory f to warehouses w.

$ctrs3_{dw}$, Transportation cost from depots d to warehouses w.

$ctrs4_{wc}$, Transportation cost from warehouses w to customers c.

chd_d, Inventory cost at depots d.

chw_w, Inventory cost at warehouse w.

hd_d, The rental cost of depot d.

hw_w, The rental cost of warehouse w.

ssd_{pd}, Safety stock for products p in depot d.

ssw_{pw}, Safety stock for products p at warehouse w.

$n1_{fdt}$, number of trucks transporting from factories f to the depots d at time t.

$n2_{fwt}$, number of trucks transport from factories f to WHs w at time t.

$n3_{dwt}$, number of trucks transport from depots d to WHs w at time t.

$n4_{wct}$, number of motorbike transport from WH w to customer c, at t.

$q1_{pfdt}$, Outputs of products p transported from factories f to depots d at t.

$q2_{pfwt}$, Outputs of products p transported from factories f to WHs w at t.

$q3_{pdwt}$, Outputs of products p transported from depots d to WHs w at t.

$q4_{pwct}$, Outputs of products p transported from WHs w to customers c, at t.

ID_{pdt}, Volume of products p inventory at the depots d at t.

IW_{pwt}, Volume of products p inventory at WHs w at t.

yd_d = [0,1], 1.

yw_w = [0,1], 1 if warehouse w is rent, 0 otherwise.

b. MILP model

***[1] Objective function*: Min costs of transport, inventory, and renting**

Transportation cost =

$$\sum_{t\in T}\sum_{f\in F}\sum_{d\in D} ctrs1_{fd} * n1_{fdt} + \sum_{t\in T}\sum_{f\in F}\sum_{w\in W} ctrs2_{fw} * n2_{fwt} + \sum_{t\in T}\sum_{d\in D}\sum_{w\in W} ctrs3_{dw} * n3_{dwt} + \sum_{t\in T}\sum_{w\in W}\sum_{c\in C} ctrs4_{wc} * n4_{wct}$$

Inventory cost =

$$\sum_{p\in P}\sum_{d\in D}\sum_{t\in T} chd_d * ID_{pdt} + \sum_{p\in P}\sum_{d\in D}\sum_{t\in T} chw_w * IW_{pwt}$$

Renting costs =

$$\sum_{d\in D} hd_d * yd_d + \sum_{w\in W} hw_w * yw_w$$

***Subject to*: (*Based on the previous paper Luu & Chromjaková 2023a)*.**

[2] At the time *t*, the sum of the transferred volumes from all warehouses *w* to customer *c* must meet customer demand for each product *p*.

$$\sum_{w\in W} q4_{pwct} \geq d_{pct} \ \forall p, c, t$$

[3] At the time *t*, the sum of the transferred volumes from factory *f* to all depots *d*, plus to all warehouses *w* must be smaller than the capacity of factory *f* for each product *p*.

$$\sum_{d\in D} q1_{pfdt} + \sum_{w\in W} q2_{pfwt} \leq cf_{pf} \quad \forall p, f, t$$

[4] At the time *t*, the sum of the transferred volumes of all products *p* from factory *f* to depot *d* must be full of a big truck capacity load.

$$\sum_{p\in P} q1_{pfdt} = 16800 * n1_{fdt} \quad \forall f, d, t$$

[5] At the time *t*, the sum of the transferred volumes of all products *p* from factory *f* to warehouse *w* must be full of a small truck capacity load.

$$\sum_{p\in P} q2_{pfwt} = 500 * n2_{fwt} \quad \forall f, w, t$$

[6] At the time *t*, the sum of the transferred volumes of all products *p* from depot *d* to warehouse *w* must be full of a small truck capacity.

$$\sum_{p \in P} q3_{pdwt} = 500 * n3_{dwt} \quad \forall d, w, t$$

[7] At the time *t*, the sum of the transferred volumes of all products *p* from warehouse *w* to customers *c* must never be greater than the motorbike capacity.

$$\sum_{p \in P} q4_{pwct} \leq 10 * n4_{wct} \quad \forall w, c, t$$

[8] At the time *t*, if there is a shipment from the factory *f* to depot *d*, the depot must be rented.

$$q1_{pfdt} \leq yd_d * M \quad \forall p, f, d, t$$

[9] At the time *t*, if the depot *d* is rented, the inventory must be smaller than the capacity of the rental depot.

$$ID_{pdt} \leq yd_d * cd_d \quad \forall p, d, t$$

[10] At the time *t*, if there is a shipment from factory *f* to warehouse *w*, the warehouse must be rented.

$$q2_{pfwt} \leq yw_w * M \quad \forall p, f, w, t$$

[11] At the time *t*, if there is a shipment from the depot *d* to warehouse *w*, the warehouse must be rented.

$$q3_{pdwt} \leq yw_w * M \quad \forall p, d, w, t$$

[12] At the time *t*, if the warehouse *w* is rented, the inventory must be smaller than the capacity of the rental warehouse.

$$IW_{pwt} \leq yw_w * cw_w \quad \forall p, w, t$$

[13] At the time *t*, the inventory of product *p* at depot *d* is equal to the previous inventory of the product at the depot, plus the sum of the transferred volumes of the product from all factories *f* to the depot, minus the sum of the delivered volumes of the product from the depot to all warehouses *w*.

$$ID_{pdt} = ID_{pdt-1} + \sum_{f \in F} q1_{pfdt} - \sum_{w \in W} q3_{pdwt} \quad \forall p, d, t$$

[14] At the time *t*, the inventory of product *p* at warehouse *w* is equal to the previous inventory of the product at the warehouse, plus the total of the sum of transferred volumes of the product from all factories *f* and all depots *d* to the warehouse, minus the sum of the delivered volumes of the product from the warehouse to all customers *c*.

$$IW_{pwt} = IW_{pwt-1} + \sum_{f \in F} q2_{pfwt} + \sum_{d \in D} q3_{pdwt} - \sum_{c \in C} q4_{pwct} \quad \forall p, w, t$$

[15] At the time *t*, the inventory of product *p* at depot *d* is greater than the safety stock of p in that depot.

$$ssd_{pd} \leq ID_{pdt} \quad \forall p, d, t$$

[16] At the time *t*, the inventory of product *p* at warehouse *w* is greater than the safety stock of p in that warehouse.

$$ssw_{pw} \leq IW_{pwt} \quad \forall p, w, t$$

c. Data collection and CPLEX running.

From the above investigation, a MILP model is outlined that orients for data collection which is one of the important steps to modify the proposed model closer to the scenarios of the SME network and then codes them into the CPLEX solver for calculation (Appendix 3).

Collected data from the Accounting Department includes capacities of 2 factories, 3 depots, and 20 warehouses; demands of 209 customers for 3 products for 12 months; holding and hiring costs of all depots and warehouses, as well as their safety stocks; especially, transportation costs matrices from factories to depots, factories to warehouses, depots to warehouses, and warehouses to customers (Luu & Chromjaková, 2023a).

Figure 12 presents the CPLEX calculation shows the crucial processed parameters of the modified network that produces a total cost of VND 22,250,892,500.

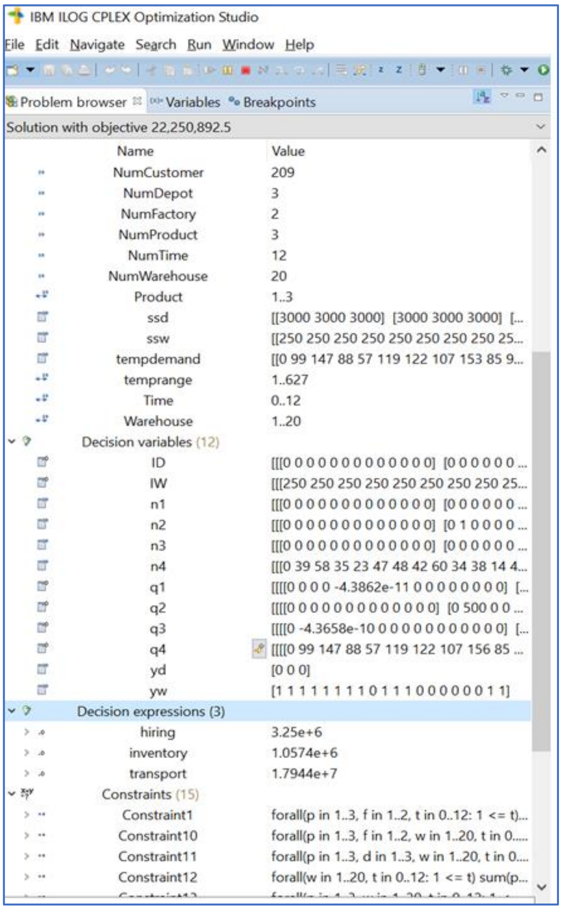


Figure 12: A screenshot of the total cost calculation for a modified model
Source: IBM ILOG CPLEX Results (Luu & Chromjaková, 2023a)

3.5.2 Research results

To test the main aim of the study, the author develops 3 scenarios of supply chain networks with specific assumptions below (Table 16). The scenarios are evaluated by their total costs (Luu & Chromjaková, 2023a).

Table 16: Testing scenarios

Scenarios	**Description**	**Total costs (VND)**
1. The current network	2 factories, 3 depots, 20 warehouses, and 209 customers	35,540,500,000
2. The old network	2 factories, 0 depots, 20 warehouses, and 209 customers	26,645,159,250
3. A modified network	2 factories, 0 depots, ≤ 20 warehouses, and 209 customers	22,250,892,500

Source: own processing (Luu & Chromjaková, 2023a)

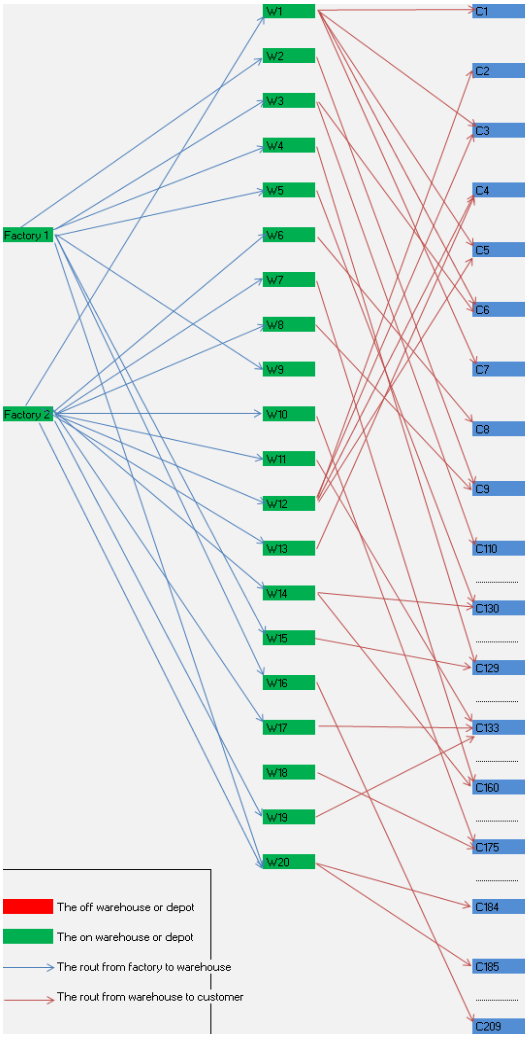


Figure 13: The old three-echelon supply chain network
Source: own processing based on CPLEX results

Scenario 1: The current network is presented in Figure 4 where the SME expands to the four-echelon network, in which the company considers all 3 depots and 20 warehouses introduced by the 3PLs. Obviously, with current needs, the rental costs are too large and dominant, the total costs are up to VND 35,540,500,000 (Luu & Chromjaková, 2023a).

Scenario 2: The old three-echelon supply chain network with zero depots (Figure 13). The SME uses 2 factories for packaging, sorting, and product quality evaluation. A total of 20 warehouses are rented, providing demands of 209 customers across the country. With this model, the total costs are VND 26,645,159,250. At the time, the company coped with uncontrollable implicit costs (Luu & Chromjaková, 2023a).

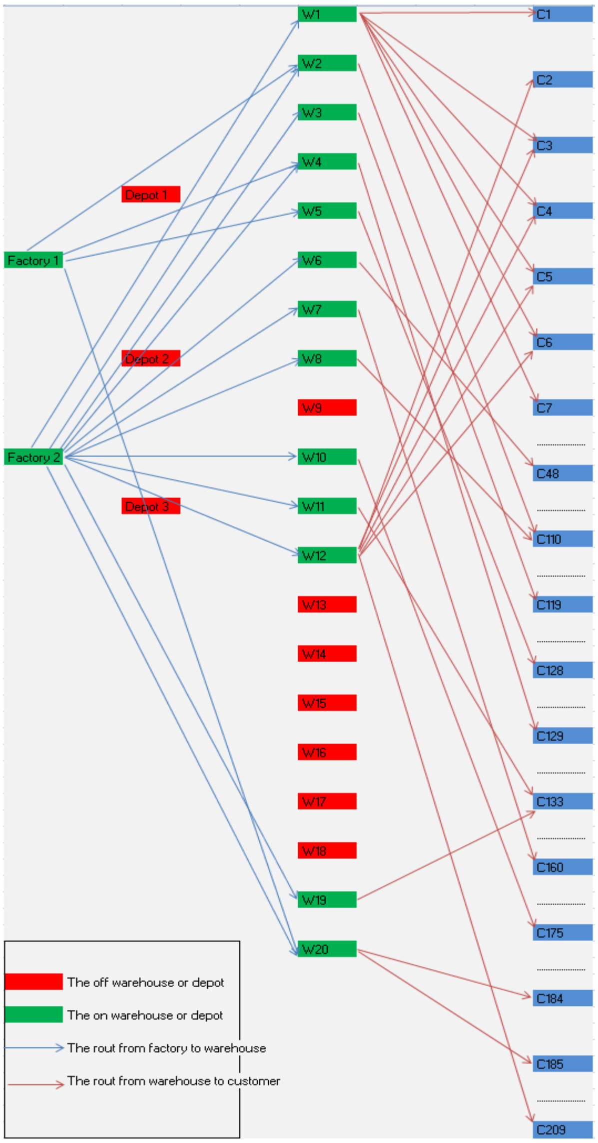


Figure 14: A modified supply chain network model
Source: own processing based on CPLEX results

Scenario 3: The modified supply chain network with 2 factories, zero depots, less than 20 warehouses, and 209 customers. In this case, the mathematical model solved by the CPLEX software produced the most minimal total cost of VND 22,250,892,500 (Figure 14).

Moreover, the results of the study suggest that the SME should decide to close 3 depots and 7 warehouses, especially, since decisions are not only considering the number of closed warehouses but also their location such as warehouse 9 and warehouses 13 to 18 (Figure 13) (Luu & Chromjaková, 2023a).

3.5.3 Discussion

This study is one of the quantitative attempts that address the last aspect of the fourth research question to satisfy the fourth research objective, particularly employing an MCDM approach (aligned in the ID403 variable: model and algorithms) for optimizing solutions in a distribution supply chain network. Indeed, compared with the above 3 networks in terms of the cost aspects, scenario 3 produces the most optimal supply chain network and gives the most effective results for the distribution system of the SME at the time (Luu & Chromjaková, 2023a).

Besides, scenario 2 can be seen as a suboptimal model which the company developed in the early periods with only a few warehouses and then gradually hired more warehouses based on the increasing number of customers. At the time, the SME should be considered more about hiring the depots and warehouses, because the costs of hiring are dominated as in scenario 1 (Luu & Chromjaková, 2023a).

The findings of the study also recommend that the SME should focus more on developing strategic alliances such as 3PLs or 4PLs selection, distribution integration, as well as retailer-supplier partnerships to build a certain level of trust in the collaboration and configuration of supply chain network so that getting more advantaged policies such as a cheapest and long-term rental quotation, etc.

