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HOW DOES COMPETITIVENESS INDEX PROMOTE FOREIGN DIRECT INVESTMENT AT THE PROVINCIAL LEVEL IN VIETNAM? A NON-PARAMETRIC APPROACH

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ABSTRACT

Foreign Direct Investment (FDI) has become crucial to global economic integration. It allows countries to participate in global value chains and access new markets, ultimately contributing to economic growth and development. Particularly in developing and emerging markets, FDI is critical in building a strong economy. This is why domestic enterprises and policymakers have been incentivized to attract FDI, recognizing its benefits, such as the transfer of technology, spillover effects, and increased competition. FDI has been vital in diversifying Vietnam's economic base. FDI has helped Vietnam move from its dependence on agriculture and traditional manufacturing industries towards more advanced and sophisticated industries, such as electronics, software, and telecommunications. This has increased competition in global markets and helped Vietnam integrate into the global economy. In particular, the provinces' effectiveness in attracting FDI is an important and decisive issue. At the provincial level in Vietnam, the set of competitive indexes is a useful measure to rank the efficiency in using resources to attract FDI of those provinces.

Therefore, in this thesis, we use an integrated model of Grey Delphi, the Data Envelopment Analysis Super Slack-Based Measure Model (DEA–Super SBM), and the Malmquist Model (DEA–Malmquist) to evaluate the FDI attractiveness of Vietnamese provinces from 2017 to 2021. First, ten critical dimensions of the provincial competitive index (PCI) affect the number of FDI by cases and amount of FDI capital were validated via the Grey Delphi method. Secondly, the Super-SBM model is applied to assess the FDI efficiency of 63 provinces in Vietnam from 2017 to 2021. Then, the DEA–Malmquist model is employed to analyze the total change in the productivity of 63 provinces' FDI performance in Vietnam.

The findings of this study revealed that the efficiency of FDI in Vietnam's provinces is relatively low, and there is a significant variation in the attractiveness of FDI among the provinces. This study can provide valuable insights for policy makers and other stakeholders in developing effective strategies to attract FDI and foster economic development.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF CHARTS

LIST OF TABLES

ABBREVIATIONS AND ACRONYMS LIST

Abbreviation	Full definition
FDI	Foreign Direct Investment
PCI	Provincial Competitiveness Index
DEA	Data Envelopment Analysis
CU	Catch-up effect
MI	Malmquist Productivity Index
FS	Frontier-shift effect
VCCI	Vietnam Chamber of Commerce and Industry
USAID	United States Agency for International Development
DMU	Decision-Making Unit
Super-SBM	Super Slacks-Based Measure
UNCTAD	United Nations Conference on Trade and Development
ASEAN	Association of Southeast Asian Nations
GIC	Global Investment Competitiveness
CIFs	Competitive Index Factors
EVIPA	Investment Protection Agreement between the European Union and the Socialist Republic of Vietnam
EVFTA	Free Trade Agreement
MCDM	Multi-criteria decision-making
GRP	Gross Regional Product

CHAPTER 1: INTRODUCTION

1.1. Topic Background

1.1.1. Importance of FDI Attractiveness

In many developing countries, foreign direct investment (FDI) has become the primary source of external financing, surpassing aid, remittances, and portfolio investment. FDI is establishing a new production line or buying an already established one in a country different from its origin to diffuse its production abroad. To achieve Sustainable Development Goals, a significant increase in capital flows to developing countries is necessary, and private-sector investment is the only way to accomplish this on the necessary scale. FDI provides funding, helps developing economies integrate into global markets, and improves productivity through competition and knowledge transfer across borders. Therefore, countries focus on attracting FDI, and understanding the key elements influencing investment decisions is essential for implementing policies attracting investors (Dang and Nguyen, 2021). In the long run, FDI can benefit the home and host countries in various important aspects, including facilitating greater access to international markets, generating much-needed foreign currency, boosting human capital development, transferring cutting-edge technologies, and increasing competition in domestic markets. These contributions can lead to economic growth, job creation, and living standards for people in homes and host countries. It can also help to modernize industries and allow small- and medium-sized businesses to participate in global value chains (Ho and Rashid, 2011).

Therefore, to effectively attract FDI, it is crucial for countries to not only concentrate on attracting FDI but also regularly evaluate their performance in this regard. In other words, performance evaluation plays a vital role in attracting FDI and should be given due importance by countries seeking to bolster their FDI inflows. Specifically, efficiency refers to using the fewest inputs to achieve the highest output, which entails reducing the resources not needed to produce a given output. This helps to limit the waste of resources such as materials, energy, and time while still achieving the desired results. In the case of FDI, due to the complexity of each country today, each actor (authorities, policymakers, and investors) conducts in-depth evaluations of different efficiency determinants.

FDI has assumed a pivotal role in the economy of Vietnam. The policy of opening up to attract foreign investment pursued by the Government over the last 30 years has proven judicious. The country has gained more than it has lost during this period, having successfully attracted the world's leading multinational corporations, including Samsung, Honda, Panasonic, and Lotte, which has caused a remarkable transformation in Vietnam's socio-economic landscape. FDI has served as a critical source of capital for investment in development, enhancing economic growth, promoting the efficient utilization of domestic investment resources, and facilitating the restructuring of the economy towards industrialization and modernization. Additionally, FDI has generated employment opportunities, enhanced the quality of human resources, and altered the labor structure while spurring domestic firms to innovate and improve technology, production, and export capabilities through positive competition. FDI inflows are presently regarded as one of the pillars of Vietnam's economic expansion, given their role in supplementing investment capital, augmenting exports, transferring technology, fostering human resource development, and creating jobs. Furthermore, FDI has been instrumental in generating revenue for the national budget and propelling Vietnam towards deeper integration with the global economy. The critical contribution of FDI has enabled Vietnam to achieve sustained high economic growth, establishing the nation as a dynamic and innovative entity that attracts the international community's attention.

1.1.2. Overview of Vietnam

Vietnam's favorable attributes in attracting FDI

In 1986, Vietnam initiated a set of reform measures called “Doi Moi”, which marked a pivotal moment in Vietnam’s economic history, as the nation instituted a policy geared towards attracting FDI as a crucial resource for fueling socio-economic development. This strategic move, accompanied by an open-door policy and a package of incentives, paved the way for a sustained and significant influx of FDI into Vietnam, yielding substantial contributions to the country’s economic expansion and progress. Since then, Vietnam has emerged as an attractive location for FDI in Southeast Asia, offering a wide range of benefits to the host country, including capital injection, finished products, components, advanced technology, organizational and managerial skills, distribution channels, and market access. In late 1987 the National Assembly of Vietnam promulgated the Law on Foreign Direct Investment, a cornerstone for regulating foreign investment. Subsequently, in 1990, the Company Law and the Law on Private Enterprises were also enacted, further establishing legal frameworks for private businesses in Vietnam. The Law on Promotion of Domestic Investment was introduced in 1994, further bolstering the country's efforts to promote and incentivize domestic investment (thuvienphapluat.vn, 1987). Furthermore, Vietnam introduced a new Law on Investment and a Law on Enterprises in 2020, which aims to simplify investment procedures and create a more favorable business environment for foreign investors (vietnam-briefing.com, 2021). Moreover, Vietnam has been implementing a series of reforms to improve the transparency and efficiency of its legal system, including adopting a new Civil Code and a new Law on Competition (vietnam-briefing.com, 2023). These reforms are expected to reduce barriers to entry for foreign investors and enhance the protection of their intellectual property rights.

Dr. Nguyen Bich Lam, the Former Director General of the General Statistics Office, assessed that Vietnam's robust institutional reform measures, concerted efforts to enhance the business investment environment, and the development of modern infrastructure had paved the way for the country to attract foreign investment on a large scale (thuongtruong.com.vn, 2021). The international community has taken note of Vietnam's economic potential and has acknowledged the country's numerous advantages in this regard. Specifically, Vietnam possesses eight distinct advantages that make it an attractive destination for foreign investment. These advantages include a stable macroeconomic environment, a dynamic and thriving economy, and a burgeoning consumption market supported by an ample supply of goods and services.

Vietnam has maintained political stability, consistently implemented economic development policies, and attracted foreign investment. The presence of an adequate legal framework has emerged as a crucial factor in enticing investors and has earned appreciation from international counterparts. The government's open foreign investment policy and liberalized market have encouraged and attracted foreign investors.

Furthermore, administrative procedures and investment incentives have been reformed to attract foreign investment. The effective implementation of the Law on Investment 2020 and the Law On Enterprises 2020 since January 1, 2021, demonstrates Vietnam's commitment to its open foreign investment policy by streamlining investment-related administrative procedures. The business environment in Vietnam has undergone a constant evolution, characterized by notable improvements in various indicators of the business environment and competitiveness.