3.6 QUANTITATIVE STUDY 6 – An optimization approach for an order picking warehouse (OPW)

3.6.1 Research design for OPW in the ATP company

Research overview

This study was detailed in the research paper Luu et al (2023). This study serves as the final slice of the thesis using optimization models (CO approach) to examines the impact of ID4.0, especially the ID403 variable of model and algorithm into the ATP warehouse operations. Warehouse in the supply chain acts as a buffer that allows companies to quickly react to fluctuation or uncertainty in the market due to unexpectedly aggressive demand changes, especially in retail distribution and e-commerce (Çelik et al., 2022; Calzavara et al., 2019). According to Khare (2015), approximately 25% of logistics costs is accounted for by warehouse activities in which order picking constitutes around 55% of the warehouse operating costs, and travel time accounts for approximately 60% of the total time of order picking activities (Tompkins et al., 2010). For the picker-to-parts order picking system, the travel time is an increasing function of the travel distance, as a result, minimizing travel distance is the primary goal in warehouse design and operations optimization.

Recent, complex market conditions, caused by e-commerce and globalization (Guo et al., 2022), leads to warehouse design is an interdependent cluster of decisions at the strategic, tactical and operational levels (Vanheusden et al., 2022; Rouwenhorst et al., 2000). This study analyses a practical case that focuses on warehouse picker-to-parts operation, which still accounts for the large majority of all order-picking systems (Zhang and Gao, 2022).

The ATP description

ATP, the biggest network provider in Vietnam, plays an important duty in receiving goods, boosting sales in Vietnam, and whole logistic control from Hong Kong to Vietnam which mainly focus on 44 SKUs which are randomly coded in Appendix 4*b*. The existing warehouse dimensions in width and length are fixed at 24m*36m, the dimension of each bay is 2m*2m, and the width of the aisle is 2m (Appendix 4*a*). Information about the ATP warehouse is outlined in Table 17.

Table 17: Current warehouse information

Warehouse Layout Design	Layout (24m*36m)	No. of doors for out/inbound	1
		Height restriction	8m (meters)
		Goods allocating policy	Randomized, block stacking
	Equipment	Material handling equipment	Casual trolley
		Storage equipment	Wooden pallets
		Automation level	0
Warehouse Operation		Picking path optimization	No proper treatment
		RMA units	No proper treatment
		Parameters for WH efficiency	0

Source: ATP database (Luu, et al., 2023)

Currently, the storage locations of products are randomly placed, which wasted a lot of time for a picker to search and travel to pick causing the picking path to be not optimized. Furthermore, in high demand season, the ATP hired intensive workers to load many boxes, in addition, the equipment being used in the warehouse is fairly invested, which causes many risks for products and laborers in placing or picking caused risk of the returned merchandise. The study aims to re-layout the allocations of goods in a more scientific way regarding picking path optimization. CO approach of the Travelling Salesman Problem (TSP) and Class-based Dedicated Assignment (CDA) are used within LINGO solver to optimize the distance that pickers must travel to collect an uncertain number of products over proposed warehouse layouts.

Research models: The study uses CDA and TSP models described below:

a. Class-based Dedicated Assignment

The study considers the mathematical model of Class-based Dedicated Assignment for determining an optimal dedicated storage layout, rectilinear travel is assumed (Tompkins et al., 2010).

The study assumes indices, parameters, and variables as below (Luu, et al., 2023).

q, number of storage locations.

n, number of products.

m, number of input/output (I/O) points (docks).

S_j, number of storage locations required for product j.

T_j, number of trips in/out of storage for product j.

p_i, percentage of travel in/out of storage to/from dock i.

d_{ik}, distance required to travel from dock i to storage location k.

x_{jk} = [0,1], 1 if product j is assigned to storage location k, 0 otherwise.

$f(x)$, average distance traveled.

[17] Objective function: The optimum dedicated storage assignment.

$$\boldsymbol{Min} \sum_{j=1}^{n} \sum_{k=1}^{q} \frac{T_j}{S_j} \sum_{i=1}^{m} p_i d_{ik}\, x_{jk}$$

Subject to:

[18] $\sum_{j=1}^{n} x_{jk} = 1,\ for\ k = 1, \dots, q$

[19] $\sum_{k=1}^{q} x_{jk} = S_j,\ for\ j = 1, \dots, n$

[20] $x_{jk} = (0,1), \forall j\ and\ \forall k$

The study summarizes the assignment procedure to minimize the total expected distance traveled (f_k) in Figure 15.

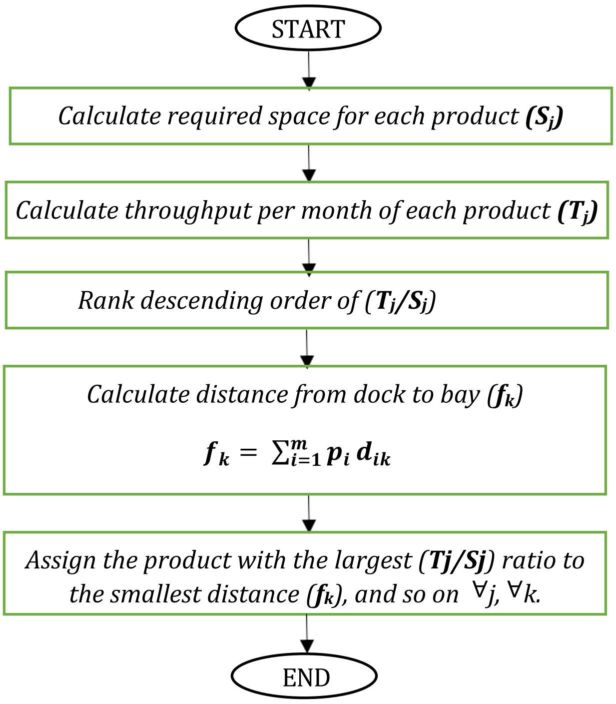


Figure 15: Dedicated assignment procedure
Source: own processing

b. Traveling Salesman Problem Model

Many TSP formulations are proposed (Davendra, 2010). This study mathematically states a symmetric TSP as follows (based on Luu, et al., 2023; Miller et al., 1960), a picker is required to visit each of n storage locations, indexed by 1, …, n. He leaves from a depot (dock) indexed by I, visits each of the n other locations exactly once, and returns to depot I, and he must visit no more than p locations in one tour. It is required to find such an itinerary that minimizes the total distance traveled. Given a 'distance matrix' $D = (d_{ij})$ where $d_{ij} = d_{ji}$ represents the distance between locations i and j, ($i \neq j = I$, 1, …, n). The model uses the following notations:

The study assumes indices, parameters, and variables as below.

I, start location index, $i = I, 1, 2, \ldots, n$

J, destination index, $j = I, 1, 2, \ldots, n$

n, number of order-picking locations including depot I.

$x_{ij} = [0,1]$, 1 if the path goes from location i to location j, 0 otherwise.

[21] Objective function: Minimization the total distance traveled.

$$\boldsymbol{Min}\ Z = \sum_{i \neq j = I}^{n} \sum_{j \neq i = I}^{n} d_{ij}\, x_{ij}$$

Subject to:

[22] $\sum_{i \neq j = I}^{n} x_{ij} = 1, \qquad j = 1, 2, \dots, n$

[23] $\sum_{j \neq i = I}^{n} x_{ij} = 1, \qquad i = 1, 2, \dots, n$

[24] $u_i - u_j + p x_{ij} \leq p - 1, \;\; i \neq j = 1, \dots, \; n$

Where objective function [21] is the minimization of the total distance to be traveled by the picker. Constraints [22] and [23] represent the conditions that each location (other than *I*) is visited exactly once. In which the x_{ij} are non-negative integers and binary, i.e., the picker proceeds from location *i* to location *j* if and only if $x_{ij} = 1$. Inequality [24] with the arbitrary real numbers (u_i), plays a role similar to node potentials in a network, and the inequalities involving them serve to eliminate tours that do not begin and end at the city *I* and tours that visit more than *p* cities. Next subsection clearly explains the above TSP heuristic algorithm.

c. Traveling Salesman Heuristic Algorithm

The detailly procedure is developed below.

- *n locations.*
- *start from depot I.*
- *go to each n other location exactly once.*
- *return to depot I.*
- *produce a distance between location i and location j: (d_{ij})*

(1) Each location j must be entered exactly once:

[25] $\sum_{i \neq j, i = I}^{n} x_{ij} = 1$ *for j = 1, …, n*

(2) Each location i must be exited exactly once:

[26] $\sum_{j \neq i, j = I}^{n} x_{ij} = 1$ *for i = 1, …, n*

(3) No sub-tours are allowed for subset of locations S not including depot 0:

[27] $\sum_{i,j \in S} x_{ij} \leq |S| - 1$ *for every subset S, where |S| is the size of S.*

(4) Alternatively, (3) may be replaced by

[28] $u_j \geq u_i + 1 - (1 - x_{ij})p$ *for j≠i = 1, 2, …, n*

```
MODEL:
!MODELING OPTIMIZATION FOR ORDER PICKING GIVEN DISTANCE MATRIX OF 3 PRODUCTS;
SETS:
PRODUCT;
ROUTE(PRODUCT, PRODUCT)|&1 #GT# &2:DISTANCE, Y;
ENDSETS
DATA:
 PRODUCT=
 A1 B3 C1 A7;
!DISTANCE MATRIX;
DISTANCE=
 207
 454 324
 345 234 510
;ENDDATA
MIN = @SUM( ROUTE: Y * DISTANCE);
@SUM( PRODUCT( I)|I #GE# 2: Y(I, 1)) = 2;
@FOR( PRODUCT( J)|J #GE# 2: @SUM(PRODUCT(I)| I #GT# J:
 Y(I, J)) + @SUM(PRODUCT(K)|K #LT# J: Y(J, K))=2);
@FOR( ROUTE: Y <= 1);
END
```

```
  LINGO/WIN32 19.0.32 (3 Dec 2020), LINDO API 13.0.4099.242
  Licensee info: Eval Use Only
  License expires: 7 JUL 2021 Global
  optimal solution found.
  Objective value:                                    1357.000
  Infeasibilities:                                    0.000000
  Total solver iterations:                                   3
  Elapsed runtime seconds:                                0.72
  Model Class:                                              LP
  Total variables:                          6
  Nonlinear variables:                      0
  Integer variables:                        0
  Total constraints:                       11
  Nonlinear constraints:                    0
  Total nonzeros:                          24
  Nonlinear nonzeros:                       0


                                      Variable           Value        Reduced Cost
                                     Y (C1, A1)        1.000000          0.000000
                                     Y (C1, B3)        1.000000          0.000000
                                     Y (A7, A1)        1.000000          0.000000
                                     Y (A7, B3)        1.000000          0.000000
                                     Y (A7, C1)        0.000000          472.0000
```

Figure 16: Algorithm model based on LINGO method
Source: own processing (Luu, et al., 2023)

Figure 16 illustrates the algorithm running with the simple case of 4 SKUs (i.e., A1, B3, C1, and A7) in the LINGO, which is shown below. The distance matrix is randomly created. According to the report, highlighted values show the distance solution of 1,357 meters with sequence A1-C1-B3-A7-A1, concerning the objective function of minimizing the picking path.

d. Data collection for Lingo solver

Data collection and data analysis procedures are the key tasks for the methodology workflow. Data is collected, calculated, and confirmed from the Operations and Finance reports that were updated in October 2020, such as the list of SKUs, warehouse dimensions, number of docks (I/O point), number of aisles, number of receiving trips of each item per month, number of shipping trips of each item per month, storage space using of each item, current storage and picking policies (strategies), purchase orders, etc.

3.6.2 Research results

a. Warehouse Layout Design

Products Ranking.

The Class-based Dedicated Storage Layout model ran with 44 SKUs which the ATP warehouse is holding, the result will show the order of priority of items. The study especially considers the experience of the Operations Department classing several SKUs together as composited SKUs such as C1-C3-C4-C5-C6, C7-C8-C9-C11-C12, C13-C14-C15-C16-C17-C18, C19-C20-C21-C22, and C23-C24-C25. Table 18 illustrates the rank of items corresponding to their activity-to-space ratios (T_j/S_j) from largest to smallest. Moreover, the study assumes that class A consists of items that have about 80% of total activity-to-space. Class B and C combine those items which have lower activity and space with 15% and 5%, respectively (Luu, et al., 2023).

Table 18: ABC classification

No.	Random Code	Activities (T_j)	# of bays (S_j)	T_j/S_j	T_j/S_j (%)	Cum. T_j/S_j	ABC
1	A7	11579	3	3859.7	8.76%	8.76%	A
2	B12	3717	1	3717.0	8.43%	17.19%	A
3	C23	3633	1	3690.0	8.37%	25.56%	A
4	C24	6					
5	C25	51					
6	B8	3054	1	3054.0	6.93%	32.48%	A
7	A5	10456	4	2614.0	5.93%	38.41%	A
8	B2	4774	2	2387.0	5.41%	43.83%	A
9	B1	2284	1	2284.0	5.18%	49.01%	A
10	C1	310	1	2243.0	5.09%	54.10%	A
11	C3	1449					
12	C4	173					
13	C5	157					
14	C6	154					
15	B6	2233	1	2233.0	5.07%	59.16%	A
16	A6	6671	3	2223.7	5.04%	64.21%	A
17	A4	12905	6	2150.8	4.88%	69.09%	A
18	C13	85	1	2056.0	4.66%	73.75%	A
19	C14	207					
20	C15	397					
21	C16	1064					
22	C17	179					
23	C18	124					
24	B4	3820	2	1910.0	4.33%	78.08%	A

25	B9	2923	2	1461.5	3.32%	81.40%	B
26	C10	1169	1	1169.0	2.65%	84.05%	B
27	B3	1060	1	1060.0	2.40%	86.45%	B
28	B5	1947	2	973.5	2.21%	88.66%	B
29	A1	9670	10	967.0	2.19%	90.86%	B
30	B11	724	1	724.0	1.64%	92.50%	B
31	C19	65					
32	C20	453	1	717.0			
33	C21	76					
34	C22	123			1.63%	94.12%	B
35	C7	43					
36	C8	216					
37	C9	243	1	662.0			
38	C11	3					
39	C12	157			1.50%	95.63%	C
40	A2	10302	16	643.9	1.46%	97.09%	C
41	B7	586	1	586.0	1.33%	98.42%	C
42	A3	5488	20	274.4	0.62%	99.04%	C
43	B10	270	1	270.0	0.61%	99.65%	C
44	C2	154	1	154.0	0.35%	100%	C
Total					100%		

Source: own processing

Layout Generating

The study proposes and evaluates 3 alternatives to the warehouse layout described in Table 19, in which Map 0 is the current warehouse.

Table 19: Layout alternative

Alternative	Description
Map 0	The 1-door current warehouse layout (see Appendix 4*a*)
Map 1	A modified 1-door current warehouse layout
Map 2	A 2-door warehouse layout

Source: own processing

- ***Map 1***

The locations of current office departments remain the same in Map 0. The total area spent for storage is 85 bays, with 2mx2m for each bay, and all I/O activities are operated through 1 dock only, hence, the probability of computing is 100% for each bay.

The overall layout is modified into five storage lines, in which three of which are double-sided designed, and the remainders are single storage lines. The aisles are created without dead-ends to ensure the constant flow of the in and out, preventing small-moving areas or congestion between orders, as well as connecting the two sides among the double-sided storage lines.