Of particular significance is Vietnam's accession to several significant multilateral and bilateral trade agreements, including the Comprehensive and Progressive Agreement for Trans-Pacific Partnership, the EVFTA Agreement, and bilateral trade agreements with the US, Korea, Japan, and the United Kingdom. Additionally, Vietnam has ratified the Investment Protection Agreement (EVIPA), which the European Union will ratify, thereby laying a strong legal foundation for Vietnam to integrate more extensively and comprehensively into the global economy and participate in the global value chain. These developments are critical factors in enhancing Vietnam's attractiveness and position in the business strategies of foreign investors.

Vietnam's labor force is characterized by its youthful and abundant population, with over 75% of individuals aged 15 years and above actively participating in the workforce. In 2020, the proportion of certified and trained workers who are certified was 23.6%. The Vietnamese workforce is highly regarded for its strong work ethic, high level of education, ease of training, and cost-effectiveness, providing a clear competitive edge over other regional labor markets.

Moreover, Vietnam's strategic geographical location, boasting a lengthy coastline and several deep-water seaports, is a vital gateway for international trade by sea. Additionally, the country's well-developed infrastructure and advanced technology further enhance its appeal to foreign investors, contributing to the surge in FDI inflows to Vietnam.

In conclusion, thanks to the above advantages, Vietnam has been positioned as a highly attractive destination for FDI.

However, there are still some challenges that Vietnam needs to address to improve its FDI attractiveness. Vietnam’s infrastructure and logistics systems are still underdeveloped compared to other countries in the region, which can create bottlenecks and increase transaction costs for foreign investors. In addition, there are concerns about the quality and availability of skilled labor in Vietnam, which can deter foreign investment (vietnam-briefing.com, 2022).

Achievements of Vietnam in recent years

Over three decades, Vietnam consistently increased the inflow of FDI from multinational companies, significantly contributing to the country's domestic economic expansion. In the initial phase, FDI served as a "push" factor, generating a breakthrough by providing essential resources for development investment and encouraging domestic resources to leverage the country's potential and advantages. This has proved particularly valuable in difficult periods of crisis, enabling Vietnam to overcome obstacles and advance toward greater prosperity.

In 2015, there was a significant increase in FDI, with newly registered and additional capital reaching 24.11 billion USD and actual capital of 14.5 billion USD, a 17.4% increase from the previous year. The following year, 2016, saw an even higher increase in FDI, with a newly registered and additional capital of 26.69 billion USD and an actual capital of 15.8 billion USD. In 2019, the total registered capital reached 38.02 billion USD, with an actual capital of 20.38 billion USD, a 6.7% increase from the previous year (fia.mpi.gov.vn, 2020).

In 2020, notwithstanding the profound impact of the COVID-19 crisis on the global supply chain, Vietnam persevered as an attractive and secure destination for foreign investors (laodong.vn, 2021). Despite these circumstances, Vietnam remained a preferred and secure option for foreign investors, indicating its appeal as an investment destination. In addition to the newly registered capital accumulated by the end of December 2020, the country has 33,070 valid foreign investment projects with a total registered capital of 384 billion USD, and 60.4 percent of the sum (231.86 billion USD) was disbursed.

According to recent statistics, Vietnam's total registered FDI capital reached nearly 27.72 billion USD in 2022 (tapchinganhang.gov.vn, 2023). The realized FDI capital hit a record high of 22.4 billion USD, representing a 13.5% increase compared to the same period in 2021. This is the largest amount of realized FDI in the past five years (2017-2022). Since 1986, Vietnam has attracted approximately 438.7 billion USD of FDI, of which 274 billion USD has been disbursed, accounting for 62.5% of the total valid registered investment capital.

Recently, several large-scale projects have been initiated with significant financial resources. One example is the Heineken Brewery, officially inaugurated in Vung Tau in September 2022. Following a capital increase, the brewery boasts a total investment of 9,151 billion VND and a production capacity of 1.1 billion liters per year - a remarkable 36-fold increase from its previous capacity. Notably, the brewery is currently the largest in Southeast Asia and is home to the world's fastest canning line among all Heineken breweries globally.

Another notable project is the Quang Ninh liquefied natural gas (LNG) power project, which was recently granted a new investment registration certificate. This project requires an almost 2 billion USD investment and is scheduled to commence operations in October 2022.

In 2022, there has been a noticeable increase in investment capital for various projects, particularly those involved in producing and manufacturing high-tech and electronic products. Several projects have received significant increases in capital, including the Samsung Electro-Mechanics Vietnam project in Thai Nguyen, which experienced two separate increases of 920 million USD and 267 million USD, respectively. Similarly, the Samsung Electronics HCMC CE Complex project has seen an increase in capital of over 841 million USD. Other manufacturing projects in Bac Ninh, Nghe An, and Hai Phong have also experienced substantial increases in capital, with Bac Ninh experiencing a 306 million USD increase, Nghe An seeing an increase of 260 million USD, and Hai Phong experiencing an increase of 127 million USD.

Based on a report published by the American weekly "News and World Report," Vietnam has been ranked 8th out of 29 countries with a conducive economic environment for investment (trucotanct.asean.vietnam.vn, 2023). Notably, Vietnam ranks highest among the member states of the Association of Southeast Asian Nations (ASEAN) in terms of attracting foreign investment. The report attributes Vietnam's success to its competitive costs, comparatively low wages, and continually developing infrastructure. FDI projects in Vietnam have been established by 129 countries and territories, spanning all provinces and covering 19 economic sectors (tapchicongthuong.vn, 2021). Unlike other Southeast Asian countries, Vietnam’s FDI inflows remained unaffected by the COVID-19 pandemic in 2020, while Singapore, Thailand, Indonesia, and Malaysia experienced a sharp decline in FDI (trungtamwto.vn, 2022). The investment report 2021 of the United Nations Conference on Trade and Development (UNCTAD) recently released shows that Vietnam's impressive performance in attracting FDI is evident as it was ranked 19th globally among the top 20 countries in 2020 (unctad.org, 2021).

Six socio-economic regions of Vietnam

According to the Ministry of Planning and Investment, Vietnam is divided into six socio-economic regions from North to South (National master plan for 2021 - 2030) (laodong.vn, 2022). Six socio-economic regions have their characteristics and advantages in attracting foreign investment, specifically as follows:

The Northern Midlands and Mountains region includes 14 provinces: Ha Giang, Cao Bang, Lang Son, Bac Giang, Phu Tho, Thai Nguyen, Bac Kan, Tuyen Quang, Lao Cai, Yen Bai, Lai Chau, Son La, Dien Bien, and Hoa Binh. Vietnam's Northern Midlands and Mountains region is known for its mountainous terrain, diverse ethnic cultures, and potential for agriculture and tourism development. However, the region has historically faced challenges in attracting foreign investment due to its remote location, underdeveloped infrastructure, and limited industrialization. The Vietnamese government has recently implemented policies encouraging regional investment, including preferential treatment for investors in specific sectors and developing industrial parks and transportation infrastructure. While the region has potential for agriculture and tourism development, it also has some natural resources that can attract investment, such as minerals, hydropower, and forestry. Moreover, the region's proximity to China can offer cross-border trade and investment opportunities. Overall, the Northern Midlands and Mountains region is still in the early stages of attracting foreign investment. Still, with government support and improving infrastructure, it has the potential to become an attractive destination for investors in the future.

The Red River Delta region includes 11 provinces: Hanoi, Hai Phong, Hai Duong, Hung Yen, Vinh Phuc, Bac Ninh, Thai Binh, Nam Dinh, Ha Nam, Ninh Binh, and Quang Ninh. The Red River Delta region is one of the most important economic regions in Vietnam, with a high concentration of population, industry, and agriculture. The region is home to the country's capital, Hanoi, and the major port city of Hai Phong. The region's well-developed infrastructure and diverse industries contribute to its attractiveness to foreign investors. Moreover, it has a significant industrial base, including manufacturing, construction, and electricity production. Key manufacturing sectors in the region include electronics, textiles, and machinery. The region has also seen growth in the services sector in recent years, particularly in finance, information technology, and logistics. In addition to its industrial base, the Red River Delta region is also known for its agriculture and aquaculture, focusing on rice, vegetables, and seafood production. The region has a well-developed transportation network, including roads, railways, and waterways, which support the movement of goods and people. The Red River Delta region is desirable for foreign investors due to its developed infrastructure, diverse industries, and strategic location in the north of Vietnam. The region has also been the focus of government policies to attract foreign investment, particularly in high-tech industries and infrastructure development.