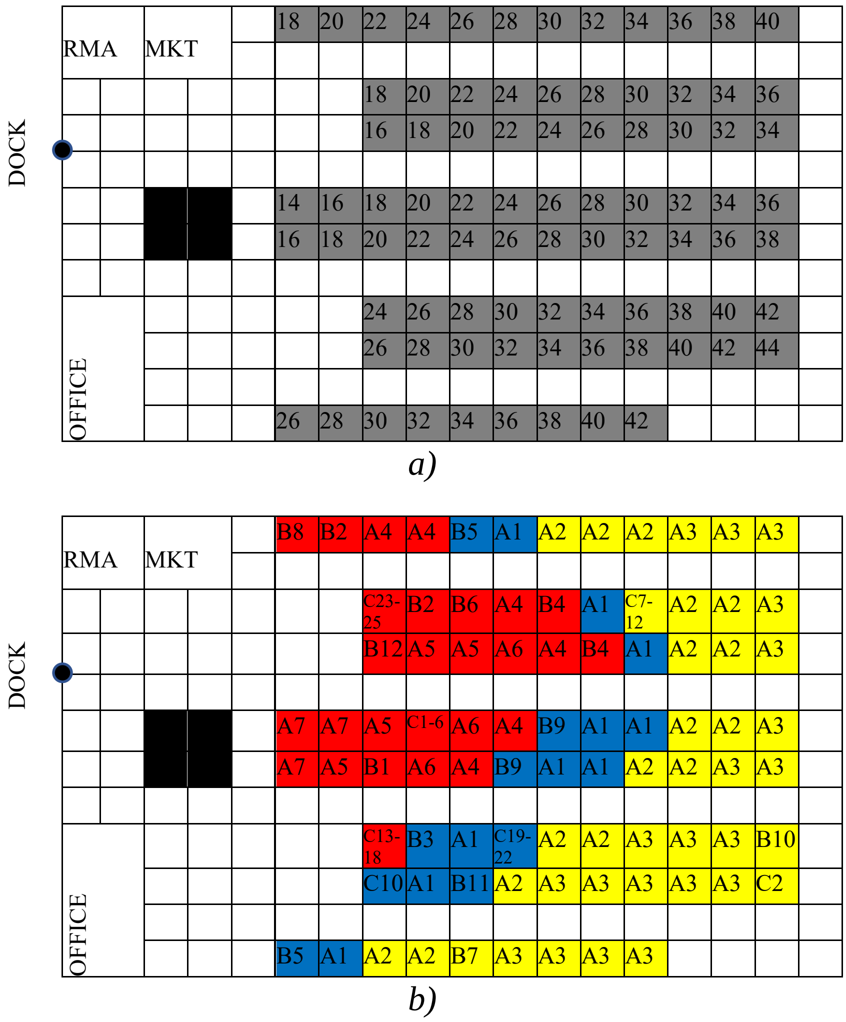


Figure 17: a) Map 1 in distance; and b) Map 1 assigned
Source: own processing

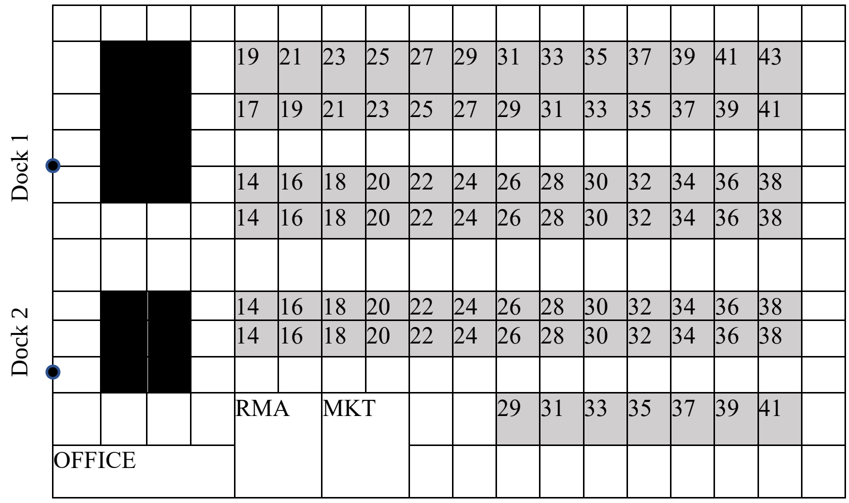
This approach recommends creating a cross-docking area to utilize the main functions of any regular warehouse. The cross-docking areas of 4mx4m, specifically located in front of the third storage line, are quite suitable to connect almost equally the lines of picking goods and the shipping path.

Appendix 5*a* shows the distance for each bay of Map 1 which is also reflected in Figure 17*a*.

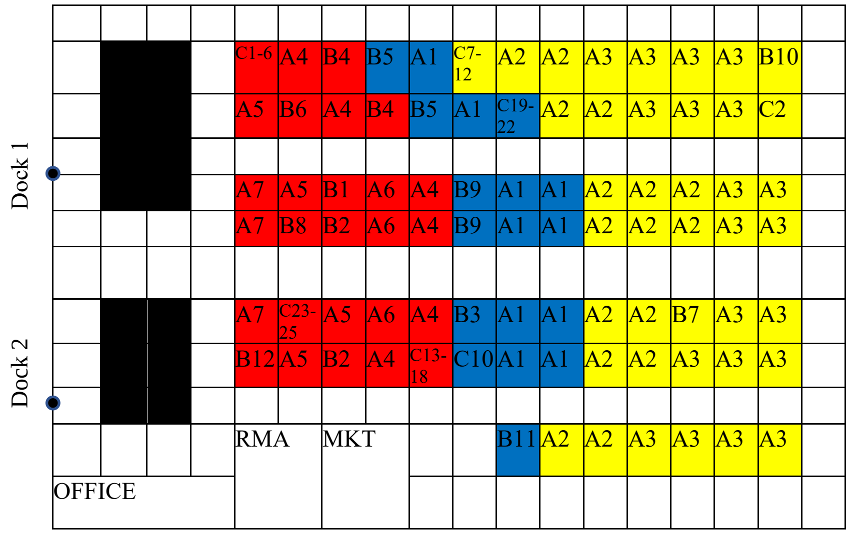
Following the procedure in Figure 15, Map 1 is assigned in which SKUs belonging to class A are first with the smallest expected distance traveled (i.e., red areas with items having the largest activity-to-space ratios). Those in green (class B) and yellow (class C) areas have moderate and low levels of activity-to-space ratios, respectively (Figure 17*b*).

- ***Map 2***

The structure of the new warehouse layout has entirely changed in this alternative by redesigning the layout for offices and other departments.



a)



b)

Figure 18: a) Map 2 in distance; and b) Map 2 assigned
Source: own processing

The number of doors is increased into two docks assuming both docks equally display functions of shipping and receiving (i.e., $p_1 = p_2 = 0.5$).

The warehouse is now divided into four storage lines. Detailly, three of them are equally double-sided lines with 26 meters in length each line. The remaining line is a single line with a length of 14 meters.

Each of the storage lines is also placed apart from each other to create a clearance of 2 meters with two-way directions aisles approached from both directions to utilize the movement within the warehouse.

Expected distance travel of 44 SKUs in this scenario is calculated (Appendix 5*b*).

Figures 18*a*, & *b* describe Map 2 with its distance and storage location assigned for all 44 SKUs, respectively.

b. Picking Path Optimization

After reassigning products into new design layouts properly, the constructed distance matrix of SKU to SKUs is computed for each layout alternative. Purchase orders are randomly picked for determining the picking path over three maps solved in LINGO with TSP heuristic algorithm to produce a feasible or near-optimal picking path (Appendices 6).

Table 20: Order picking performance in 3 Maps

		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Average distance**	**Total distance**
Distance per order (m)	Map 0	100	90	66	72	116	94	96	64	79	88	87	865
	Map 1	80	76	60	66	28	82	66	72	80	92	70	702
	Map 2	48	68	48	40	50	88	64	64	60	68	60	598
Map 1 improvement		20 %	16 %	09 %	08 %	76 %	13 %	31 %	-13 %	-01 %	-05 %		
Map 2 improvement		52 %	24 %	27 %	44 %	57 %	06 %	33 %	00 %	24 %	23 %		

Source: own processing

For example, an order of 7 SKUs (i.e., A1, B1, A4, B10, A2, A3, and C2) is used 10 times in the model (Appendix 7), and the LINGO outcomes in average distance travel are 87m, 70m, and 60m over Map 0, Map 1, and Map 2, respectively (Table 20).

As a result, Map 2 has been chosen with the final percentage utilization and optimization of approximately 31% and 15% compared to Map 0 and Map 1, respectively (Table 21). Map 2 has been determined as the greatest 'candidate' that the study is aiming for. In addition, Map 1 which has small modification is also considered a second choice in case the ATP does not want to change department layouts due to its overall improvement in the distance of 19% compared with Map 0 although Map 1 has negative impacts on running times of 8 to 10 (see Table 20).

Table 21: Pair comparison of maps

Pair Comparison		**Map 0**	**Map 1**	**Map 2**
		87	*70*	*60*
Map 2	*60*	31%	15%	-
Map 1	*70*	19%	-	
Map 0	*87*	-		

Source: own processing

3.6.3 Discussion and recommendation

In summary, this study is the final quantitative attempt of the thesis to satisfy the fourth research question and associated objective of the proposed model optimization using the CO approach of the CDA and TSP to suggest a class of decisions in warehouse layouts to optimize the picking paths. This study, once again, highlights the outstanding impact of high-technology applications (Hypothesis 1*a* & *b*) on a company in which warehouse layout is a crucial function of supply chain operations that was outlined in the proposed research framework and design, specifically in the ID403 variable of model and algorithms.

Obviously, the study satisfies established objectives that utilize ID4.0 techniques (ID403: the mathematical models and algorithms) in rearranging the current layout and optimizing picking traveled distance to list out suggestions insightfully for the better executive performance of the ATP management. Specifically, through practical testing and programming running, the total time traveling as well as expected distances traveled is massively decreased with Map 2 and Map 1 by redistributing the storages in a more reasonable consideration, logical calculation, and reorganizing the warehouse layout. From a management perspective, ATP should run the most beneficial Map 2 for outstanding warehouse management. Aside from that, satisfaction and the requirements of customers are achieved.

By observing the current storage equipment that ATP is using, which is wooden pallets to store the products. Authors recommend applying suitable disinfestations to avoid possible destruction caused by termites and other insects, massive effect on products within the warehouse area as well as the workplace environment in general. The author highly suggests using high-tech applications in automation and optimization to enable the ATP logistics operations to operate more quickly, efficiently, and in response to shifting market need (Orkestra, 2023). If the ATP is geared toward smart logistics, other smart equipment with AI applications should be explored (Kalkha et al., 2023). Another approach is recommended to help workers enhance their awareness of correct working postures, especially mentioned in the ergonomics and motion study.

A deeper analysis should be conducted to learn more about the frequency and forecasting of future demands from main ATP consumers. Better visions of the demand tendency would affect a lot the way of management as well as the final warehouse layout, which could be effectively used and conducted over a long time.

Finally, the study orients insight into concerns in competitiveness and sustainable development that satisfy three dimensions of economy, environment, and society.

For example, the renewed layout brings economic advantages for ATP by minimizing the logistic costs as well as significant impacts on the entire ATP supply chain environmentally friendly, reducing travel time and distance and causing lower energy usage and CO_2 emission. Moreover, the improved order picking ensures labor health and safety as well as customer satisfaction which leads ATP to become a unique competitive advantage in the labor market.

In summary, three quantitative studies in real cases aim thereby learning how Vietnamese businesses approach the circular economy model in their green and sustainable operations for business performance assessment to ensure a competitive advantage in the era of Industry 4.0 or beyond (Luu, et al., 2023; Luu, 2022).

4 DISCUSSION AND CONTRIBUTIONS

4.1 Discussion

Obviously, the thesis outlines that the green logistics and sustainable supply chain is motivated and oriented by the convergence of three driving forces: economic trends, technological advancements, and policy challenges (World

Bank, 2017)[11] in light of two theoretical lenses of Resource-Based View (Barney, 1991) and Policy Feedback Theories (Pierson, 1993) (Luu, et al., 2023). Additionally, it emphasizes two autonomous components, namely, the configuration and collaboration within supply chain networks (CON and COL). These interrelated factors play an integral role in shaping the complexity of global logistics networks, facilitating the movement of goods and services across international boundaries.

Economic trends encompass a wide range adoption of circular economies (CEA) or green economies and sharing economies in a knowledge-based economy context that exerts significant influence on GLS. Understanding these trends is crucial for logistics stakeholders to optimize their operations and adapt to changing market dynamics.

Technological advancements usher in a new era of efficiency, effectiveness, and connectivity within GLS transitions and practices. Such as ID4.0 technologies are defined in the thesis as the number of high-tech applications (ID401), the number of digitalized processes (ID402), and the applied mathematical model and its algorithm (ID403) that enable visibility, transformation, and redesign networks, minimize logistics costs, optimize distance traveled and times, etc., to enhance the overall resilience of logistics and supply chain networks and sustainable competitiveness of an organization or country.

Policy challenges encompass a spectrum of regulatory, government legal, geopolitical issues (GOP), and design strategies (CE Framework) that logistics professionals must handle. Staying abreast of evolving regulations and developing strategies to mitigate their impact is crucial for sustainable and compliant logistics operations.

In summary, green logistics and sustainable supply chain is a complex and dynamic field that integrates of economic forces, technological innovations, and policy considerations (Luu, 2022). Recognizing and utilizing these driving forces is critical for organizations engaged in global logistics to remain competitive, efficient, and adaptable in an ever-evolving global marketplace. This research contributes both theoretical and practical insights as follows.

4.2 Theoretical implications

The research examined two theoretical lenses of Resource-Based View and Policy Feedback Theories (Luu, et al., 2023). Circular economics, green logistics & sustainable supply chain are the main areas of knowledge. Literacy on high-tech applications such as the adoption of blockchain, and AI technologies in

[11] *https://www.worldbank.org/en/news/speech/2017/05/22/performance-and-prospects-of-global-logistics*

Vietnam SMEs is scarce (Luu, 2022). The study contributes to developing the conceptual framework of the CE model on green logistics and sustainable supply chain transitions and practices (see Figure 3*b*) as well as in the knowledge economy context (KCE model in Section 3.4) (Luu, et al., 2023; Luu & Chromjaková, 2023a, 2023b; Luu, 2022). The detail theoretical contributions as follows.

Firstly, this thesis makes significant contributions to the body of knowledge in the areas of knowledge-based economics, circular economics (CE), and green logistics and sustainable supply chain (GLS) literature highlighting the impacts of ID4.0 on circular economy adoption within the context of GLS transitions (Luu, et al., 2023). This research augments the existing literature by addressing a critical gap, specifically, the scarcity of studies that have comprehensively examined the interactive dynamics of GLS practices within a CE context, under the impact of ID4.0.

Although some scholars have delved into GLS-oriented investigations, primarily exploring ID4.0 and its associated consequences on CEs and GLS to foster operational excellence and sustainable performance (Luu, et al., 2023; Rehman Khan et al., 2022; Shayganmehr et al., 2021; Ghadimi, Wang and Lim, 2019; Kouhizadeh, Zhu and Sarkis, 2020), the specific integration of CE and ID4.0 explored in this study represent a novel contribution to the existing body of literature.

Moreover, an unexpected but insightful revelation emerging from this study is the absence of a correlation between government policy and the adoption of the circular economy, particularly within the context of Vietnam.

Secondly, this research extends the contributions of prior studies by emphasizing the implementation of circular economy principles in green logistics and sustainable supply chain, both in the development of a conceptual framework and practical applications. Existing literature has predominantly focused on conceptual framework development. However, the practical considerations of these concepts, particularly within developing countries, have received limited attention. Thus, this study broadens our understanding by shedding light on the practical concerns between GLS transitions and the optimization of business process management, subsequently impacting business performance.

Lastly, this study addresses revealed gaps within green logistics and sustainable suppy chain research, marking one of the initial endeavors to advance the understanding of circular economy adoption under a high-technology context specific to GLS. Consequently, it underscores the importance of future research efforts aimed at refining and further elucidating the outcomes and findings.

4.3 Practical implications

The study provides practical implications to answer each of the corresponding research questions as below.

RQ1 "Do high-tech applications impact CE adoption and GLS?"

The research framework offers valuable insights for practitioners, including companies, universities, and government sectors, particularly within the context of high-tech adoption in Circular Economy Adoption and Green logistics and Sustainable Supply Chai. It facilitates the adoption of CE principles on GLS practices. This research represents one of the initial empirical validations of the connections between ID4.0 and CEA in GLS in the Vietnam context. Furthermore, the robust influence of ID4.0 underscores the significance of high-tech applications within companies, driving strategic changes and decisions to optimize GLS operations and foster sustainable development (Luu, et al., 2023; Luu, 2021a, 2021b). This also enhances Vietnam's competitiveness within ASEAN such as Thailand and helps reduce the gap with more developed countries.

RQ2 "How government policies influence CE adoption?"

The study reveals that the relationship between government policy and CE adoption reflects the current strategic awareness and operations in Vietnam, as well as the formulation and implementation of policies (Luu, et al., 2023). This finding offers valuable insights for government stakeholders to enhance their legal services. It also benefits universities by encouraging the development of modern logistics and supply chain programs, equipping human resources with contemporary concepts and technologies for Vietnam's logistics and supply chain industry, which plays a crucial role in the global supply chain network.