The North Central and Central Coast region includes 14 provinces: Thanh Hoa, Nghe An, Ha Tinh, Quang Binh, Quang Tri, Thua Thien Hue, Da Nang, Quang Nam, Quang Ngai, Binh Dinh, Phu Yen, Khanh Hoa, Ninh Thuan, and Binh Thuan. Vietnam's North Central and Central Coast region has diverse industries, including manufacturing, agriculture, forestry, fisheries, and tourism. The region includes several major ports and transportation hubs, such as Da Nang and Nha Trang, making it an important trade and transportation gateway in Vietnam. The region's manufacturing sector includes textiles, garments, footwear, and electronics. The region is also home to several large industrial zones and manufacturing parks, such as the Dung Quat Economic Zone in Quang Ngai Province, which has attracted significant foreign investment in recent years. The North Central and Central Coast region also has a significant agriculture sector, focusing on rice, corn, sugarcane production, livestock, and aquaculture. The region is also known for its seafood processing industry, with significant fishery centers in Quang Ninh, Nghe An, and Khanh Hoa provinces.

Regarding tourism, the region has several world-renowned tourist destinations, such as the ancient city of Hue, the Hoi An old town, and the beaches of Nha Trang. The region has also been the focus of several tourism development initiatives, such as the Central Coast Tourism Stimulus Program, which aims to promote tourism and attract investment in the sector. Overall, the North Central and Central Coast region of Vietnam has significant potential for further development in various industries and has been the focus of government policies to attract foreign investment, particularly in manufacturing, tourism, and infrastructure development.

The Central Highlands region comprises five provinces: Kon Tum, Gia Lai, Dak Lak, Dak Nong, and Lam Dong. The region of Vietnam is known for its diverse natural resources, including mineral resources, agricultural land, and forests. The region has significant potential for agricultural development, particularly for cultivating coffee, rubber, pepper, and cashew nuts. The region is also a significant livestock producer, such as cattle and pigs. The Central Highlands region is known for its high-quality coffee and is the largest coffee-producing region in Vietnam. In addition to agriculture, the region has significant potential for mineral development, including bauxite, gold, and iron ore. The region has also seen tourism growth, particularly in areas such as Da Lat, known for its scenic beauty, cool climate, and historical landmarks. Despite its potential for development, the Central Highlands region faces several challenges in attracting foreign investment, including its remote location, underdeveloped infrastructure, and limited industrialization. However, the Vietnamese government has implemented policies encouraging regional investment, particularly in infrastructure development, such as constructing the Ho Chi Minh Highway and upgrading airports and seaports.

The Southeast region includes six provinces: Ho Chi Minh City, Dong Nai, Ba Ria Vung Tau, Binh Duong, Binh Phuoc, and Tay Ninh. The Southeast region of Vietnam is one of the country's most developed and dynamic regions. The region is home to Ho Chi Minh City, Vietnam's largest city and economic hub, which accounts for a significant portion of the country's GDP. The city is known for its modern infrastructure, high-tech industries, and bustling commercial activity, and it is a major center for finance, trade, and tourism in Southeast Asia. In addition to Ho Chi Minh City, the Southeast region is home to several industrial zones and manufacturing parks, such as the Bien Hoa Industrial Park in Dong Nai Province, the My Phuoc Industrial Park in Binh Duong Province, and the Phu My Industrial Park in Ba Ria Vung Tau Province. These zones have attracted significant foreign investment, particularly in electronics, textiles, and footwear manufacturing. Overall, the Southeast region of Vietnam has diverse industries and significantly contributes to the country's economic growth. The region has been the focus of government policies to attract foreign investment, particularly in high-tech industries, infrastructure development, and tourism. With its favorable business environment and strategic location, the Southeast region is expected to continue to be an attractive destination for investors.

The Mekong Delta region includes 13 provinces: Can Tho, Long An, Tien Giang, Ben Tre, Tra Vinh, Vinh Long, An Giang, Dong Thap, Kien Giang, Hau Giang, Soc Trang, Bac Lieu, and Ca Mau. The Mekong Delta region of Vietnam is known for its fertile agricultural land, abundant water resources, and diverse ecosystems. The region is a central agricultural region in Vietnam, known for producing rice, fruits, vegetables, and seafood. The region also significantly produces aquaculture products such as shrimp, fish, and crabs. In addition to agriculture and fisheries, the Mekong Delta region has the potential for development in other sectors, such as tourism, manufacturing, and renewable energy. The region is home to several industrial zones and seaports, including the Cai Cui seaport in Can Tho and the Phu My Hung industrial park in Long An, attracting significant foreign investment. The region has also seen tourism growth, particularly in areas such as Phu Quoc

Island in Kien Giang Province, known for its pristine beaches and luxury resorts. The region also has potential for renewable energy development, particularly solar and wind power.

Despite its potential for development, the Mekong Delta region faces several challenges, including climate change, environmental degradation, and limited infrastructure. However, the Vietnamese government has implemented policies to promote sustainable regional development, particularly in water management, agriculture, and renewable energy.

Figure 1.1. The list of six socio-economic regions of Vietnam

1.1.3. Practical Problem

However, there has been a recent shift in direct investment in Vietnam, with an increasing number of investors choosing to engage in mergers and acquisitions rather than greenfield investments. This change in investment patterns has important implications for Vietnam's FDI policy framework and incentive system, which may need to be revised to maintain the country's attractiveness to foreign investors. Furthermore, Vietnam's current investment incentives system is distributed across various laws, locations, and regulations, which can make it difficult for authorities and businesses to understand and apply them effectively. This lack of transparency can also increase corruption and rent-seeking risk. In this thesis, we aim to examine the factors that influence FDI in Vietnam, including the impact of the changing investment landscape and the effectiveness of existing investment incentives.

Table 1.1. Foreign investment in Vietnam by Provinces (Accumulated until 2022)

No	Provinces	FDI by cases	FDI by capital (Million USD)	No	Provinces	FDI by cases	FDI by capital (Million USD)
1	Ho Chi Minh City	11,272	55,828.96	33	Can Tho	86	2,222.86
2	Binh Duong	4,074	39,633.40	34	Quang Ngai	63	2,124.71
3	Ha Noi	7,019	38,743.15	35	Phu Yen	51	2,034.81
4	Dong Nai	1,818	34,992.05	36	Ninh Thuan	56	1,735.14
5	Ba Ria Vung Tau	533	33,304.09	37	Thai Binh	112	1,664.43
6	Hai Phong	982	25,274.13	38	Ninh Binh	94	1,602.84
7	Bac Ninh	1,819	23,170.76	39	Ben Tre	65	1,585.02
8	Thanh Hoa	174	14,798.91	40	Binh Dinh	99	1,203.46
9	Long An	1,293	12,912.83	41	Quang Binh	24	1,116.28
10	Ha Tinh	80	12,014.24	42	Vinh Long	71	1,007.16
11	Thai Nguyen	197	10,448.39	43	Hoa Binh	51	720.14
12	Quang Ninh	159	10,172.66	44	Hau Giang	30	686.09
13	Bac Giang	595	9,382.47	45	Dak Lak	27	642.12
14	Tay Ninh	363	9,155.05	46	Lao Cai	32	582.63
15	Hai Duong	507	9,148.14	47	Lam Dong	102	514.62
16	Vinh Phuc	502	6,742.20	48	Yen Bai	35	456.85
17	Hung Yen	533	6,620.40	49	Soc Trang	16	340.61
18	Quang Nam	224	6,336.69	50	An Giang	31	317.31
19	Da Nang	927	6,138.81	51	Dak Nong	20	311.87
20	Ha Nam	374	5,327.52	52	Kon Tum	9	245.36
21	Kien Giang	63	4,810.15	53	Lang Son	42	240.36

22	Bac Lieu	15	4,490.06	54	Dong Thap	21	231.58
23	Khanh Hoa	119	4,395.09	55	Tuyen Quang	18	208.82
24	Thua Thien Hue	130	4,239.03	56	Ca Mau	11	157.83
25	Binh Phuoc	413	3,971.80	57	Son La	10	135.73
26	Binh Thuan	158	3,838.76	58	Gia Lai	8	92.09
27	Nam Đinh	130	3,713.29	59	Cao Bang	16	30.63
28	Tra Vinh	38	3,188.03	60	Bac Kan	4	7.90
29	Phu Tho	217	3,099.49	61	Ha Giang	6	4.15
30	Tien Giang	138	2,799.66	62	Dien Bien	1	3.00
31	Quảng Trị	25	2,523.91	63	Lai Chau	1	1.50
32	Nghe An	125	2,481.57		**Total**	**36,278**	**438,692.29**

Despite Vietnam's commendable efforts in attracting FDI, it is observed that the inflow of FDI into the country needs to be more evenly distributed across its various provinces. There has been a severely unequal distribution of FDI among provinces, a remarkable aspect of Vietnam's FDI inflow distribution. While others fall behind, certain provinces can attract FDI (Chien and Zhang, 2012). In Vietnam, there is a concentration of FDI in major economic centers such as Hanoi, Ho Chi Minh, and Da Nang. In contrast, regions such as the northern mountainous provinces and the Central Highlands receive minimal FDI, resulting in substantial disparities in development between different areas. The localities that attract a significant amount of FDI experience fast growth and modernization, characterized by urbanization. At the same time, other regions remain undeveloped and primarily depend on agriculture and resource extraction (vjst.vn, 2021). In Vietnam, as in many other countries, disparities exist between regions regarding natural and social conditions. The capital, Hanoi, and the southern economic hub of Ho Chi Minh City have received a significant amount of investment capital due to specific policies and mechanisms.