RQ3 "Do supply chain collaboration and configurations play a role in a GLS network?"

In terms of supply chain collaboration and configurations within the GLS network, this research elucidates their role and impact. These insights aid in optimizing supply chain structures, fostering collaboration, and enhancing overall network performance, contributing to more efficient and sustainable GLS practices.

RQ4 "How does a CE model adoption for GLS?"

Finally, this thesis investigates a model of CE adoption for GLS both validation and optimization under a high-technology context. It provides guidance and applicable insights for the Board of Management to embrace CE practices in their operations including facility requirements, logistics cost optimization (e.g., SME), warehouse layout improvements for efficient pick paths and sustainability (e.g., ATP), and enhancements in business process management within a knowledge-based, circular economics context for sustainable competitiveness (e.g., MVN). This aligns with the core corporate values of green and sustainable practices essential in a premium circular economy that aligns with the research motivation and achieving the objectives.

In summary, this study not only addresses the raised research questions but also offers practical solutions and insights that can benefit a wide range of stakeholders, from companies and universities to government sectors, and ultimately contribute to the advancement of sustainable practices within the GLS industry.

5 CONCLUSIONS

5.1 Conclusion of the thesis

According to the existing literature, although the theme of CE and GLS and its adoption have attracted scholars, this thesis is motivated by emerged research gaps, as follows:

a) Contributions of CE integrated with high-tech applications for GLS transitions and practices to corporation performance, in both sides of framework validation and optimization, have been still missing.

b) There has been a lack of studies aimed at investigating GLS practices-oriented along with green and sustainable mindsets in Vietnam.

In order to conduct this study, the author refers to mixed research approaches. These approaches are an appropriate way to understand the complexity of the research statement (Creswell & Creswell, 2017). The study is designed to cooperate with the qualitative and quantitative data collection and analysis procedures which are employed sequentially in six single studies in which the author emphasizes on three key companies in Vietnam for conducting quantitative studies.

In general, the first two qualitative studies aim to explore CE adoption for GLS transitions to develop the conceptual framework, associated hypotheses, and its measurement development that are important fundamentals for employment another qualitative technique of interview and review with 18 key persons to finalize the questionnaire that use for collecting primary data for the next quantitative study (Luu, et al., 2023).

The third quantitative study of validating the proposed model and its hypotheses using PLS-SEM technique. There were 210 valid respondents for this study. Respondents come from the network of universities, companies, and public sectors with a range of positions on professors, CEO/managers, students, and employees who have knowledge and/or experience on logistics, supply chain fields (Luu, et al., 2023). The main findings confirmed the dominant impacts, directly and indirectly, of Industry 4.0 on Circular Economy Adoption and Green logistics and Sustainable Supply Chain; Circular Economy Adoption positively affects Green Logistics and Sustainable Supply Chain; Circular Economy Framework positively impacts the Circular Economy Adoption; Collaboration and Configuration positive impact on Green Logistics and Sustainable Supply Chain network, correspondently. Due to hypotheses of H1a, H1b, H2, H3, H5, and H6 are accepted, respectively (Luu, et al., 2023). Nevertheless, there is no evidence for the impact of the Government Policy on Circular Economy Adoption, because of rejecting H4.

The fourth quantitative study investigate a Vietnam company in their secondary data, in which, a critical analysis was used for the MVN company to examine the impact of the CE framework on their business process management under the knowledge economy context and high-tech applications. This work focuses on the value chains of the MVN by assessing the business performance as a resulted-on adoption of a premium circular economy model.

The last two quantitative studies employ MCDM and CO approaches for offering optimal solutions for distribution supply chain network design and order-picking warehouse operations in the SME and the ATP companies, respectively. The main findings help the CEO and managers make or change their strategic, tactical, and operational decisions to improve the business processes in an optimization manner along with competitiveness and sustainable development.

In summary, the results point out that green and sustainable mindsets and practices are the main factor that stimulates the adoption of circular economics for GLS transitions and practices under the impact of high-tech applications in a knowledge economy context. Next section outlines several limitations and further studies.

5.2 Limitation and further research

The limits of this study provide novel prospects for the conduct of further research in the relevant area.

Firstly, this research primarily focused on the Vietnamese industry. In future investigations, it is imperative to expand the scope by incorporating other countries into the analysis. This comparative approach will facilitate an examination of divergent experiences in adopting CE principles within GLS transitions and operations.

Secondly, within the broader context of green and sustainability concerns, there exists an opportunity for further inquiry into alternative sectors, such as agriculture, where Vietnam holds a pivotal role as a major global supplier of rice. This sector could serve as a noteworthy subject for future studies, exploring the integration of CE principles and sustainable practices.

Thirdly, the scales, algorithms, and programming languages employed in this study are primarily drawn from existing software with established validation in small and medium sizes. It is recommended that forthcoming research endeavors aim to develop and assess novel measurement scales, advanced algorithms like metaheuristics, and modern programming languages such as Python. These innovations will enhance the capacity for evaluating and optimizing GLS operations.

In conclusion, future research should strive to broaden its scope to foster sustainable development not only within logistics and supply chains but also across diverse sectors, encompassing manufacturing, and agriculture, within the context of various countries. Comprehensive sustainability, encompassing economic, environmental, and social dimensions, necessitates the infusion of green principles into all facets of society, including the educational system, spanning from primary schools to universities, as well as the daily routines of individuals. Cultivating an understanding and appreciation of these principles among individuals is a critical step toward embracing a culture of ‘green and sustainability’.

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Journals

Luu, T. V., and Chromjaková, F. (2023). Knowledge-based circular economics model for sustainable competitiveness: Framework development and analysis. *Environment, Development and Sustainability, ISSN 1387585X, 15732975,* Accepted December 23, 2023. DOI :10.1007/s10668-023-04415-2 (***IF^{2022}=4.9, SCIE***).

Luu, T. V., Chromjaková, F., & Bobák, R. (2023). An optimization approach for an order-picking warehouse: An empirical case. *Journal of Competitiveness*, 15(4), 154-178. https://doi.org/10.7441/joc.2023.04.09 (***IF^{2019}=3.649; SSCI/Q1***).

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Conferences

Luu, T. V., & Chromjaková, F. (2023). An Optimization Model for a Retail Distribution Supply Chain Network Design – A Case Study. *Proceedings of the 6th European Conference on Industrial Engineering and Operations Management*: Sustainable Data Driven Supply Chain, ISBN: 979-8-3507-0547-8 ISSN/E-ISSN: 2169-8767, https://doi.org/10.46254/EU6.20230036, Publisher: IEOM Society International (***EBSCO, Google Scholar and IEOM Index***).

Luu, T. V. (2022). Impacts of COVID-19 on customer behavior along green logistics operations: A conceptual framework. *Proceedings of the 16th International Scientific Conference INPROFORUM* - DIGITALIZATION. Society and Markets, Business and Public Administration, 1st edition, pp. 90-95, 2022, ISBN 978-80-7394-976-1, online ISSN 2336-6788 (http:/inproforum.ef.jcu.cz/INP2022), DOI: 10.32725/978-80-7394- 976-1.14 (***WoS indexing***).

Luu, T. V. (2022). Adoptions of industry 4.0 and circular economics for green logistics and sustainable supply chain: a proposed research framework for Vietnam industry. *International Doctoral Seminar 2022 Proceedings*, 1st edition, pp. 140-153, 2022, ISBN 978-80-8096-292-0 EAN 9788080962920

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Work experience

- 2010 – to date: Lecturer at International University, VNU- HCMC.
- 2001-2010: Lecturer and director at AITVN, STU, TDTU, TNV, and BigC.
- 1996-2001: Supervisor and manager at KAO; S.C. Johnson & Son

Education

- 2020 – to date: Ph.D. student at Tomas Bata University, Czech Republic
- 2002 – 2003: Master's degree at Katholieke Univeriteit Leuven, Belgium
- 2001-2002: Diploma program at Asian Institute of Technology, Thailand
- 1991-1996: University Degree at HCMC Polytechnic University, Vietnam

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- Green Logistics and Sustainable Supply Chain and Production
- Optimization and data analysis using statistical tools.

Research activities at Tomas Bata University in Zlin

- M-SI-1817-2324-172622. Tourism and Agriculture Sustainable Alliances - #TASA network, BOKU - University of Natural Resources and Life Sciences, Vienna, Department for Landscape, Spatial and Infrastructure Sciences, 10-11/2023.
- M-RS-1011-2223-162043. Fostering sustainable partnership between academia and industry in improving the applicability of logistics thinking (FINALIST), University of Maribor, Faculty of Logistics, Slovenia, 02-05/2023.
- IGA/FaME/2022/005 - Industry 4.0 and Circular Economy Adoption for Manufacturing and Logistics Processes, 2022-2023.
- IGA/FaME/2020/011 - Investigation of the current economic topics in the Southeast Asia region, 2020-2021.
- Peer Review for the manuscript of "Environmentally sustainable supplier development and environmental sustainability practices' adoption among suppliers", *Business Strategy & Development*, Web of Science record, 2023-12-08.
- Peer Review for the manuscript of "Collaborative Technologies and Project Performance in Manufacturing in the Industry 4.0 Environment: Mediating Effect of Individual, Organizational, Sociotechnical Factors", *Business Strategy & Development*, Web of Science record, 2023-08-29.
- Peer Review for the manuscript of "Drivers and barriers in the institutionalization of circular economy practices in food supply chains: A review", *Business Strategy & Development*, Web of Science record, 2023-06-17.

APPENDICES

APPENDIX 1a - Interview protocol

Interviewees will get the semi-structured interview process (with the format of questionnaire in Vietnamese and English) to provide them with a point of reference and allow them to prepare for the interview. The interview will take about 60 minutes.

A. Warm up Step

1. Greetings, providing information regarding the researcher, the study overview, and the interview goal.

"*The project aims to understand an overview of circular economy adoption for green logistics and sustainable supply chain transitions" in Vietnam. The project is a part of the doctoral thesis. Its output will be published in academic conferences or journals"*.

2. The researcher is obligated to keep the following commitments:

- Maintain confidentiality for all information provided (answers recorded will be discarded after being transcribed).
- Cause no harm to any individual or organization.
- Valuable responses and contributions (with a 75 percent agreement rate) to be contributed to the research.

B. Development Step

I. **Collects interviewees' information.**

Name, background, position, organization, department, etc.

II. General Questions.

- Have you known "green and sustainable mindset" in logistics and supply chain operations (GLS)? and in adopting the circular economy model (CE)?
- What green practices are applied in your organization?
- Can you give me some examples, please?

III. Look at the questionnaire.

1. Questions about supply chain collaboration and configuration (COL and CON) impact to GLS

- Do you agree that COL and CON impact positively the GLS network?
- Do you think the 6 proposed indicators (i.e., …) have a relationship closely to COL and CON, respectively that enables GLS network?
- Do you have any thoughts/practices about anything else about and within COL and CON development?

2. **Questions about green logistics and sustainable supply chain (GLS)**

- Do you agree with 9 proposed indicators (i.e., ….) contribute to GLS transitions and practices in the context of CE?
- If there is anything else, kindly share it with me.

3. **Questions about circular economy adoption (CEA)**

- Do you think CEA positively affects GLS transitions?
- Do you think the 5 proposed indicators (i.e., ….) have a close relationship with CEA that enables GLS transitions?
- If there is anything else, kindly share it with me.

4. **Questions on designing of circular economy framework (CEF)**

- Do you think CEF positively impacts CEA?
- Do you agree with the 5 proposed strategies (i.e., ….) that enough for a CEF design?
- If there is anything else, kindly share it with me.

5. **Questions about high-tech application (ID4.0)**

- Do you think ID4.0 directly and indirectly impacts CEA and GLS, respectively?
- Do you agree with the 3 proposed indicators (i.e., ….) have a close relationship with ID4.0?
- If there is anything else, kindly share it with me.

6. **Questions about government policy (GOP)**

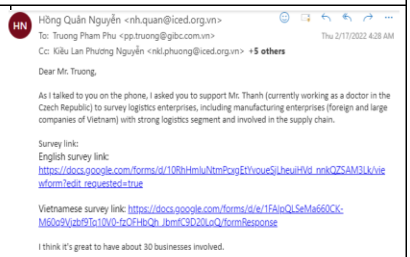
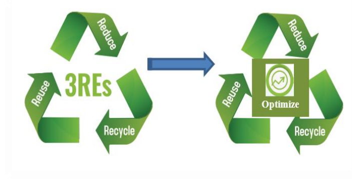
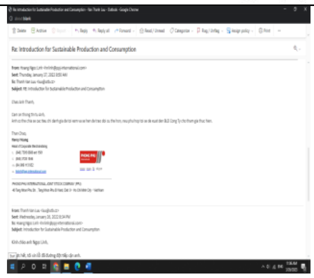
- Do you think GOP positively impacts CEA?
- Do you agree with the 4 proposed indicators (i.e., ….) have a close relationship with the GOP?
- If there is anything else, kindly share it with me.

C. Closing Step: Thank you for your time and contribution to the thesis.

APPENDIX 1b - List of key persons

No	Cat.	Name	Involved Activities			Position & Institution
			Consult	Interview	Review	
1	Universities - Professors	Prof. Ing. Felicita Chromjaková	✓			Professor at TBU, Czech Republic
2		Assoc.Prof.Dr. Ing. Roman Bobák	✓			Thesis Supervisor at TBU, Czech Republic
3		Dr. Pham Thi Hoa		✓		Professor at IU – VNU, HCMC
4		Dr. Pham Ngoc		✓		Professor at IU – VNU, HCMC
5		Dr. Nguyen Cong Thanh		✓		Professor at Asian Institute of Technology
6	Universities - Lecturers	Dr. Nguyen Dinh Hung		✓		Lecture at Vietnamese-German University, VN
7		Msc. Bui Doan Danh Thao		✓		Lecturer at IU – VNU, HCMC
8		Dr. Tran Thanh Tu		✓		Lecturer at IU – VNU, HCMC
9		Msc. Le Thi Nam Phuong		✓		Lecturer at Gia Dinh University, Vietnam
10	Companies	Dr. Nguyen Hong Quan		✓		Director/Assoc. Prof. at the ICED in VNU -VN
11		Msc. Pham Phu Truong		✓		CEO/Deputy Director at the ICED, Vietnam
12		Mr. Hoang Ngoc Linh			✓	CEO/Director at the PPJ, Vietnam
13		Mr. Thong			✓	Logistics Manager at the Akzonobel, VN
14		Mr. Le Tuan Anh			✓	Production Manager at the Vinamilk, Vietnam
15	Public Departments	Dr. Nguyen Kieu Lan Phuong		✓		Senior Leader at ICED in Vietnam
16		Msc. Tran Thi Diem Phuc		✓		Associate at ICED in Vietnam
17		Msc. Le Ba Nhat Minh		✓		Assistant Director at ICED in Vietnam
18		Msc. Nguyen Thi Minh		✓		Manager at Agriculture Institute in Vietnam

APPENDIX 1c - List of key companies

Companies	%	Contactor	Facilitator	Communication channel	
1. CO. OP Mark: Retail distributor with supermarket networks. http://www.co-opmart.com.vn/	33.4	Partners of CEO Pham Phu Truong	CEO Pham Phu Truong, Dr. Nguyen Hong Quan	Email, meeting	 Hồng Quân Nguyễn <nh.quan@iced.org.vn> To: Truong Pham Phu <pp.truong@gibc.com.vn> Thu 2/17/2022 4:28 AM Cc: Kiều Lan Phương Nguyễn <nkl.phuong@iced.org.vn> +5 others Dear Mr. Truong, As I talked to you on the phone, I asked you to support Mr. Thanh (currently working as a doctor in the Czech Republic) to survey logistics enterprises, including manufacturing enterprises (foreign and large companies of Vietnam) with strong logistics segment and involved in the supply chain. Survey link: English survey link: https://docs.google.com/forms/d/10RhHmluNtmPcxgEtYvoueSjLheuiHVd_nnkQZSAM3Lk/viewform?edit_requested=true Vietnamese survey link: https://docs.google.com/forms/d/e/1FAIpQLSeMa660CK-M60o9Vjzbf9Tq10V0-fzOFHbQh_JbmfC9D20LoQ/formResponse I think it's great to have about 30 businesses involved.
2. Vinh Nghiep Ltd. Company: a retail distribution company.		Mrs. Nguyen Thi Ngoc Mai - Chief of accounting	Mr. Huynh Quoc Gia	Tel., email, etc. 	**The SME case in the thesis** 
3. TP-link Technologies Vietnam Co., Ltd.: networking equipment and accessories. https://www.tp-link.com/vn/	16.7	Mrs. Nguyen Thi Ngoc Hang – Operations Depart. of TP-Link	Mrs. Pham Bich Khue, Nguyen Nhu Phuong, Duong Minh Hien	Email, visiting, etc..	**The ATP case in the thesis** 
4. Vietnam Dairy Product Joint Stock Company: Dairy/nutrition products https://www.vinamilk.com.vn/en	49.9	Mr. Le Tuan Anh - Production Line Manager	Dr. Nguyen Hong Quan and Msc. Le Thi Nam Phuong.	Zalo web, website, etc.	**The MVN case in the thesis** 
5. Akzonobel Company: Paints & coatings. https://www.akzonobel.com		Mr. Thông - Logistics Manager	Dr. Pham Thi Hoa.	Mobil message, email, etc.	
6. Phong Phu International Joint Stock Comapany (PPJ): Textile and garment. https://www.ppj-international.com/index.html		Mr. Hoang Ngọc Linh - Head of Corporate Merchandising	Msc. Le Thi Nam Phuong	Zalo web, email, etc.	