Meanwhile, cities such as Hai Phong, Da Nang, and Can Tho that fall directly under the Central Government have experienced relatively synchronous development in terms of technical and social infrastructure. Proximity to major economic centers has proven advantageous for neighboring provinces, attracting more FDI and fostering higher levels of development. For example, during the first four months of 2022, Binh Duong province attracted the highest FDI capital in Vietnam (laodong.vn, 2023). The province has made a sustained effort to channel its investment resources into improving its infrastructure system and providing high-quality training for its human resources. Furthermore, it has prioritized administrative procedure reforms and the development of top-quality services to create the most favorable conditions for businesses to invest. However, unequal distribution of FDI across industries, sectors, and regions can negatively impact the country's overall economic sustainability, including reliance on technology and markets and domestic pressure businesses (baodautu.vn, 2017). Thus, assessing the efficiency of a specific region in drawing in FDI is vital for comprehending the reasons for differences among regions and offers policy makers a basis for consistently improving FDI appeal.

1.1.4. Provincial Competitiveness Index (PCI) in Vietnam

Regarding competitiveness indicators, many countries have employed different regional competitiveness indexes to foster a sustained enhancement in business efficiency and the quality of life for the region's residents (Benzaquen *et al.*, 2010). Similarly, Vietnam has also implemented the Provincial Competitiveness Index (PCI), which incorporates ten sub-indexes that reflect various aspects of economic governance affecting the development of the private sector. The PCI measures and evaluates the quality of economic management, the degree of favorability and friendliness of the business environment, and the administrative reform efforts of the government of provinces and cities in Vietnam, thereby promoting the development of the private economic sector (Dalkey and Helmer, 1963). Specifically, the index is carried out by the Vietnam Chamber of Commerce and Industry (VCCI) with the support of the United States Agency for International Development (USAID) in Vietnam. Built from the largest-scale annual enterprise survey data, con-ducted most meticulously in Vietnam today, the PCI is the "collection of voices" of the business community about the business environment in provinces and cities in Vietnam. The PCI is not intended for purely scientific research or to praise or criticize provinces with high or low PCI scores. Instead, the PCI aims to investigate and explain why some provinces or cities surpass others in private economic development, job creation, and economic growth.

1.2. Research Objectives

For nearly four decades (1986 - 2023), Vietnam has been recognized as a successful model for attracting FDI due to its favorable investment environment, stable political foundation, and potential for high economic growth. As of 2022, foreign investors continue to pour capital into Vietnam, considering it an attractive investment destination due to its advantageous geography, established institutions, and continually improving investment environment. The positive impact of FDI has led to significant accomplishments in Vietnam's economic development. However, an issue of great concern is the uneven distribution of FDI across provinces, which has resulted in numerous consequences and presents a significant gap in Vietnam's development process. Therefore, evaluating each province's performance in attracting FDI is vital using a suitable set of competitive indexes. Furthermore, this evaluation will provide an overview of provinces' effective utilization of resources to attract FDI and demonstrate how they have optimized capital over time. This evaluation aims to identify areas for improvement in FDI attraction strategies at the provincial level as follows:

Objective 1: To formulate a set of Competitive Index to assess the effectiveness of Vietnamese provinces in attracting FDI**.**

Objective 2: To analyze and evaluate Vietnam provinces' effectiveness in using resources to attract FDI.

Objective 3: To see the change in optimizing the resources of Vietnamese provinces over the years (2017-2021).

1.3. Research Questions

To address the objective correctly, this thesis mainly schedules several questions to aim the purposes:

Question 1: Is the PCI an appropriate set of competitive indexes to assess the effectiveness of Vietnamese provinces in attracting FDI?

Question 2: Are Vietnam’s provinces effectively using resources to attract FDI?

Question 3: Over the years, how has there been a change in optimizing the resources of Vietnamese provinces?

1.4. Research Scope

This thesis evaluates the efficiency of Vietnam’s provinces in attracting FDI. This study carefully considers the 63 provinces in Vietnam from 2017-2021.

1.5. Methodology and data overview

1.5.1. Research Methodology

The authors have applied the Grey Delphi method to answer the first question by considering the comparative regional indexes among different countries. The Delphi Method has been widely used to determine industry performance indicators (Kuo and Chen, 2008). Multiple investigations are required to ensure the consistency of expert opinions and agreements to reach the mean value of all opinions. As a result, the authors obtained an agreement among FDI specialists. The authors' objective has been achieved based on this method, giving a complete and accurate set of competition indicators.

In evaluating efficiency from an operational standpoint, two main methodologies are used for measurement: parametric and non-parametric. The parametric method is a statistical method that demands the formulation of a special function to describe the statistical distribution of a sample using a particular set of parameters that need estimation. Certain presumptions, including normality, homoscedasticity, independence, and identical stochastic distribution of errors, must be fulfilled for this technique (Henke *et al.*, 2021). However, these hypotheses can often be difficult to justify, and the distribution model may be unknown. In contrast, Data Envelopment Analysis (DEA) is a non-parametric technique considering various outputs and inputs. This method has become popular in recent decades for its ability to test various aspects of FDI, perform multidimensional comparisons, and process multiple input and output variables concurrently, leading technical software development (Nguyen *et al.*, 2022).

The authors use the two-stage DEA approach to answer the second and third questions, which combines the Super Slacks-Based Measure (Super-SBM) and DEA Malmquist models. As a result, the authors' purposes were achieved. Using the Super SBM model, this paper assessed the efficiency and inefficiency of Vietnamese provinces in using resources to attract FDI. The provinces with the most room for growth and those with the best practices are identified using projection analysis of inputs and outputs. Moreover, with the DEA Malmquist model, the authors have measured Vietnamese provinces' change in resource optimization.

1.5.2. Data View

The data collected from the Vietnam Chamber of Commerce and Industry (VCCI) regarding 10 Competitiveness Indexes and collected from the General Statistics Office of Vietnam (GSO) regarding the number of FDI cases and capital for 2017–2021. The DEA Solver software is processed to analyze nonparametric input/output variables and represents 63 distinct provinces in Vietnam.

1.6. Conclusion

Chapter 1 provides background information and some key points of the topic relevant to this study. This chapter covers the thematic background, practice problem, research objective, research question, research scope, and methodology. It also kicks off the main idea of the study. The following chapter will highlight technical terms used in the research.

1.7. Thesis Outline

Chapter 1: Introduction

This section introduces the role of FDI in the economy, an overview of FDI in Vietnam, and the importance of using resources to attract FDI. This section also provides research objectives, scope, subjects, questions, methodology, and data used in the research.

Chapter 2: Literature review

The second chapter contains some literature reviews relevant to the thesis topic. It identifies and provides comments and assessments on the Vietnam provinces' effectiveness in attracting FDI. This chapter will go over the fundamentals of efficiency and productivity. The literature review will also review studies conducted to assess the effectiveness of provinces in attracting FDI in Vietnam, as well as the specific implementation of DEA methods.

Chapter 3: Methodology

Research methods are introduced in this third chapter to clarify the research topic. The research team used three techniques: Grey Delphi, Super-SBM model, and DEA Malmquist. Based on established theories and assumptions, research formulas and conclusions were developed.

Chapter 4: Results and Discussions

This chapter is an important chapter of the research topic. From the data analysis, the research team offers the results of research methods and discussion about their significant implications.

Chapter 5: Conclusions, Limitations, and Future Works

Chapter five outlines the research's important conclusion and the study's limitations.

Furthermore, proposals for future works will be explained here.

CHAPTER 2: LITERATURE REVIEW

2.1. Literature Review on the Competitiveness Index

Competitiveness has several definitions, but one commonly used by the World Economic Forum is the "*set of institutions, policies, and factors*" that affect a country's productivity and determine its prosperity level (World Economic Forum, 2016). From a similar perspective, the World Bank developed the concept of Global Investment Competitiveness (GIC) to measure a country's ability to attract and retain FDI. It involves evaluating a country's investment climate, including the quality of institutions, regulatory frameworks, infrastructure, and human capital. The GIC framework aims to provide policy makers with a comprehensive and data-driven approach to attract more FDI and improve the country's competitiveness in the global market (World Bank Group, 2020).