APPENDIX 2a - Questionnaire (English and Vietnamese)

My name is Luu Van Thanh, a Ph.D. student at Tomas Bata University in Zlin, the Czech Republic. I am investigating an integrated Industry 4.0 and Circular Economy model for Green Logistics and Sustainable Closed-loop Supply Chain. I am looking forward to receiving your comments on the model. I promise that the information you provide will be kept confidential and only used for the research process. I thank you very much for your answer.
Tôi là Lưu Văn Thành, là nghiên cúu sinh tiến sĩ tại Đại học Tomas Bata ở Cộng hòa Séc, hiện tôi đang nghiên cứu về áp dụng mô hình tích hợp kinh tế tuần hoàn và công nghệ 4.0 cho logistics xanh & chuỗi cung ứng khép kín bền vững. Tôi rất mong sẽ nhận được sự góp ý của Quý Anh/ Chị cho mô hình mà tôi đang nghiên cứu. Tôi cam kết những thông tin Quý Anh/ Chị cung cấp được bảo mật, chỉ phục vụ cho quá trình nghiên cứu. Tôi rất cảm ơn sự cộng tác của Anh/ Chị.

I – Integrated Industry 4.0 (ID4.0) and Circular Economics (CE) Model and for Green Logistics and Sustainable Supply Chain (GLS).
Nội dung về mô hình tích hợp công nghệ 4.0 và kinh tế tuần hoàn cho logistics xanh và chuỗi cung ứng bền vững.
Circular economy and Industry 4.0 are emerging concepts. While ID4.0 resulted from technological innovation that focuses on production, a CE was formed from social innovation that focuses on consumption. There are cross-cutting and influencing business models and strategies. The concepts benefit each other (Cagáňová, Chromjaková, & Sujanová, 2020). ID4.0 technology is a foundation for CE strategies by addressing those technologies as a basis for sustainable management decision-making.
There is a need for a better understanding of an integrated framework of ID4.0 and CE for green logistics and sustainable supply chain (GLS) that aims to improve three pillars of their sustainability performance, i.e., economic, environmental, and social objectives.
The proposed framework for GL & SCSC is constructed of 7 factors (32 observed variables) with three main aspects of government, enterprise, and university. This research involves how CE and ID4.0 can influence and adopt for logistics and supply chain field to solve problems that arise in their operations along with the new trend of a green and sustainable mindset. In general, the circular economy can be considered as a tool to solve social-economic-environmental problems to achieve sustainable development goals in the context of environmental pollution and resource depletion.

Kinh tế tuần hoàn và Công nghệ 4.0 là những khái niệm mới nổi. Trong khi ID4.0 là kết quả của sự đổi mới công nghệ tập trung vào sản xuất, thì CE được hình thành từ sự đổi mới xã hội định hướng vào tiêu dùng. Chúng xuyên suốt, ảnh hưởng qua lại và mang lợi ích cho nhau. Công nghệ 4.0 là nền tảng cho các chiến lược kinh tế tuần hoàn làm cơ sở cho việc ra quyết định quản lý bền vững.
Nhu cầu cấp thiết phải hiểu rõ về khuôn khổ tích hợp của mô hình kinh tế tuần hoàn và công nghệ 4.0 cho lĩnh vực logistics xanh và quản lý chuỗi cung ứng bền vững (GLS) nhằm mục đích cải thiện hoạt động bền vững, tức là thỏa cả ba mục tiêu kinh tế, môi trường và xã hội.
Khung đề xuất cho GLS được xây dựng bằng 7 nhân tố (32 biến quan sát) ở ba khía cạnh khảo sát chính là nhà nước, doanh nghiệp và trường đại học. Nghiên cứu này khảo sát ảnh hưởng và ứng dụng của kinh tế tuần hoàn và công nghệ 4.0 trong lĩnh vực logistics và chuỗi cung ứng để giải quyết các vấn đề nảy sinh trong hoạt động của nó theo tư duy xanh và bền vững. Nhìn chung, kinh tế tuần hoàn có thể coi là công cụ giải quyết các vấn đề xã hội - kinh tế - môi trường nhằm đạt được các mục tiêu phát triển bền vững trong bối cảnh ô nhiễm môi trường và cạn kiệt tài nguyên.

1. Please give some information about your understanding of CE and ID4.0? Please tick (X) on the correct box.
Anh/ Chị hãy cho biết một vài thông tin về CE và ID4.0. Xin hãy tích (X) vào ô mà Anh/ Chị thấy đúng.

☐ Your organization has applied new business models and high-tech in its operations. (*Công ty Anh/ Chị có áp dụng các mô hình kinh doanh mới và công nghệ cao trong hoạt động).*

☐ You have knowledge/ information of CE & ID4.0 (A*nh/ Chị có hiểu biết/ thông tin về kinh tế tuần hoàn và công nghiệp 4.0*)

☐ You have been trained in CE for the last 5 years (*Anh/ Chị được đào tạo về kiến thức về kinh tế tuần hoàn trong thời gian 5 năm gần đây*)

☐ You have been trained in the new technologies in ID4.0 for the last 5 years (*Anh/ Chị được đào tạo về các công nghệ mới trong Công nghiệp 4.0 trong thời gian 5 năm gần đây*)

☐ You have studied, researched, and taught on the application of CE, ID4.0 and GLS (*Anh/ Chị từng tìm hiểu, nghiên cứu và giảng dạy về việc áp dụng mô hình kinh tế tuần hoàn, công nghệ 4.0, cũng như lĩnh vực logistics và chuỗi cung ứng*)

If you do not have any understanding of CE and ID4.0, the survey ends here. If you choose any of the above options, please continue the survey. Thank you very much.
Nếu Anh/ Chị không có bất kỳ sự hiểu biết gì về kinh tế tuần hoàn và công nghiệp 4.0 thì cuộc khảo sát đến đây kết thúc. Nếu Anh/ Chị chọn bất kỳ

tùy chọn nào ở trên thì xin mời tiếp tục cuộc khảo sát. Cảm ơn Anh/ Chị rất nhiều.

2. The factors of CE and ID4.0 model for GLS.

Please rate the importance of the factors in the proposed CE and ID4.0 model for GLS that I have given by ticking (X) in the appropriate boxes with the following convention:

(1: least important; 2: less important; 3: moderately important; 4: more important; 5: most important)

You rate the factors based on your knowledge and experience to answer the question "What factors are important for the proposed CE & ID4.0 model?". This question is NOT about evaluating the implementation in your company.

Anh/ Chị hãy đánh giá sự quan trọng của các yếu tố trong mô hình CE & ID4.0 cho logistics xanh và chuỗi cung ứng bền vững mà tôi đã đưa ra bằng cách đánh dấu (X) vào các ô thích hợp với qui ước sau:

(1: Rất ít quan trọng; 2: Ít quan trọng; 3: Quan trọng; 4: Rất quan trọng; 5: Hoàn toàn quan trọng)

Anh/ Chị hãy đánh giá các yếu tố dựa trên kiến thức và kinh nghiệm của mình để trả lời câu hỏi "Yếu tố nào là quan trọng của mô hình CE và ID4.0 được đề xuất?". Câu hỏi này KHÔNG đánh giá việc thực hiện trong công ty của Anh/ Chị.

	Factors and observed variables (Các yếu tố và biến quan sát)	**1**	**2**	**3**	**4**	**5**
I	**Supply Chain Collaboration_COL (Hợp tác trong chuỗi cung ứng)**					
I.1	In the CE & ID4.0 model, GLS is enabled by collaboration with supply chain partners within and beyond the immediate industrial boundaries. *Trong mô hình kinh tế tuần hoàn và công nghệ 4.0, logistics xanh và chuỗi cung ứng bền vững được kích hoạt bởi sự hợp tác với các đối tác chuỗi cung ứng từ nhiều ngành công nghiệp.*	**1**	**2**	**3**	**4**	**5**
I.2	In the CE & ID4.0 model, GLS is enabled by a supply chain wide responsibility for implementing CE principles. *Trong mô hình kinh tế tuần hoàn và công nghệ 4.0, logistics xanh và chuỗi cung ứng bền vững được kích hoạt bởi trách nhiệm được phân bổ trên toàn chuỗi cung ứng cho việc thực hiện các nguyên tắc kinh tế tuần hoàn.*	**1**	**2**	**3**	**4**	**5**
I.3	In the CE & ID4.0 model, GLS is enabled by enhanced information sharing and technical support within the value chain. *Trong mô hình kinh tế tuần hoàn và công nghệ 4.0, logistics xanh và chuỗi cung ứng bền vững được kích hoạt nhờ sự tăng cường chia sẻ thông tin và hỗ trợ công nghệ trong chuỗi giá trị.*	**1**	**2**	**3**	**4**	**5**

II	**Supply Chain Configuration_CON (Cấu trúc chuỗi cung ứng)**					
II.1	In the CE and ID4.0 model, GLS is enabled by the application of similar operational and logistical practices across the supply chain network *Trong mô hình kinh tế tuần hoàn và công nghệ 4.0, logistics xanh và chuỗi cung ứng bền vững được kích hoạt bằng cách áp dụng các thông lệ vận hành và phân phối logistics tương tự trong mạng lưới chuỗi cung ứng.*	**1**	**2**	**3**	**4**	**5**
II.2	In the CE & ID4.0 model, GLS is enabled by supply chain restructuring to include processes for end-of-life returns, managing the by-products, and waste produced during the production process. *Trong mô hình kinh tế tuần hoàn và công nghệ 4.0, logistics xanh và chuỗi cung ứng bền vững được kích hoạt bằng cách tái cấu trúc chuỗi cung ứng, bao gồm các quy trình thu lợi nhuận cuối đời sản phẩm; quản lý các sản phẩm phụ, và chất thải tạo ra trong quá trình sản xuất.*	**1**	**2**	**3**	**4**	**5**
II.3	In the CE & ID4.0 model, GLS is enabled by a greater structural flexibility of the supply chain that breaks the ‘linear lock-in’ and geographical barriers. *Trong mô hình kinh tế tuần hoàn và công nghệ 4.0, logistics xanh và chuỗi cung ứng bền vững được kích hoạt nhờ sự linh hoạt hơn về cấu trúc chuỗi cung ứng, giúp phá vỡ các rào cản địa lý.*	**1**	**2**	**3**	**4**	**5**
III	**Green Logistics and Sustainable Supply Chain_GLS** **(Các hoạt động logistics xanh và chuỗi cung ứng bền vững)**					
III. 1	In the CE and ID4.0 model, the operations of GLS are in compliance with the applicable environmental laws and regulations by adopting of circular economy practices *Trong mô hình kinh tế tuần hoàn và công nghệ 4.0, hoạt động logistics xanh và chuỗi cung ứng bền vững tuân thủ các luật và quy định hiện hành về môi trường bởi ứng dụng các thực hành kinh tế tuần hoàn.*	**1**	**2**	**3**	**4**	**5**
III. 2	In the CE & ID4.0 model, the operations of GLS in reducing energy consumptions by the adoption of circular economy practices. *Trong mô hình kinh tế tuần hoàn và công nghệ 4.0, hoạt động logistics xanh và chuỗi cung ứng bền vững giảm tiêu thụ năng lượng bằng cách áp dụng các phương thức kinh tế tuần hoàn.*	**1**	**2**	**3**	**4**	**5**
III. 3	In the CE & ID4.0 model, the operations of GLS in reducing the usage of hazardous/ toxic material by the adoption of circular economy practices.	**1**	**2**	**3**	**4**	**5**

	Trong mô hình kinh tế tuần hoàn và công nghệ 4.0, hoạt động logistics xanh và chuỗi cung ứng bền vững giảm thiểu việc sử dụng vật liệu nguy hiểm/ độc hại bằng cách áp dụng các thực hành kinh tế tuần hoàn.					
III. 4	In the CE & ID4.0 model, the operations of GLS in enhancing the green information technology and communication by adopting circular economy practices. *Trong mô hình kinh tế tuần hoàn và công nghệ 4.0, vận hành logistics xanh và chuỗi cung ứng bền vững tăng cường công nghệ thông tin và truyền thông xanh bằng cách áp dụng các thông lệ kinh tế tuần hoàn.*	**1**	**2**	**3**	**4**	**5**
III. 5	In the CE & ID4.0 model, the operations of the GLS in enhancing green transportation by adopting circular economy practices. *Trong mô hình kinh tế tuần hoàn và công nghệ 4.0, vận hành logistics xanh và chuỗi cung ứng bền vững tăng cường vận chuyển xanh bằng cách áp dụng các phương thức kinh tế tuần hoàn.*	**1**	**2**	**3**	**4**	**5**
III. 6	In the CE & ID4.0 model, the operations of the GLS in enhancing green manufacturing by the adopting circular economy practices. *Trong mô hình kinh tế tuần hoàn và công nghệ 4.0, vận hành logistics xanh và chuỗi cung ứng bền vững tăng cường sản xuất xanh bằng cách áp dụng các phương thức kinh tế tuần hoàn.*	**1**	**2**	**3**	**4**	**5**
III. 7	In the CE & ID4.0 model, the operations of the GLS in enhancing the green storage and packaging by the adopting circular economy practices. *Trong mô hình kinh tế tuần hoàn và công nghệ 4.0, vận hành logistics xanh và chuỗi cung ứng bền vững tăng cường tồn trữ và đóng gói xanh bằng cách áp dụng các phương thức kinh tế tuần hoàn.*	**1**	**2**	**3**	**4**	**5**
III. 8	In the CE & ID4.0 model, the operations of the GLS in enhancing the green procurement by the adopting circular economy practices. *Trong mô hình kinh tế tuần hoàn và công nghệ 4.0, vận hành logistics xanh và chuỗi cung ứng bền vững tăng cường mua sắm xanh bằng cách áp dụng các phương thức kinh tế tuần hoàn.*	**1**	**2**	**3**	**4**	**5**
III. 9	In the CE & ID4.0 model, the operations of the GLS in enhancing the reverse logistics and renewable materials by the adopting circular economy practices. *Trong mô hình kinh tế tuần hoàn và công nghệ 4.0, vận hành logistics xanh và chuỗi cung ứng bền vững tăng cường logistics*	**1**	**2**	**3**	**4**	**5**