As earlier stated, the term "*regional*" pertains to the territorial segmentation of a nation, which can be established based on multiple criteria such as demographics, historical background, cultural identity, economic conditions, and climatic factors, to name a few. As part of resource and capability management, each country has employed distinct regional competitiveness indexes to foster a sustained enhancement in business efficiency and the quality of life for the region's residents. For instance, Vukmirović et al. (Vukmirović *et al.*, 2021) highlighted the significance of FDI and the competitiveness of emerging and developing countries, focusing on Serbia. They examined the correlation between FDI, GDP, unemployment rate, and GCI and compared FDI inflows from China, Russia, and EU countries.

For Vietnam, the competition among countries in the region has intensified, making it increasingly difficult for countries like Vietnam to attract and retain foreign investors. To address this challenge, policy makers need to understand how the competitive index affects FDI attractiveness and identify the most effective policies and incentives for promoting FDI. Several studies have examined the relationship between the competitive index and FDI attractiveness in Vietnam. For example, Le and Dang (2022) highlighted FDI's importance for sustainable socio-economic growth and international economic integration by employing the provincial competitiveness index along with others crucial indicators: labor force, gross regional domestic product, FDI by capital, and FDI by cases.

Elkomy, Ingham, and Read (2016) found that the effects of FDI on growth are influenced by the level of human capital and political development, with political development suppressing FDI effects on growth in authoritarian countries and enhancing them in hybrid democracies. The study also found that domestic investment is a more important growth driver in more democratic countries. Similarly, Siyue et al. (2022) studied Chinese companies' location choices for outward foreign direct investment (OFDI), focusing on the ASEAN region. Specifically, among institutional quality factors, the rule of law and corruption control significantly promote market-seeking, resource-seeking, and efficiency-seeking investments, while regulatory quality and government effectiveness significantly promote market-seeking and efficiency-seeking investments. Le et al. (2021) argued that policies should focus on improving economic governance, investing in public education and human capital, and addressing the negative impact of urbanization on income inequality.

Several South American countries have different methods to evaluate the competitiveness of their regions (Mendes Resende, 2013). Peru and Chile have regional competitiveness indexes, while Colombia has two indicators: the Structural Departmental Competitiveness Index and the Revealed Departmental Competitiveness Index. Mexico also has two sets of State Competitiveness indexes and a Competitiveness of Mexican cities index (González Catalán, 2021). Similarly, Vietnam has implemented the PCI since 2005 to assess the ability of each region to attract foreign investment (pcivietnam.vn, 2020). Since the set of PCI indicators was not purposely designed to evaluate the effect of FDI, but to assess the quality of economic governance, the degree of convenience, the friendly business environment and administrative reform efforts of the governments of provinces and cities in Vietnam, thereby promoting the development of the private sector. In which, we realized that not all indicators are suitable for assessing FDI attractiveness performance for each region of Vietnam. Research in diverse domains may not necessarily generate cohesive outcomes when dealing with many indicators at distinct strategic, tactical, and operational levels (Kuo and Chen, 2008). Therefore, referring to other sets of indicators that evaluate the effectiveness of FDI attraction at the provincial level is necessary. Adapt from various provincials/regional competitive indexes, we extracted 16 potential inputs for our evaluation as shown in **Table 2.1**: (1) entry costs (EC); (2) land access and security (LS); (3) transparency (TR); (4) informal charges (IC); (5) time costs and regulatory compliance (LT); (6) policy bias (PB); (7) proactivity of provincial leadership (PL); (8) business support service (SS); (9) labor training (LA); (10) legal institution (LI); (11) education (ED); (12) financial market (FIN); (13) innovation factor (IN); (14) integration into the global economy (GL); (15) socio-demographic (SD); and (16) urban-environmental (UE).

Table 2.1. Definitions of PCI indexes.

No	Competitive Index	References
1	Entry costs (EC): the entry costs for new firms of a province	(Mendes Resende, 2013; pcivietnam, 2020; González Catalán, 2021)
2	Land access and security (LS): how easy it is to access land and the security of tenure once the land is acquired	
3	Transparency (TR): a measure of whether firms have access to the proper planning and legal documents necessary to run their businesses	
4	Informal charges (IC): how much of an obstacle the extra fees pose for the firm's business operations	
5	Time Costs and Regulatory Compliance (LT): how much time firms waste on bureaucratic compliance, how often and for how long firms must shut their operations down for inspections by local regulatory agencies	
6	Policy bias (PB): measure privileges to the state-owned economic group, corporations, causing difficulties to your business	
7	The proactivity of provincial leadership (PL): the measure of the creativity and cleverness of provinces in implementing central policy, designing their initiatives for private-sector development, and working within sometimes unclear national regulatory frameworks to assist and interpret in favor of local private firms	
8	Business support service (SS): a measure of provincial services for private-sector trade promotion, provision of regulatory information to firms, business partner matchmaking, provision of industrial zones or industrial clusters, and technological services for firms	
9	Labor training (LA): the efforts to promote vocational training and skills development for local industries and to assist in the placement of local labor	
10	Legal institution (LI): a measure of the private sector's confidence in provincial le-gal institutions	

11	Education (ED): a measure of the skilled and educated workforce	(Elkomy, Ingham and Read, 2016; Le and Duy, 2021)
12	Financial market (FIN): the strength and stability of a country's financial market	
13	Innovation factor (IN): measures new opportunities for growth and competitiveness, which helps companies stay ahead of the curve in a rapidly changing global economy.	
14	Integration into the global economy (GL): a country's level of integration into the global economy, measured by the volume of trade and investment flows, is a key factor that attracts FDI.	
15	Socio-demographic (SD): demographic factors such as population size, age structure, and income levels	
16	Urban-environmental (UE): the measure of the quality of a country's urban and environmental infrastructure	

2.2. Literature Review on Methods

2.2.1. Delphi Method

The Delphi method, developed by Olaf Helmer and Norman Dalkey of the Rand Corporation in the 1950s, is a forecasting technique that involves multiple rounds of questionnaires administered to a group of experts (Dalkey and Helmer, 1963). Consistency of expert opinions is ensured through multiple rounds of investigation. Experts must adjust their opinions to match the mean value of all expert opinions, resulting in a consensus-building process involving expert discussion and multiple rounds of questionnaires to achieve a shared understanding. For example, Nong (2023) measured the performance efficiency of 22 ports in Vietnam using a hybrid method of the Delphi technique with the KAMET principle and input and output-oriented DEA method. Additionally, Nong (2022) assessed the performance efficiency of retail stores in the fashion industry using the integrated approach of Delphi and DEA techniques. According to Sykianakis (2007), the Delphi method plays a crucial role in the initial stage of the FDI decision-making process, which involves gathering information about the economic, political, and market environment to assess whether a project aligns with the company's expansion strategy and estimate the future demand for its products. The method helps set preferences for accepting FDI, such as having a local partner or maintaining full control of the investment. It serves as a platform for individual and collective judgments to determine subsequent actions for the project. Therefore, the Delphi method plays a significant role in determining the attractiveness of FDI for a company. Huang et al. (2021) combined Fuzzy Delphi and DEMATEL methods to identify the key factors and construct causal relationships among key investment factors. Fazelian, Arefnejad, and Rosta (2022) identified the obstacles to FDI in Iran, and data gathered by questionnaires were analyzed using the Fuzzy Delphi technique.

However, the Delphi method requires experts to modify their opinions to match the mean value of all expert opinions, resulting in a loss of individual expertise. Furthermore, the Delphi method does not consider the uncertainty and imprecision of data. On the other hand, the Fuzzy theory and Grey System Theory can handle uncertain, indistinct, and missing data (Ma *et al.*, 2011). Therefore, combining the Fuzzy sets, Grey System Theory, and the conventional Delphi method is applied to validate critical factors and select evaluation indicators using a grey whitening weight/defuzzying function based on questionnaires. Fuzzy and Grey System theories can handle uncertain, indistinct, and missing data. However, they have some differences in their advantages: Fuzzy theory is a mathematical framework that deals with uncertainty and imprecision by allowing variables to have partial membership in a set. This means that instead of using binary true/false values, Fuzzy theory allows for more nuanced and probabilistic descriptions of variables, which can be useful when dealing with complex or vague concepts. Fuzzy theory is particularly useful when dealing with linguistic variables, such as “high” or “low” levels of a certain factor. It allows for degrees of membership in a set rather than forcing a binary classification.