	ngược và vật liệu tái tạo bằng cách áp dụng các phương thức kinh tế tuần hoàn.					
IV	**CE adoption_CEA (Ứng dụng kinh tế tuần hoàn)**					
IV. 1	A mutual understanding of CE principles and insights by management and employees enables a transition to GLS. Sự hiểu biết lẫn nhau về các nguyên tắc và giá trị ngầm của kinh tế tuần hoàn giữa ban *quản lý và nhân viên sẽ giúp chuyển đổi sang logistics xanh và chuỗi cung ứng bền vững.*	**1**	**2**	**3**	**4**	**5**
IV. 2	General awareness of sustainability by management and employees enables a transition to GLS. Nhận thức chung về tính bền vững của cấp quản lý và nhân viên giúp chuyển đổi sang logistics *xanh và chuỗi cung ứng bền vững.*	**1**	**2**	**3**	**4**	**5**
IV. 3	An awareness of the potential of CE for economic performance such as revenue gains and cost savings by management and employees enables a transition to GLS. Nhận *thức về tiềm năng của kinh tế tuần hoàn đối với các mục tiêu kinh tế như tăng doanh thu và tiết kiệm chi phí của ban quản lý và nhân viên sẽ cho phép chuyển đổi sang logistics xanh và chuỗi cung ứng bền vững.*	**1**	**2**	**3**	**4**	**5**
IV. 4	An awareness of the potential of CE for environmental performance such as reduction on CO_2 emission and hazardous materials by management and employees enables a transition to GLS. Nhận thức về tiềm năng của kinh tế tuần hoàn đối với các mục tiêu môi trường như việc *giảm phát thải CO_2 và giảm sử dụng vật liệu nguy hiểm của ban quản lý và nhân viên sẽ cho phép chuyển đổi sang logistics xanh và chuỗi cung ứng bền vững.*	**1**	**2**	**3**	**4**	**5**
IV. 5	An awareness of the potential of CE for social performance such as reduction in the unemployment rate and covid-19 affects by the management and employees enables a transition to GLS. Nhận *thức về tiềm năng của kinh tế tuần hoàn đối với các mục tiêu xã hội như việc giảm tỉ lệ thất nghiệp và các tác động của covid-19 của ban quản lý và nhân viên sẽ cho phép chuyển đổi sang logistics xanh và chuỗi cung ứng bền vững.*	**1**	**2**	**3**	**4**	**5**
V	**CE Framework Design_CEF (Thiết kế khung kinh tế tuần hoàn)**					
V.1	Design for ‘systems change’ when considering any circular design strategy such as the framework of various Rs strategies, for example, the 3R (reduce-reuse-recycle)/ 4R/ 10R/ ReSOLVE/ other CE strategies. *Thiết kế để ‘thay đổi hệ thống’ khi xem xét bất kỳ chiến lược thiết kế tuần hoàn nào, chẳng hạn như các chiến lược R, ví dụ: chiến*	**1**	**2**	**3**	**4**	**5**

	lược 3R (giảm thiểu-tái sử dụng-tái chế), hoặc 4R/ 10R/ ReSOLVE/ các chiến lược CE khác.					
V.2	Design follows the basic principles, such as Design out waste (reduce)/ Design for reuse (reuse)/ Build resilience through diversity (recycle)/ Rely on energy from renewable sources (recovery)/ Think in 'systems' *Thiết kế luôn theo các nguyên tắc cơ bản: thiết kế loại bỏ chất thải (giảm thiểu)/ Thiết kế để tái sử dụng (tái sử dụng)/ Xây dựng khả năng phục hồi (tái chế)/ Dựa vào năng lượng từ các nguồn tái tạo (phục hồi)/ Tư duy hệ thống.*	**1**	**2**	**3**	**4**	**5**
V.3	Design by systematic thinking for optimization. *Thiết kế theo tư duy hệ thống để tối ưu hóa.*	**1**	**2**	**3**	**4**	**5**
V.4	Design with different participants in the value chain. *Thiết kế với nhiều thành phần tham gia khác nhau trong chuỗi giá trị*	**1**	**2**	**3**	**4**	**5**
V.5	Design with 'hands-on' experiences. *Thiết kế với trải nghiệm 'thực hành'.*	**1**	**2**	**3**	**4**	**5**
VI	**ID4.0 Technology_ID4.0 (Ứng dụng công nghệ 4.0)**					
VI.1	High-tech applications are one of the fundamental values in the organization, such as IoT, artificial intelligence, robot applications, blockchain technologies, etc. *Ứng dụng công nghệ cao là một trong những giá trị nền tảng của tổ chức, như ứng dụng internet vạn vật (IoT), Trí tuệ nhân tạo, người máy, các công nghệ blockchain, ...*	**1**	**2**	**3**	**4**	**5**
VI.2	Level of modern systems applied in the operations: MRP/MRPII/ERP, machine learning, etc. *Mức độ ứng dụng các hệ thống hiện đại trong các hoạt động doanh nghiệp, như ứng dụng hệ thống hoạch định nguồn nguyên liệu/ nguồn lực sản xuất/ nguồn lực doanh nghiệp (MRP/MRPII/ ERP), máy học, ...*	**1**	**2**	**3**	**4**	**5**
VI.3	Level of model and algorithms applied in the systems: optimization models/ heuristic/ meta-heuristic algorithms, and/or continuous improvement projects deployment, etc. *Mức độ ứng dụng các mô hình và các thuật toán tối ưu trong các hệ thống, như thuật toán heuristic/ meta-heuristic, tối ưu hóa, và/ hoặc thực hiện các dự án cải tiến liên tục, ...*	**1**	**2**	**3**	**4**	**5**
VII	**Government Policies_GOP (Chính sách, luật nhà nước)**					
VII.1	The appropriate level of legislation, regulation, and standards development as well as definitions of policy-related barriers for GLS in the CE context. *Mức độ quan trọng của việc phát triển các luật định, quy định và tiêu chuẩn phù hợp, cũng như việc xác định các rào cản liên*	**1**	**2**	**3**	**4**	**5**

	quan đến chính sách đối với logistics xanh và chuỗi cung ứng bền vững trong bối cảnh kinh tế tuần hoàn.					
VII. 2	Government policies promote the capacity building for GLS in the context of CE. *Các chính sách của chính phủ thúc đẩy xây dựng năng lực cho logistics xanh và chuỗi cung ứng bền vững trong bối cảnh kinh tế tuần hoàn.*	**1**	**2**	**3**	**4**	**5**
VII. 3	Plan of education and training to support and facilitate the thinking, behavior, and operations of organizations with a green and sustainable mindset. *Kế hoạch giáo dục và đào tạo nhằm hỗ trợ và tạo điều kiện cho tư duy, hành vi, và hoạt động của các tổ chức theo tư duy xanh và bền vững.*	**1**	**2**	**3**	**4**	**5**
VII. 4	Urban planning: Construction of synchronous infrastructure for GLS in the context of CE. *Quy hoạch đô thị: xây dựng cơ sở hạ tầng đồng bộ cho logistics xanh và chuỗi cung ứng bền vững trong bối cảnh kinh tế tuần hoàn.*	**1**	**2**	**3**	**4**	**5**

II. Phần câu hỏi mở

1. Do you have any comments on the integrated CE & ID4.0 model for GLS above?
Anh/ Chị có đóng góp ý kiến gì cho mô hình trên?
……………………………………………………………………………… ……………………………………………………………………………… …………………………

2. In addition to the above factors, what factors belong to the CE & ID4.0 model for GLS that I have not mentioned (for example, your own way for the application of CE and ID4.0 in your company).
Ngoài các yếu tố trên, theo Anh/ Chị các yếu tố nào thuộc mô hình CE & ID4.0 trong lĩnh vực logistics xanh và chuỗi cung ứng bền vững mà tôi chưa nhắc đến (Ví dụ như việc áp dụng cụ thể về CE và ID4.0 trong doanh nghiệp của Anh/ Chị)
……………………………………………………………………………… ……………………………………………………………………………… …………………………

III. General information section *(Phần thông tin tổng quan)*

1. **Please tell us about the field of the company for which you are working:**

Vui lòng cho biết về lĩnh vực hoạt động của công ty Anh/ Chị đang làm việc:

☐ Universities (*Các trường đại học*)
☐ Government/ state sectors (*Các tổ chức công, nhà nước*)
☐ Companies (*Các công ty đa quốc gia, công ty nhà nước, công ty tư nhân)*
☐ Others (*Khác*)

2. Please tell us about your position:

Xin vui lòng cho biết về vị trí Anh/ Chị đang làm việc:

☐ Directors/ entrepreneurs (*Tổng giám đốc/ chủ doanh nghiệp*)
☐ Managers/ officers (*Giám đốc/ trưởng/ phó phòng*)
☐ Supervisors (*Quản đốc*)
☐ Professor/ lecturers (*Giáo sư/ Giảng viên*)
☐ Others (*Khác*)

3. How long have you worked?

Vui lòng cho biết số năm kinh nghiệm của Anh/ Chị?

☐ Under 5 years (*Dưới 5 năm*) ☐ 5-10 years (*5-10 năm*)

☐ 11-15 years (*11-15 năm*) ☐ 16-20 years (*16-20 năm*)

☐ Above 20 years (*Trên 20 năm*)

Thank you very much for your cooperation.

APPENDIX 2b - Questionnaire (English and Czech)

My name is Luu Van Thanh, a Ph.D. student at Tomas Bata University in Zlin, the Czech Republic. I am investigating an integrated model of Industry 4.0 and Circular Economy for Green Logistics and Sustainable Supply Chain. I am looking forward to receiving your comments on the model. I promise that the information you provide will be kept confidential and only used for the research process. I thank you very much for your answer.

Jmenuji se Luu Van Thanh, Ph.D. jsem student Univerzity Tomáše Bati ve Zlíně, Česká republika. Zkoumám integrovaný model Průmyslu 4.0 a cirkulární ekonomiky pro zelenou logistiku a udržitelný uzavřený dodavatelský řetězec. Budu rád za Vaše komentáře k uvedenému výzkumu. Vámi poskytnuté informace budou důvěrné a budou použity pouze pro výzkumný proces. Děkuji moc za odpověď.

I – Integrated Industry 4.0 (ID4.0) and Circular Economics (CE) Model and for Green Logistics and Sustainable Supply Chain (GLS).

Integrovaný model Průmyslu 4.0 a cirkulární ekonomiky pro zelenou logistiku a udržitelný uzavřený dodavatelský řetězec

Circular economy and Industry 4.0 are emerging concepts. While ID4.0 resulted from technological innovation that focuses on production, a CE was formed from social innovation that focuses on consumption. There are cross-cutting and influencing business models and strategies. The concepts benefit each other (Cagáňová, Chromjaková, & Sujanová, 2020). ID4.0 technology is a foundation for CE strategies by addressing those technologies as a basis for sustainable management decision-making.

There is a need for a better understanding of an integrated framework of ID4.0 and CE for green logistics and sustainable supply chain (GLS) that aims to improve three pillars of their sustainability performance, i.e., economic, environmental, and social objectives.

The proposed framework for GLS is constructed of 7 factors (32 observed variables) with three main aspects of government, enterprise, and university. This research involves how CE and ID4.0 can influence and adopt for logistics and supply chain field to solve problems that arise in their operations along with the new trend of a green and sustainable mindset. In general, the circular economy can be considered as a tool to solve social-economic-environmental problems to achieve sustainable development goals in the context of environmental pollution and resource depletion.

Cirkulární ekonomika (CE) a Průmysl 4.0 (ID4.0) jsou nově se objevující pojmy. Zatímco ID4.0 je výsledkem technologické inovace, která se zaměřuje na výrobu, CE byla vytvořena ze sociální inovace, která se zaměřuje na spotřebu. Existují průřezově a ovlivňující obchodní modely a strategie. Koncepty si navzájem prospívají (Cagáňová, Chromjaková, and Sujanová, 2020). Technologie ID4.0 je základem strategií CE tím, že tyto technologie řeší jako základ pro rozhodování v oblasti udržitelného managementu.

Je potřeba lépe porozumět integrovanému rámci ID4.0 a CE pro zelenou logistiku a udržitelný uzavřený dodavatelský řetězec, jehož cílem je zlepšit tři pilíře výkonnosti v oblasti udržitelnosti, tj. ekonomický, environmentální a sociální.

Navrhovaný rámec pro GLS je sestaven ze 7 faktorů (32 pozorovaných proměnných) se třemi hlavními aspekty vládním, podnikovým a univerzitním. Tento výzkum se týká toho, jak mohou firmy pro CE a ID4.0 ovlivnit a přijmout koncept logistiky a dodavatelského řetězce, aby vyřešily problémy, které vznikají v jejich provozech spolu s novým trendem zeleného a udržitelného myšlení. Obecně lze oběhové hospodářství považovat za nástroj k řešení sociálně-ekonomicko-

environmentálních problémů k dosažení cílů udržitelného rozvoje v kontextu znečišťování životního prostředí a vyčerpávání zdrojů.

1. Please give some information about your understanding of CE and ID4.0? Please tick (X) on the correct box.
Uveďte prosím informace o tom, jak rozumíte CE a ID4.0? Zaškrtněte (X) ve správném políčku.

☐ Your organization has applied new business models and high-tech in its operations. (*Vaše organizace ve svých operacích aplikovala nové obchodní modely a špičkové technologie).*

☐ You have knowledge/ information of CE & ID4.0 (*Máte znalosti/informace o CE a ID4.0*)

☐ You have been trained in CE for the last 5 years (*Posledních 5 let jste byli vyškoleni v CE*)

☐ You have been trained in the new technologies in ID4.0 for the last 5 years (*Posledních 5 let jste byli školeni v nové technologii v ID4.0*)

☐ You have studied, researched, and taught on the application of CE, ID4.0 and GLS (*Studovali jste, zkoumali a učili jste se o aplikaci CE, ID4.0 a GLS*)

If you choose any of the above options, please continue the survey. Thank you very much.

Pokud nerozumíte CE a ID4.0, průzkum zde končí. Pokud zvolíte některou z výše uvedených možností, pokračujte prosím v průzkumu. Děkuji mnohokrát.

2. The factors of CE and ID4.0 model for GLS (*Faktory modelu CE a ID4.0 pro GLS*).

Please rate the importance of the factors in the proposed CE and ID4.0 model for GLS that I have given by ticking (X) in the appropriate boxes with the following convention:

(1: least important; 2: less important; 3: moderately important; 4: more important; 5: most important)

You rate the factors based on your knowledge and experience to answer the question "What factors are important for the proposed CE & ID4.0 model?". This question is NOT about evaluating the implementation in your company.

Ohodnoťte prosím důležitost faktorů v navrhovaném modelu CE a ID4.0 pro GLS, které jste uvedli zaškrtnutím (X) v příslušných polích s následující konvencí:

(1: nejméně důležité; 2: méně důležité; 3: středně důležité; 4: důležitější; 5: nejdůležitější)

Faktory hodnotíte na základě svých znalostí a zkušeností, abyste odpověděli na otázku „Jaké faktory jsou důležité pro navrhovaný model CE & ID4.0?".

Tato otázka NENÍ o hodnocení implementace ve vaší společnosti.