On the other hand, Grey System Theory is a methodology that deals with data sets that are incomplete or have missing information. It does this by using limited information to make predictions or draw conclusions. Grey System Theory is particularly useful when dealing with data sets that are limited in size or scope or when there are gaps in the data. It can also be useful when dealing with data that is noisy or has a high degree of uncertainty.

In this study, the authors aim to enhance the decision-making process related to FDI by utilizing the Grey Delphi method, which combines the Delphi method and Grey System Theory. This method can address uncertainties and provide a more comprehensive understanding of the key factors affecting FDI. The outcome of this approach is the construction of competitiveness indexes that can effectively evaluate the performance of FDI in different provinces in Vietnam.

2.2.2. Data Envelopment Analysis (DEA) Methods

The DEA method is widely utilized for evaluating decision-making units’ performance (DMUs). DEA can be traced back to Farrell’s work in 1957. His concept of the production possibility frontier judges the effectiveness of businesses operating in the same industry, incorporating resource allocation efficiency and total technological efficiency (Farrell, 1957). However, input and output weighting is the main drawback of Farrell’s efficiency. Charnes, Cooper, and Rhodes (CCR) addressed this issue and introduced an improved technique in 1978 (Charnes, Cooper, and Rhodes, 1978). The CCR approach utilized a non-parametric method to generate a production possibility frontier curve from DMU data and applied various mathematical programming techniques to calculate the efficiency of DMUs. Without using fixed weights or time series analysis, this method determines the relative efficacy of DMUs (Aldamak and Zolfaghari, 2017). In 1984, Banker, Charnes, and Cooper (BCC) expanded upon the CCR model by determining variable returns to scale (VRS) scenarios, enabling a more thorough examination of DMU efficiency (Banker, Charnes, and Cooper, 1984). Incorporating dummy or categorical variables, discretionary and non-discretionary variables, and non-parametric Malmquist indices are just a few modifications to the DEA approach over time (Kahraman and Tolga, 1998). Tone (2001) later proposed the slacks-based measure of efficiency (SBM), which incorporated the slack's objective function to demonstrate a unit's input surplus and output shortage, transforming the model non-radial since inputs and outputs did not need to be verified simultaneously (Lozano and Gutiérrez, 2011). The DEA Malmquist model, an expansion of the original DEA model, is a very useful instrument for assessing the productivity of DMUs, with the Malmquist Productivity Index (MPI) being the result of the catch-up index (technical efficiency) and the frontier-shift index (technological efficiency) (Jafari, 2014). This study uses the MPI obtained from the Malmquist model to identify the provinces in Vietnam that are most effective at attracting FDI.

Table 2.2 summarizes the applications of DEA, with input and output factors in the literature to determine the relative efficiency of provinces in attracting FDI. Several notable studies have utilized this methodology in their analysis. Suyanto, Salim, and Bloch (2009) applied the generalized MPI to examine the spillover effects of FDI on Indonesian chemical and pharmaceutical companies. The Malmquist DEA model was used in the research article of Lei et al. (2013). They assessed the attractiveness of FDI for sustainable development using data from China from 1997 to 2008. This paper enriches the literature by delivering valuable input information for decision-makers in improving a framework to attract FDI in the host country. Thanh Tung (2014) also applied the DEA Malmquist method to assess the influence of PCI factors on FDI in 63 provinces in Vietnam. While traditional DEA requires precise input and output data, most available data could be more precise and clearer. FDEA incorporates Fuzzy set theory into traditional DEA using Fuzzy sets to represent imprecise and ambiguous data. The research of Aydin (2014) considers applications of the FDEA method in FDI performance measurement to assess the efficiency of FDI in 12 transition economies that broke away from the USSR. Wang and Le (2019) combined DEA Malmquist with the SBM model to evaluate the efficiency of FDI on the economic growth of 20 Asian and African developing countries during 2012–2017. In the same year, Zhang et al. (2019) conducted an out-put-oriented return-to-scale DEA model to calculate the efficiency of China's environmental protection spending. Liu et al. (2022) published a study that is considered the first examination of China's industrial green competition through a panel dataset. The dataset encompasses 30 provinces and spans from the years 2001 to 2017. The study employs a super SBM model for evaluating the competition. In the paper by Le and Dang (2022), five key indicators, including labor force, gross regional domestic product, the PCI, FDI by capital, and FDI by cases, were studied to see how they affect the efficiency of attracting FDI into provinces. The paper first uses a combination of Simple Moving Average (SMA) and Improved Fuzzy Time Series (IFTS) to predict the future values of the indicators from 2021 to 2022 using historical data from 2012 to 2020, combined with DEA window analysis to assess provinces' effectiveness in attracting FDI over the same period. However, this study has a limitation in not conducting a thorough examination of the surplus or shortage of inputs and outputs, resulting in a preliminary evaluation of the efficiency of each province. Starčević et al. (2022) utilized the original DEA model to examine the effect of FDI on the sustainability of the economic system in Bosnia and Herzegovina and Serbia from 2005 to 2020. The findings affirm that DEA is an effective tool in evaluating the efficiency of FDI. Polloni-Silva et al. (2022) conducted an excellent study on the environmental costs of FDI in Brazil. This group suggests using traditional panel data econometrics with the DEA model to study the environmental impact in regions with high foreign investment potential.

Table 2.2. List of related studies.

No.	Papers	Inputs	Outputs	Methods	Sample and Region
1	(Suyanto, Salim and Bloch, 2009)	Spillovers from FDI	Productivity growth	Generalized Malmquist	Indonesian chemical and pharmaceutical firms
2	(Lei *et al.*, 2013)	Material capital Human Capital Energy degree of openness	FDI performance index FDI potential index	CCR model, Malmquist	Chinese provinces
3	(Thanh Tung, 2014)	Provincial Competitive Index (2012 version)	FDI and domestic investment	DEA Malmquist, bootstrapping	63 provinces of Vietnam
4	(Noyan Aydin, 2014)	Gross domestic product, population, and global competitiveness index	FDI	FDEA	12 transition economies for 2011

5	(Wang and Le, 2019)	FDI, exchange rate, CSR spending	Gross domestic product; GDP per capita	GM (1,1) model, DEA Malmquist, Super SBM	20 developing countries
6	(Zhang *et al.*, 2019)	FDI	The efficiency of government expenditure on environmental protection	The output-oriented DEA scale return model	China
7	(Liu *et al.*, 2022)	Land, capital, natural resources, labor	Air pollution, Water pollution, Solid Waste pollution, CO_2 Emissions, the added value of industrial output	Super SBM model	China
8	(Le and Dang, 2022)	Labor force, gross regional product, and the PCI	FDI by capital (cumulative) and FDI by cases (cumulative)	IFTS, SMA DEA window	42 of Vietnam's 63 provinces
9	(Starčević *et al.*, 2022)	FDI, RER, Inflation rate	GDP, RER, employment rate, import, export, inflation rate	DEA, PCA, IMF SWARA method, CRADIS method	Bosnia, Herzegovina, and Serbia
10	(Polloni-Silva *et al.*, 2022)	Population density, GDP per capita, industry share of GDP, service's share of GDP, education	Intensity of FDI	Traditional panel data econometrics, DEA	All municipalities of the State of São Paulo, Brazil

	level, productivity, and infrastructure	

2.3. Research Gaps

According to the literature review mentioned earlier, no existing study has combined the novel Super-SBM and DEA Malmquist methods in assessing how effective FDI promotion is at the provincial level, particularly in a developing nation such as Vietnam.

The Super-SBM model will be applied to investigate the slacks of inputs-outputs of this case study. Slack refers to the potential improvement in the input and output variables for the inefficiency units compared to the benchmark objective (Fried, Schmidt, and Yaisawarng, 1999). The super-efficiency DEA model can process and further rank the DMUs whose efficiency value is 1 in the traditional model (Pan *et al.*, 2020). In performance evaluation, the frontier is held constant for DMUs with efficiency value $\theta < 1$, the frontier is maintained fixed, and the Super-SBM model is evaluated similarly to the SBM model. The Super-SBM model varies from the SBM model in that for a DMU with an efficiency value of $\theta = 1$, the Super-SBM model removes the DMU to be evaluated, reforms a new frontier, and then evaluates the distance of the DMU from the new frontier to determine its final ranking (Su and Ji, 2020). In other terms, the Super-SBM model can measure and compare the efficiency of DMUs by permitting a DMU's efficiency value to exceed 1. In addition, it is important to note that the DMU can still be ranked even if the efficiency value is less than 1 (Long, Ouyang, and Guo, 2020).

Furthermore, the outcomes of DEA–SBM efficiency evaluations enable projections analyses to assist inefficient DMUs in improving their efficiency and to provide quantitative and qualitative managerial recommendations by reducing excesses and increasing shortfalls (Cook and Zhu, 2003; Lobo and Araujo, 2017; Atta Mills *et al.*, 2021). Since the Super-SBM model provides more precise measurements than the conventional DEA model, it is chosen for performance evaluation analysis. The strength of the Super-SBM model has been exploited in many fields, e.g., green innovation performance (Tang, Qiu and Zhou, 2020), land usage (Zhu et al., 2019); financial efficiency (Chiu and Chen, 2009) and transportation (Tian *et al.*, 2020).

However, the Super-SBM model has its limitations. It can only perform static analysis and not reflect the changes during the specified period. The Malmquist Index (MI) can evaluate the relative growth in productivity between two time periods (Färe, Grosskopf, and Roos, 1998). Malmquist's model is incredibly useful for assessing productivity. The DEA Malmquist model enhances the standard DEA model, which is useful for measuring DMU productivity over time. MPI equals the product of the catch-up index and the frontier-shift index (Bjurek, 1996). The catch-up effect (CU) describes how close a DMU approaches the production frontier with the highest performance. The frontier-shift effect (FS) describes the technological advancement of the sample. Aspects of the MPI that have been deconstructed can determine how much of an increase in relative efficiency from period t to period t+1 can be attributed to individual effort and how much can be attributed to industry development. Efficiency change quantifies the degree to which a DMU's efficiency increases or decreases, whereas technological change, quantifies the efficiency of FS between two periods (Greer, 2008). There have been numerous Malmquist model applications in various fields over time. For example, Firsova and Chernyshova (2020) used DEA Malmquist to estimate direct and indirect innovation effects on Russian regions according to variables of the innovative product volume, the share of high-tech products in the gross regional product (GRP) structure, the number of used patents, and investment in innovation activity from 2006 to 2017. DEA was also employed to measure the Malmquist productivity of the driving forces of China's provincial energy intensity (Huang, Du, and Hao, 2017), the banking industry in Canada (Asmild *et al.*, 2004), and the computer industry (Chen and Iqbal Ali, 2004). The combination of DEA and MI, due to their mutual support, is widely used in jointly conducting static and dynamic performance evaluation in many research fields, e.g., the performance of semiconductor packaging and testing firms (Liu and Wang, 2008), export market selection and efficiency (Wang and Le, 2018), road safety assessment (Ganji and Rassafi, 2019).

Recognizing the methods' superiority and comprehensiveness over other efficiency evaluation methods, this study attempts to measure FDI performance in Vietnam provinces using the integrated super-SBM model and DEA Malmquist. First, Super-SBM offers a detailed comparison and recommendation between inefficient and efficient DMUs based on scores, rankings, and slack indicators. Then, DEA Malmquist is utilized to calculate the efficiency changes score for 2017–2021 based on output variables, including FDI by case and capital, and input variables, including Competitive Indexes. Input indicators that best match the characteristics of FDI evaluation will be well considered.

2.4. Conclusion

Therefore, this study uses a functional model to assess how the competitive index affects FDI attractiveness by using an integrated model of Grey Delphi, the Data Envelopment Analysis Super Slack-Based Measure Model (DEA–Super SBM), and the Malmquist Model (DEA–Malmquist) to evaluate the FDI attractiveness of Vietnamese provinces from 2017 to 2021. Firstly, ten critical dimensions of the provincial competitive index (PCI) affecting the number of FDI by cases and amount of FDI capital were validated via the Grey Delphi method. Secondly, the Super-SBM model is applied to assess the FDI efficiency of 63 provinces in Vietnam from 2017 to 2021. Then, the DEA–Malmquist model is employed to analyze the total change in the productivity of 63 provinces' FDI performance in Vietnam. The findings of this study revealed that the efficiency of FDI in Vietnam's provinces is relatively low, and there is a significant variation in the attractiveness of FDI among the provinces. This study can provide valuable insights for policymakers and other stakeholders in developing effective strategies to attract FDI and foster economic development.

CHAPTER 3: METHODOLOGY

3.1. Research Process

As stated in the preceding sections, this study presents a hybrid technique of Grey Delphi, Super-SBM, and DEA Malmquist to assess the efficacy of FDI in Vietnam. The Delphi and DEA methods can investigate various aspects of a research problem or question. However, they differ in their approach to testing hypotheses. The Delphi method focuses on obtaining consensus among experts on a particular topic or issue. The experts are usually chosen based on their knowledge and experience in the field. They are asked to provide their opinions on questions or statements about the research problem. The method does not rely on pre-defined hypotheses but rather seeks to gather insights and opinions from the experts that can be used to inform the research project. Similarly, DEA focuses on measuring the efficiency and performance of a set of entities or decision-making units (DMUs) based on multiple inputs and outputs. The analysis does not rely on pre-defined hypotheses but seeks to identify the most efficient DMUs and determine the factors that contribute to their performance. While the Delphi method and DEA do not rely on pre-defined hypotheses, they can generate insights and data that can inform and guide the development of hypotheses for further research. For example, the insights and opinions gathered through the Delphi method can be used to identify key areas of research or potential hypotheses to test. In contrast, the findings from DEA can be used to inform hypotheses about the factors contributing to the efficiency and performance of DMUs.

Figure 3.1 depicts the research process for the technique. The process includes seven steps as follows:

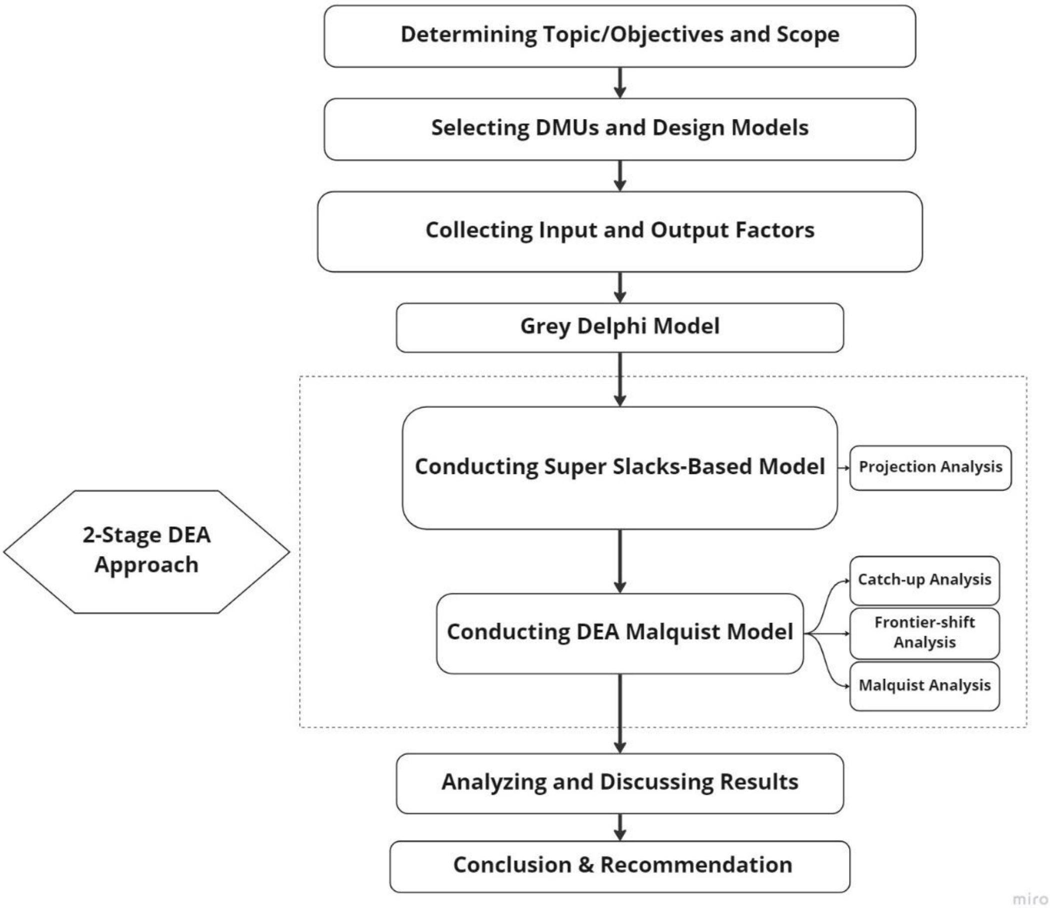

Figure 3.1. The research processes

Step 1: Determine the topic, objectives, and scope of the research

Identifying the research topic, specifying the study's objectives, and defining the research scope. This step is essential to ensure the research topic is relevant, feasible and has significant academic value.

Step 2: Selecting DMUs and design models

This step involves selecting the Decision-Making Units (DMUs) and designing the appropriate models to evaluate their efficiency. The DMUs are the entities that will be analyzed to assess their performance, and the models are the analytical tools that will be used to evaluate efficiency.