	Factors and observed variables (Faktory a proměnné)	**1**	**2**	**3**	**4**	**5**
I	**Supply Chain Collaboration_COL (Spolupráce v dodavatelském řetězci)**					
I.1	In the CE & ID4.0 model, GLS is enabled by collaboration with supply chain partners within and beyond the immediate industrial boundaries. *V modelu CE & ID4.0 je GLS umožněna spoluprace s partnery v dodavatelském řetězci v rámci bezprostředních průmyslových hranic i za nimi.*	**1**	**2**	**3**	**4**	**5**

I.2	In the CE & ID4.0 model, GLS is enabled by a supply chain wide responsibility for implementing CE principles. *V modelu CE & ID4.0 je GLS umožněná široká odpovědnost dodavatelského řetězce za implementaci principů CE.*	**1**	**2**	**3**	**4**	**5**
I.3	In the CE & ID4.0 model, GLS is enabled by enhanced information sharing and technical support within the value chain. *V modelu CE & ID4.0 je GLS umožněné zlepšené sdílení informací a technická podpora v rámci hodnotového řetězce.*	**1**	**2**	**3**	**4**	**5**
II	**Supply Chain Configuration_ (*Konfigurace dodavatelského řetězce*)**					
II.1	In the CE and ID4.0 model, GLS is enabled by the application of similar operational and logistical practices across the supply chain network *V modelu CE a ID4.0 je GLS umožněná aplikace podobných provozních a logistických postupů v celé síti dodavatelského řetězce.*	**1**	**2**	**3**	**4**	**5**
II.2	In the CE & ID4.0 model, GLS is enabled by supply chain restructuring to include processes for end-of-life returns, managing the by-products, and waste produced during the production process. *V modelu CE & ID4.0 je GLS umožněná restrukturalizace dodavatelského řetězce tak, aby zahrnovala procesy návratupo skončení životnosti, správu vedlejších produktů a odpadu produkovaného během výrobního procesu.*	**1**	**2**	**3**	**4**	**5**
II.3	In the CE & ID4.0 model, GLS is enabled by a greater structural flexibility of the supply chain that breaks the 'linear lock-in' and geographical barriers. *V modelu CE & ID4.0 je GLS umožněná větší strukturální flexibilita dodavatelského řetězce, která překonává „lineární uzamčení" a geografické bariéry.*	**1**	**2**	**3**	**4**	**5**
III	**Green Logistics and Sustainable Supply Chain_GLS (*Zelená logistika a udržitelné operace s uzavřeným dodavatelským řetězcem*)**					
III.1	In the CE and ID4.0 model, the operations of GLS in compliance with the applicable environmental laws and regulations by adopting of circular economy practices	**1**	**2**	**3**	**4**	**5**

	V modelu CE a ID4.0 jsou operace GLS v souladu s platnými zákony a předpisy o životním prostředí přijetím postupů oběhového hospodářství.					
III. 2	In the CE & ID4.0 model, the operations of GLS in reducing energy consumptions by the adoption of circular economy practices. *V modelu CE & ID4.0 operace GLS při snižování spotřeby energie přijetím postupů oběhového hospodářství.*	**1**	**2**	**3**	**4**	**5**
III. 3	In the CE & ID4.0 model, the operations of GLS in reducing the usage of hazardous/ toxic material by the adoption of circular economy practices. *V modelu CE & ID4.0 operace GLS umožňují snižování používání nebezpečných/toxických materiálů přijetím postupů oběhového hospodářství.*	**1**	**2**	**3**	**4**	**5**
III. 4	In the CE & ID4.0 model, the operations of GLS in enhancing the green information technology and communication by adopting circular economy practices. *V modelu CE & ID4.0 operace GLS přispívají zlepšování zelených informačních technologií a komunikace přijetím postupů oběhového hospodářství.*	**1**	**2**	**3**	**4**	**5**
III. 5	In the CE & ID4.0 model, the operations of the GLS in enhancing green transportation by adopting circular economy practices. *V modelu CE & ID4.0 operace GLS umožňují zlepšování zelené dopravy přijetím postupů oběhového hospodářství.*	**1**	**2**	**3**	**4**	**5**
III. 6	In the CE & ID4.0 model, the operations of the GLS in enhancing green manufacturing by the adopting circular economy practices. *V modelu CE & ID4.0 operace GLS zlepšují procesy zelené výroby přijetím postupů oběhového hospodářství.*	**1**	**2**	**3**	**4**	**5**
III. 7	In the CE & ID4.0 model, the operations of the GLS in enhancing the green storage and packaging by the adopting circular economy practices. *V modelu CE & ID4.0, operace GLS prospívají zlepšování ekologického skladování a balení přijetím postupů oběhového hospodářství.*	**1**	**2**	**3**	**4**	**5**

III. 8	In the CE & ID4.0 model, the operations of the GLS in enhancing the green procurement by the adopting circular economy practices. *V modelu CE & ID4.0 operace GLS přispívají zlepšování zeleného zadávání zakázek přijetím postupů oběhového hospodářství.*	**1**	**2**	**3**	**4**	**5**
III. 9	In the CE & ID4.0 model, the operations of the GLS in enhancing the reverse logistics and renewable materials by the adopting circular economy practices. *V modelu CE & ID4.0 operace GLS přispívají zlepšování zpětné logistiky a obnovitelných materiálů přijetím postupů oběhového hospodářství.*	**1**	**2**	**3**	**4**	**5**
IV	**CE adoption_CEA (Přijetí CE)**					
IV. 1	A mutual understanding of CE principles and insights by management and employees enables a transition to GLS. Vzájemné *porozumění principům CE a postřehů ze strany vedení a zaměstnanců umožňuje přechod na GLS.*	**1**	**2**	**3**	**4**	**5**
IV. 2	General awareness of sustainability by management and employees enables a transition to GLS. *Obecné povědomí o udržitelnosti ze strany vedení a zaměstnanců umožňuje přechod na GLS.*	**1**	**2**	**3**	**4**	**5**
IV. 3	An awareness of the potential of CE for economic performance such as revenue gains and cost savings by management and employees enables a transition to GLS. Povědomí *o potenciálu CE pro ekonomickou výkonnost, jako jsou zisky z příjmů a úspory nákladů ze strany vedení a zaměstnanců, umožňuje přechod na GLS.*	**1**	**2**	**3**	**4**	**5**
IV. 4	An awareness of the potential of CE for environmental performance such as reduction on CO_2 emission and hazardous materials by management and employees enables a transition to GLS. Povědomí *o potenciálu CE pro environmentální výkonnost, jako je snížení emisí CO2 a nebezpečných materiálů ze strany vedení a zaměstnanců, umožňuje přechod na GLS.*	**1**	**2**	**3**	**4**	**5**

IV. 5	An awareness of the potential of CE for social performance such as reduction in the unemployment rate and covid-19 affects by the management and employees enables a transition to GLS. Vědomí *potenciálu CE pro sociální výkonnost, jako je snížení míry nezaměstnanosti a dopadů Covid-19 ze strany vedení a zaměstnanců, umožňuje přechod na GLS*.	**1**	**2**	**3**	**4**	**5**
V	**CE Framework Design_CEF (*Návrh rámce CE*)**					
V.1	Design for 'systems change' when considering any circular design strategy such as the framework of various Rs strategies, for example, the 3R (reduce-reuse-recycle)/ 4R/ 10R/ ReSOLVE/ other CE strategies. *Design pro „změnu systémů" při zvažování jakékoli cirkulární dizajnové strategie, jako je rámec různých strategií Rs, například strategie 3R (snížit-znovu použít-recyklovat)/ 4R/ 10R/ ReSOLVE/ další strategie CE*.	**1**	**2**	**3**	**4**	**5**
V.2	Design follows the basic principles, such as Design out waste (reduce)/ Design for reuse (reuse)/ Build resilience through diversity (recycle)/ Rely on energy from renewable sources (recovery)/ Think in 'systems'. *Dizajn se řídí základními principy, jako je navrhnout odpad (snížit)/ navrhnout pro opětovné použití (opětovné využití)/ vybudovat odolnost prostřednictvím rozmanitosti (recyklovat)/ spoléhat se na energii z obnovitelných zdrojů (rekuperace)/ uvažovat v ‚systémech'*.	**1**	**2**	**3**	**4**	**5**
V.3	Design by systematic thinking for optimization. *Navrhování systematickým myšlením pro optimalizaci*.	**1**	**2**	**3**	**4**	**5**
V.4	Design with different participants in the value chain. *Dizajn s různými účastníky hodnotového řetězce*.	**1**	**2**	**3**	**4**	**5**
V.5	Design with 'hands-on' experiences. *Dizajn s ‚praktickými' zkušenostmi*.	**1**	**2**	**3**	**4**	**5**
VI	**ID4.0 Technology_ID4.0 (Technologie ID4.0)**					
VI. 1	High-tech applications are one of the fundamental values in the organization, such as IoT, artificial intelligence, robot applications, blockchain technologies, etc.	**1**	**2**	**3**	**4**	**5**

	High-tech aplikace jsou jednou ze základních hodnot v organizaci, jako je IoT, aplikace umělé inteligence, robot, a technologie blockchain, atd.					
VI. 2	Level of modern systems applied in the operations: MRP/MRPII/ERP, machine learning, etc. *Úroveň moderních systémů aplikovaných v provozech: MRP/MRPII/ERP, strojové učení atd.*	**1**	**2**	**3**	**4**	**5**
VI. 3	Level of model and algorithms applied in the systems: optimization models/ heuristic/ meta-heuristic algorithms, and/or continuous improvement projects deployment, etc. *Úroveň modelu a algoritmů používaných v systémech: optimalizační modely/ heuristické/ metaheuristické algoritmy a/nebo zavádění projektů neustálého zlepšování atd.*	**1**	**2**	**3**	**4**	**5**
VII	**Government Policies_GOP (Vládní politiky)**					
VII. 1	The appropriate level of legislation, regulation, and standards development as well as definitions of policy-related barriers for GLS in the CE context. *Odpovídající úroveň legislativy, regulace a vývoje norem, stejně jako definice bariér souvisejících s politikou pro GLS v kontextu CE.*	**1**	**2**	**3**	**4**	**5**
VII. 2	Government policies promote the capacity building for GLS in the context of CE. *Vládní politiky podporují budování kapacit pro GLS v kontextu CE.*	**1**	**2**	**3**	**4**	**5**
VII. 3	Plan of education and training to support and facilitate the thinking, behavior, and operations of organizations with a green and sustainable mindset. *Plán vzdělávání a školení na podporu a usnadnění myšlení, chování a provozu organizací s ekologickým a udržitelným myšlením.*	**1**	**2**	**3**	**4**	**5**
VII. 4	Urban planning: Construction of synchronous infrastructure for GLS in the context of CE. *Urbanismus: výstavba synchronní infrastruktury pro GLS v kontextu CE.*	**1**	**2**	**3**	**4**	**5**

II. Phần câu hỏi mở

1. Do you have any comments on the integrated CE & ID4.0 model for GLS above?

Máte nějaké připomínky k výše uvedenému integrovanému modelu CE & ID4.0 pro GLS?

……………………………………………………………………………………

…………………………………

2. In addition to the above factors, what factors belong to the CE & ID4.0 model for GLS that I have not mentioned (for example, your own way for the application of CE and ID4.0 in your company).

Kromě výše uvedených faktorů, jaké faktory patří k modelu CE & ID4.0 pro GLS, které jsem nezmínil (například Váš vlastní způsob aplikace CE a ID4.0 ve Vaší společnosti).

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………

III. General information section (*Obecné informace*)

1. Please tell us about the field of the company for which you are working:

☐ Universities (*Univerzitním*)

☐ Companies (*Podnikovým)*

☐ Government/ state sectors (*Vládní/státní sektory*)

☐ Others (*Ostatní*)

2. Please tell us about your position:

Řekněte nám prosím o své pozici:

☐ Directors/ entrepreneurs (*Ředitelé/podnikatelé*)

☐ Managers/ officers (*Manažeři/Administrativa*)

☐ Supervisors (*Supervizoři*)

☐ Professor/ lecturers (*Profesor/lektoři*)

☐ Others (*Ostatní: Konzultant/výzkumník/atd*)

3. How long have you worked?

Jak dlouho jste zaměstnán?

☐ Under 5 years (*Méně než 5 let*) ☐ 5-10 years (*5-10 let*)

☐ 11-15 years (*11-15 let*) ☐ 16-20 years (*16-20 let*)

☐ Above 20 years (*Víc než 20 let*)

Thank you very much for your cooperation.

Děkuji za Váš čas a spolupráci.

APPENDIX 2c – Sample distribution

Indicators		Frequency	Percentage
Working fields	Universities	76	36.2%
	Companies	70	33.3%
	Government sectors	39	18.6%
	Others	25	11.9%
Working positions	CEOs	37	17.6%
	Managers	53	25.2%
	Supervisors	14	6.7%
	Professors/Lecturers	64	30.5%
	Others	42	20.0%
Working years of experience	Under 5 years	52	24.8%
	5-10 years	36	17.1%
	11-15 years	36	17.1%
	16-20 years	47	22.4%
	Above 20 years	39	18.6%

Source: Own processing

APPENDIX 3 - Code for the SCND model of SME company

```
int NumCustomer = ...;
int NumDepot =...;
int NumWarehouse = ...;
int NumFactory = ...;
int NumTime = ...;
int NumProduct = ...;
int M = 999999;

range Customer = 1..NumCustomer;
range Depot = 1..NumDepot;
range Warehouse = 1..NumWarehouse;
range Factory = 1..NumFactory;
range Time = 0..NumTime;
range Product = 1..NumProduct;
range temprange = 1..NumProduct*NumCustomer;
int tempdemand[temprange][Time] = ...;

int demand[p in Product][c in Customer][t in Time] = tempdemand[(p-1)*NumCustomer+c][t];

int cf[Product][Factory] = ...;
int cd[Depot] = ...;
int cw[Warehouse] = ...;
float ctrs1[Factory][Depot] = ...;
float ctrs2[Factory][Warehouse]= ...;
float ctrs3[Depot][Warehouse] = ...;
float ctrs4[Warehouse][Customer] = ...;
int chd[Depot] = ...;
int chw[Warehouse] = ...;
int hd[Depot] = ...;
int hw[Warehouse] = ...;

int ssd[Product][Depot] = ...;
int ssw[Product][Warehouse] = ...;

dvar float+ q1[Product][Factory][Depot][Time];
dvar float+ q2[Product][Factory][Warehouse][Time];
dvar float+ q3[Product][Depot][Warehouse][Time];
dvar float+ q4[Product][Warehouse][Customer][Time];

dvar int+ n1[Factory][Depot][Time];
dvar int+ n2[Factory][Warehouse][Time];
dvar int+ n3[Depot][Warehouse][Time];
dvar int+ n4[Warehouse][Customer][Time];

dvar float+ ID[Product][Depot][Time];
dvar float+ IW[Product][Warehouse][Time];

dvar boolean yd[Depot];
dvar boolean yw[Warehouse];
```

```
dexpr float transport = sum(f in Factory, d in Depot, t in Time: t >= 1)ctrs1[f][d]*n1[f][d][t]+
                                                        sum(f in Factory, w in Warehouse, t in Time: t >=
1)ctrs2[f][w]*n2[f][w][t]+
                                                        sum(d in Depot, w in Warehouse, t in Time: t >=
1)ctrs3[d][w]*n3[d][w][t]+
                                                        sum(w in Warehouse, c in Customer, t in Time: t
>= 1)ctrs4[w][c]*n4[w][c][t];

dexpr float inventory = sum(p in Product, d in Depot, t in Time: t >= 1)chd[d]*ID[p][d][t]+
                                                        sum(p in Product, w in Warehouse, t in Time: t
>= 1)chw[w]*IW[p][w][t];

dexpr float hiring = sum(d in Depot)hd[d]*yd[d] + sum(w in Warehouse)hw[w]*yw[w];

minimize transport + inventory + hiring;

subject to
{
        forall(p in Product, d in Depot)
          ID[p][d][0] == 3000*yd[d];

        forall(p in Product, w in Warehouse)
          IW[p][w][0] == 250*yw[w];

        Constraint1:
        forall(p in Product, f in Factory, t in Time: t >= 1)
                sum(d in Depot)q1[p][f][d][t] + sum(w in Warehouse)q2[p][f][w][t] <= cf[p][f];

        Constraint2:
        forall(f in Factory, d in Depot, t in Time: t >= 1)
                sum(p in Product)q1[p][f][d][t] == 1680*n1[f][d][t];

        Constraint3:
        forall(p in Product, d in Depot, t in Time: t >= 1)
                ID[p][d][t] == ID[p][d][t-1] + sum(f in Factory)q1[p][f][d][t] - sum(w in
Warehouse)q3[p][d][w][t];

        Constraint4:
        forall(p in Product, f in Factory, d in Depot, t in Time: t >= 1)
                q1[p][f][d][t] <= yd[d]*M;

        Constraint5:
        forall(d in Depot, t in Time: t >= 1)
                sum(p in Product)ID[p][d][t] <= yd[d]*cd[d];

        Constraint6:
        forall(p in Product, d in Depot, t in Time: t >= 1)
                yd[d]*ssd[p][d] <= ID[p][d][t];
```

```
    Constraint7:
    forall(f in Factory, w in Warehouse, t in Time: t >= 1)
        sum(p in Product)q2[p][f][w][t] == 500*n2[f][w][t];

    Constraint8:
    forall(d in Depot, w in Warehouse, t in Time: t >= 1)
        sum(p in Product)q3[p][d][w][t] == 500*n3[d][w][t];

    Constraint9:
    forall(p in Product, w in Warehouse, t in Time: t >= 1)
        IW[p][w][t] == IW[p][w][t-1] + sum(f in Factory)q2[p][f][w][t] + sum(d in
Depot)q3[p][d][w][t] - sum(c in Customer)q4[p][w][c][t];

    Constraint10:
    forall(p in Product, f in Factory, w in Warehouse, t in Time: t >= 1)
        q2[p][f][w][t] <= yw[w]*M;

    Constraint11:
    forall(p in Product, d in Depot, w in Warehouse, t in Time: t >= 1)
        q3[p][d][w][t] <= yw[w]*M;

    Constraint12:
    forall(w in Warehouse, t in Time: t >= 1)
        sum(p in Product)IW[p][w][t] <= yw[w]*cw[w];

    Constraint13:
    forall(p in Product, w in Warehouse, t in Time: t >= 1)
        yw[w]*ssw[p][w] <= IW[p][w][t];

    Constraint14:
    forall(w in Warehouse, c in Customer, t in Time: t >= 1)
        sum(p in Product)q4[p][w][c][t] <= 10*n4[w][c][t];

    Constraint15:
    forall(p in Product, c in Customer, t in Time: t >= 1)
        sum(w in Warehouse)q4[p][w][c][t] >= demand[p][c][t];

}
```

APPENDIX 4a - The current warehouse of ATP company.

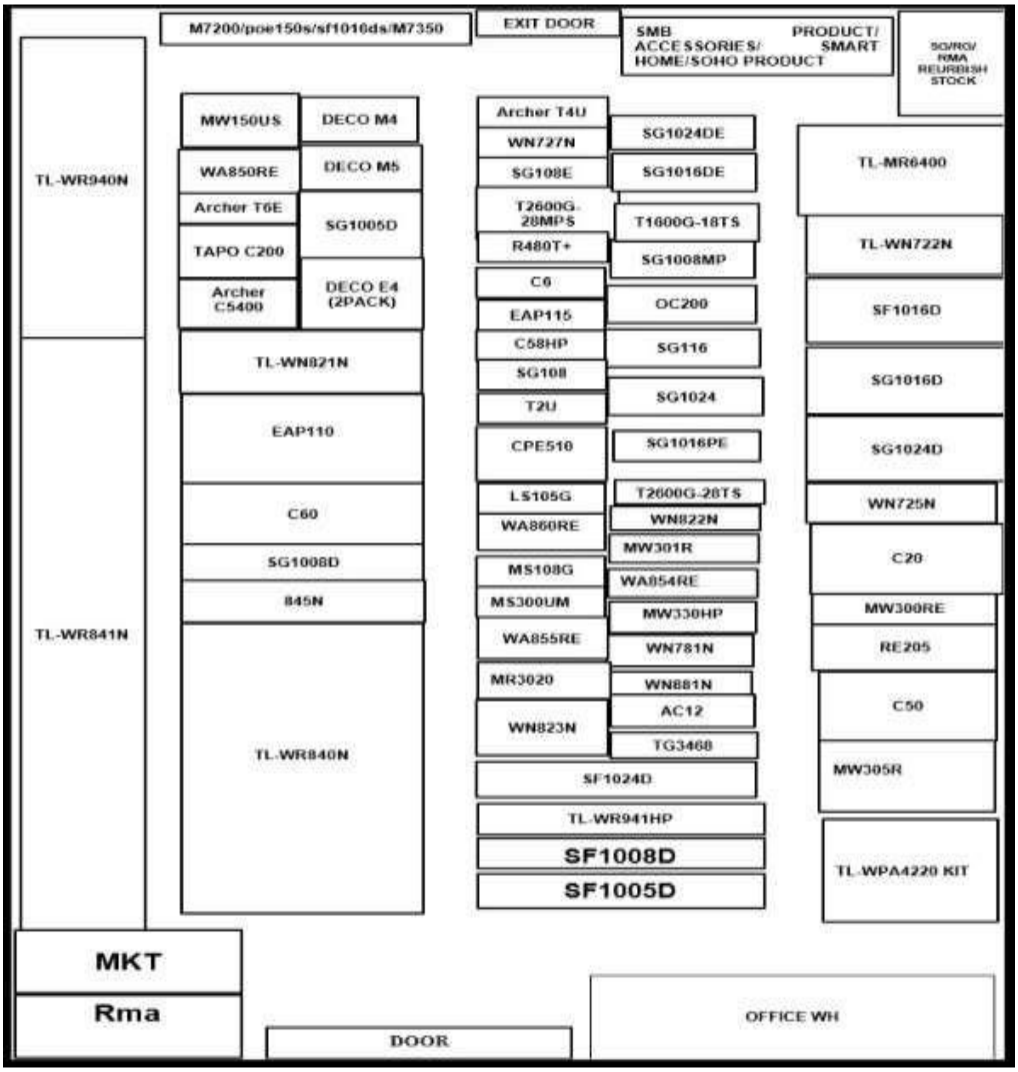


Figure: Current warehouse since March 2011
(Map 0)

APPENDIX 4b - Random code for 44 SKUs of ATP company.

No.	Random code	Item model
1	A1	TL-WN722N
2	A2	TL-SF1005D
3	A3	TL-SF1008D
4	A4	TL-WN725N
5	A5	TL-WR840N
6	A6	Archer C20
7	A7	TL-WR841N
8	B1	TL-WN781ND
9	B2	TL-WA850RE
10	B3	TL-WR845N
11	B4	TL-SG1008D
12	B5	TL-SG1005D
13	B6	Archer C60
14	B7	M7350
15	B8	TL-SG1016D
16	B9	TL-SF1016D
17	B10	Archer C6
18	B11	TL-WN822N
19	B12	Archer C50
20	C2	M7200
21	C10	TL-SG1024D
22	C1	Deco M5(3-pack)
23	C3	TL-WN821N
24	C4	TL-MR6400
25	C5	Archer T2U Nano
26	C6	TL-WR940N
27	C7	Deco M4(2-pack)
28	C8	LS105G
29	C9	TL-WA860RE
30	C11	RE205
31	C12	Archer C58HP
32	C13	Deco E4(2-pack)
33	C14	EAP110
34	C15	TL-WA855RE
35	C16	TL-SF1024D
36	C17	Archer T4U
37	C18	RE200
38	C19	TL-WPA4220 KIT
39	C20	MW150US
40	C21	TL-WN727N
41	C22	Archer T6E
42	C23	MW305R
43	C24	Archer C5400
44	C25	TL-R480T+

APPENDIX 5a - Expected distance travel for Map 1 of the ATP.

Bay$_k$	***p$_1$***	***d_{1k} (m)***	**f_k_EDT (m)**	**Bay$_k$**	***d_{1k} (m)***	**f_k_EDT (m)**
1	1	18	**18**	44	36	**36**
2	1	20	**20**	45	16	**16**
3	1	22	**22**	46	18	**18**
4	1	24	**24**	47	20	**20**
5	1	26	**26**	48	22	**22**
6	1	28	**28**	49	24	**24**
7	1	30	**30**	50	26	**26**
8	1	32	**32**	51	28	**28**
9	1	34	**34**	52	30	**30**
10	1	36	**36**	53	32	**32**
11	1	38	**38**	54	34	**34**
12	1	40	**40**	55	36	**36**
13	1	18	**18**	56	38	**38**
14	1	20	**20**	57	24	**24**
15	1	22	**22**	58	26	**26**
16	1	24	**24**	59	28	**28**
17	1	26	**26**	60	30	**30**
18	1	28	**28**	61	32	**32**
19	1	30	**30**	62	34	**34**
20	1	32	**32**	63	36	**36**
21	1	34	**34**	64	38	**38**
22	1	36	**36**	65	40	**40**
23	1	16	**16**	66	42	**42**
24	1	18	**18**	67	26	**26**
25	1	20	**20**	68	28	**28**
26	1	22	**22**	69	30	**30**
27	1	24	**24**	70	32	**32**
28	1	26	**26**	71	34	**34**
29	1	28	**28**	72	36	**36**
30	1	30	**30**	73	38	**38**
31	1	32	**32**	74	40	**40**
32	1	34	**34**	75	42	**42**
33	1	14	**14**	76	44	**44**
34	1	16	**16**	77	26	**26**
35	1	18	**18**	78	28	**28**
36	1	20	**20**	79	30	**30**
37	1	22	**22**	80	32	**32**
38	1	24	**24**	81	34	**34**
39	1	26	**26**	82	36	**36**
40	1	28	**28**	83	38	**38**
41	1	30	**30**	84	40	**40**
42	1	32	**32**	85	42	**42**
43	1	34	**34**			

APPENDIX 5b - Expected distance travel for Map 2 of the ATP.

Bay_k	p_1	p_2	d_{1k}	d_{2k}	f_k_EDT (m)	Bay_k	d_{1k}	d_{2k}	f_k_EDT (m)
1	0.5	0.5	14	24	**19**	44	20	24	**22**
2	0.5	0.5	16	26	**21**	45	22	26	**24**
3	0.5	0.5	18	28	**23**	46	24	28	**26**
4	0.5	0.5	20	30	**25**	47	26	30	**28**
5	0.5	0.5	22	32	**27**	48	28	32	**30**
6	0.5	0.5	24	34	**29**	49	30	34	**32**
7	0.5	0.5	26	36	**31**	50	32	36	**34**
8	0.5	0.5	28	38	**33**	51	34	38	**36**
9	0.5	0.5	30	40	**35**	52	36	40	**38**
10	0.5	0.5	32	42	**37**	53	16	12	**14**
11	0.5	0.5	34	44	**39**	54	18	14	**16**
12	0.5	0.5	36	46	**41**	55	20	16	**18**
13	0.5	0.5	38	48	**43**	56	22	18	**20**
14	0.5	0.5	12	22	**17**	57	24	20	**22**
15	0.5	0.5	14	24	**19**	58	26	22	**24**
16	0.5	0.5	16	26	**21**	59	28	24	**26**
17	0.5	0.5	18	28	**23**	60	30	26	**28**
18	0.5	0.5	20	30	**25**	61	32	28	**30**
19	0.5	0.5	22	32	**27**	62	34	30	**32**
20	0.5	0.5	24	34	**29**	63	36	32	**34**
21	0.5	0.5	26	36	**31**	64	38	34	**36**
22	0.5	0.5	28	38	**33**	65	40	36	**38**
23	0.5	0.5	30	40	**35**	66	18	10	**14**
24	0.5	0.5	32	42	**37**	67	20	12	**16**
25	0.5	0.5	34	44	**39**	68	22	14	**18**
26	0.5	0.5	36	46	**41**	69	24	16	**20**
27	0.5	0.5	10	18	**14**	70	26	18	**22**
28	0.5	0.5	12	20	**16**	71	28	20	**24**
29	0.5	0.5	14	22	**18**	72	30	22	**26**
30	0.5	0.5	16	24	**20**	73	32	24	**28**
31	0.5	0.5	18	26	**22**	74	34	26	**30**
32	0.5	0.5	20	28	**24**	75	36	28	**32**
33	0.5	0.5	22	30	**26**	76	38	30	**34**
34	0.5	0.5	24	32	**28**	77	40	32	**36**
35	0.5	0.5	26	34	**30**	78	42	34	**38**
36	0.5	0.5	28	36	**32**	79	34	24	**29**
37	0.5	0.5	30	38	**34**	80	36	26	**31**
38	0.5	0.5	32	40	**36**	81	38	28	**33**
39	0.5	0.5	34	42	**38**	82	40	30	**35**
40	0.5	0.5	12	16	**14**	83	42	32	**37**
41	0.5	0.5	14	18	**16**	84	44	34	**39**
42	0.5	0.5	16	20	**18**	85	46	36	**41**
43	0.5	0.5	18	22	**20**				

APPENDIX 6 - A packing order of the ATP.

TP-LINK TECHNOLOGIES VIETNAM COMPANY LIMITED

12A-15, Vincom Center 45A Ly Tu Trong StreetBen Nghe Ward , District 1null

Packing List

PI NO.: TPV1917630 **Date:** 11/11/2019

PO NO.: SOHO Team **Shipping#** 20191105014

From:

TP-LINK TECHNOLOGIES VIETNAM COMPANY

12A-15, Vincom Center 45A Ly Tu Trong Street

Ben Nghe Ward , District 1

Attn: Gavin Liu

Tel: +84 (8) 626 15047

Fax:

Ship To:

TUONG AN - T.A.K.O TECHNOLOGY ELECTRONIC COMPANY LIMITED,

Số 3, lô 1C khu đô thị Trung Yên, Phường Trung Hòa, Quận Cầu Giấy, TP Hà Nội

Attn:

Tel:

Fax:

Incoterms2000: Door to Door

Payment term: NET 25 DAYS

Salesman: Myuyen Nguyen

Item Number	Item Model	Product Description	Quantities (PCS)	CTNS
0152502228	TL-WN722N(EU)	150Mbps High Gain Wireless USB Adapter	300	5
0152502203	TL-WN781ND(EU)	150Mbps Wireless N PCI Express Adapter	60	2
0152502243	TL-WN725N(EU)	150Mbps Wireless N Nano USB Adapter	300	5
1750502335	Archer C6(EU)	AC1200 Wireless MU-MIMO Gigabit Router	20	2
1730502144	TL-SF1005D(UN)	5-Port 10/100Mbps Desktop Switch	900	10
1730502143	TL-SF1008D(UN)	8-Port 10/100Mbps Desktop Switch	900	15
0173500033	M7200(EU)	4G LTE Mobile Wi-Fi	60	1
		Total:	2600	40

Total: **KG** **CBMS**

Drivers Signature

TP-LINK TECHNOLOGIES VIETNAM COMPANY

Lê Thị Ngọc Huyền

APPENDIX 7 - Lingo codes for 3 maps of the ATP.

```
MODEL:
SETS:
PRODUCT;
ROUTE(PRODUCT, PRODUCT)|&1 #GT# &2:DISTANCE, Y;ENDSETS
DATA:
PRODUCT=
A1 B1 A4 B10 A2 A3 C2;
!DISTANCE MATRIX;
DISTANCE=
18
14 10
24 38 30
28 14 20 28
26 12 14 22 2
24 34 30 14 40 34;ENDDATA
MIN = @SUM( ROUTE: Y * DISTANCE);
@SUM( PRODUCT( I)|I #GE# 2: Y(I, 1)) = 2;
@FOR( PRODUCT( J)|J #GE# 2: @SUM(PRODUCT(I)| I #GT# J:Y(I, J)) + @SUM(PRODUCT(K)|K #LT# J: Y(J, K))=2);
@FOR( ROUTE: Y <= 1);END
```

```
MODEL:
SETS:
PRODUCT;
ROUTE(PRODUCT, PRODUCT)|&1 #GT# &2:DISTANCE, Y;ENDSETS
DATA:
PRODUCT=
A1 B1 A4 B10 A2 A3 C2;
!DISTANCE MATRIX;
DISTANCE=
24
16 24
8 24 26
12 12 4 10
4 16 10 4 4
10 28 28 4 12 4;ENDDATA
MIN = @SUM( ROUTE: Y * DISTANCE);
@SUM( PRODUCT( I)|I #GE# 2: Y(I, 1)) = 2;
@FOR( PRODUCT( J)|J #GE# 2: @SUM(PRODUCT(I)| I #GT# J:Y(I, J)) + @SUM(PRODUCT(K)|K #LT# J: Y(J, K))=2);
@FOR( ROUTE: Y <= 1);END
```

```
MODEL:
SETS:
PRODUCT;
ROUTE(PRODUCT, PRODUCT)|&1 #GT# &2:DISTANCE, Y;ENDSETS
DATA:
PRODUCT=
A1 B1 A4 B10 A2 A3 C2;
!DISTANCE MATRIX;
DISTANCE=
8
6 4
16 28 22
4 12 10 10
8 18 16 4 4
16 24 22 4 10 4;ENDDATA
MIN = @SUM( ROUTE: Y * DISTANCE);
@SUM( PRODUCT( I)|I #GE# 2: Y(I, 1)) = 2;
@FOR( PRODUCT( J)|J #GE# 2: @SUM(PRODUCT(I)| I #GT# J:Y(I, J)) + @SUM(PRODUCT(K)|K #LT# J: Y(J, K))=2);
@FOR( ROUTE: Y <= 1);END
```

Thanh Van Luu

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Doctoral Thesis

Published by: Tomas Bata University in Zlín,

nám. T. G. Masaryka 5555, 760 01 Zlín

Edition: 5pcs

Typesetting by: Thanh Van Luu

This publication has not undergone any proofreading or editorial review.

Publication year: 2024