Step 3: Collecting Input and Output factors

Collecting data on the Input and Output factors of the DMUs. Inputs are the resources used by the DMUs, while Outputs are the products or services produced by the DMUs. Collecting accurate and comprehensive data is crucial for ensuring the validity and reliability of the research results.

Step 4: Grey Delphi

This step involves using the Grey Delphi method to establish the weights of the Input and Output factors. The Grey Delphi method is a systematic approach that combines expert opinions and statistical analysis to estimate the importance of the Input and Output factors.

Step 5: 2-Stage DEA Approach

In the first stage, a Super-SBM model is used to evaluate the efficiency and inefficiency of the DMUs. The Super-SBM model is a method used to assess the efficiency of DMUs and identify areas where improvements can be made. It helps to identify inefficient DMUs and guide them towards better efficiency by projecting potential improvements and highlighting areas for improvement. Projection analysis predicts the future performance of inefficient DMUs by projecting their performance towards the efficient frontier.

In the second stage, the Malmquist DEA model was used to estimate the change in total productivity caused by a change in CU and FS. Finally, research results are analyzed and discussed before managerial implications are proposed to improve the efficiency of the FDI attraction in Vietnam's provinces.

Step 6: Analyzing and discussing the results

This step involves analyzing the research results and discussing the implications of the findings. The analysis should be comprehensive, objective, and supported by evidence. The discussion should provide insights into the research topic and the broader context of the research.

Step 7: Conclusion and Recommendation

This step involves summarizing the research findings, drawing conclusions based on the results, and making recommendations for future research or practical applications. The conclusion should be based on the evidence presented in the research, and the recommendations should be practical and relevant.

3.2. Grey Delphi Method

Multi-criteria decision-making (MCDM) methods rely on expert judgments, which are often uncertain. To deal with this uncertainty, this study employs the grey systems theory. The grey systems theory (Liu and Lin, 2006) categorizes information into fully certain (white), inadequate (grey), and unknown (black). This study employs the Grey System Theory's concept of interval grey numbers. The Delphi method was proposed by Dalkey and Helmer (1963). It is a popular survey method for synthesizing the opinion of experts on a particular issue to reach a consensus. The conventional Delphi method has drawbacks, such as the need for multiple iterations to reach an agreement, subjectivity, and bias among experts. The grey theory integration could help surmount these limitations (Ma *et al.,* 2011). Consequently, the Delphi and grey set theories are combined to form the grey Delphi approach. The grey Delphi approach involves several steps:

Step 1. Identification of competitive index factors (CIFs) of FDI

The literature review is used to identify potential CIFs of FDI in this step. Based on these CIFs, a questionnaire is created to gather data from the experts.

Step 2. Response collection from experts

The questionnaire prepared for this study is being delivered to specialists, who must respond using a linguistic scale. **Table 4.1** shows the linguistic scales and their accompanying grey numbers.

Step 3. Overall evaluation using the grey number.

The responses obtained from the experts have been converted to corresponding grey numbers. These grey numbers are then used to integrate the responses of the experts. Consider the case of an expert panel consisting of p members. The evaluation of the factor $\otimes G_i$ is as follows:

$$\otimes G_i = \frac{\left(G_i^1 + \otimes G_i^2 + \cdots + \otimes G_i^h + \cdots + \otimes G_i^p\right)}{p} \qquad (1.1)$$

where $\otimes G_i$ is the overall evaluation of CIF's importance and $\otimes G_i^h$ denotes the h^{th} expert's evaluation of CIF_i of FDI adoption.

Step 4. Whitening of the grey number

The grey number having the interval $\otimes G = [G^L, G^R] = [G' \in G \,|G^L \leq G' \leq G^R|]$ Moreover, their equivalent whitenization value is $\otimes G^{\sim}$. The whitenization of grey numbers is obtained through **Equation (1.2).**

$$\otimes G^{\sim} = \alpha . G^{L} + (1-\alpha). G^{R}, \alpha = [0,1] \quad (1.2)$$

Step 5. Setting threshold limit and CIFs selection

CIFs are selected and rejected in the Grey Delphi method's ultimate stage. To determine the importance of the factor, a total score is computed and compared to a threshold value (λ). If the value of $\otimes G^{\sim} \geq \lambda$, the factor is selected; otherwise, it is rejected.

3.3. DEA Models

3.3.1. DEA Originality

Performance Evaluation and Tradeoffs

Performance evaluation is an essential aspect of any business operation as it helps identify areas for improvement and increase efficiency. Businesses use performance measures or metrics to evaluate their performance regarding the resources used, quality of products or services, customer satisfaction, and other outcomes. Performance evaluation is crucial for businesses to remain competitive in today's global market, where competition is fierce. By continuously improving their operations, businesses can stay ahead of the competition.

Single-measure-based gap analysis is commonly used in performance evaluation. However, it is not always sufficient, as a business's performance is a complex phenomenon that requires multiple criteria to characterize it. For example, a bank branch's profitability does not necessarily indicate if the resources used to provide customer services are managed efficiently. Each business operation has specific performance measures or metrics, which may involve tradeoffs, interactions, or substitutions. Benchmarking and performance evaluation can help identify these tradeoffs and improve efficiency.

For example, consider the tradeoff between total supply chain cost and supply chain response time, measured by the time between an order and its corresponding delivery. **Figure 3.2** illustrates alternate supply chain operations S1, S2, S3, and S, and the best-practice (efficient) frontier or tradeoff curve determined by them. A supply chain whose performance (or strategy) is on the efficient frontier is non-dominated (efficient) because no alternate supply chain's performance is strictly better in cost and response time. Through performance evaluation, the efficient frontier that represents the best practice is identified, and an inefficient strategy (e.g., point S) can be improved (moved to the efficient frontier) with suggested directions for improvement (to S1, S2, S3, or other points along the frontier).

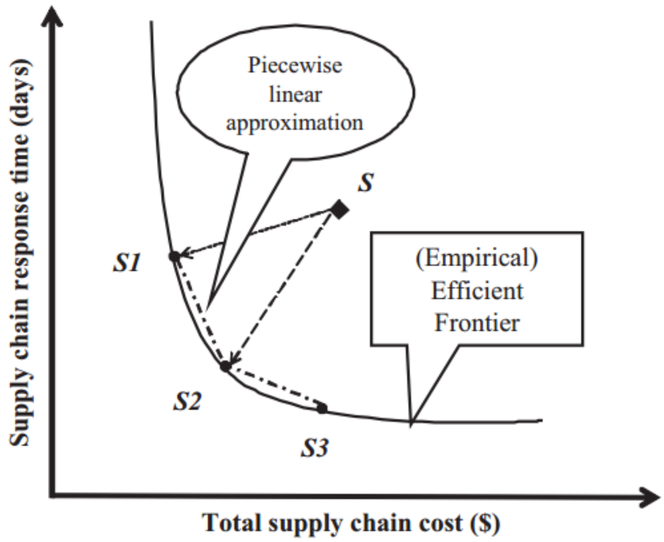

Figure 3.2. (Example) Best efficient frontier of supply chain operations

Optimization techniques can be used to estimate the efficient frontier of a business operation if we have information on the functional forms of the relationships among various performance measures. For example, stockout levels and inventory turns are mutually dependent variables with tradeoffs that technological and process innovations can shift. However, such information is not always available, making it difficult to characterize business operations and processes fully. Performance evaluation aims to evaluate and benchmark the current operation internally and externally to identify best practices, which can be empirically identified based on observations of one business operation over time or similar operations at a specific period.

Parametric & non-parametric

There are two main types of statistical analysis methods: parametric and non-parametric. The main difference is that parametric tests assume that the data follow a particular distribution, while non-parametric tests do not make such assumptions. Parametric tests are used when the population distribution is known and has fixed parameters. In contrast, non-parametric tests are used when there is uncertainty or skewness in the distribution of populations under study.

Examples of parametric tests include paired and unpaired t-tests, Pearson's product-moment correlation, ANOVA, and multiple regression. These tests have their non-parametric counterparts, such as the Mann-Whitney U Test, Wilcoxon Signed Rank Test, Sign Test, and Kruskal Wallis Test, which are used when uncertain or skewness in the distribution of populations under study.

Parametric tests should be used when the data follows a normal distribution, and there are equal variances across groups. They provide higher statistical power and can be used with limited sample size. Non-parametric tests should be used when the data does not follow a normal distribution, measured on different scales, or when the population distribution is unknown.

Data Envelopment Analysis (DEA) is a non-parametric technique considering various outputs and inputs.

Data Envelopment Analysis

DEA is a data analysis tool for identifying best practices when multiple performance metrics characterize such a best-practice frontier. In DEA, performance metrics are classified as “inputs” and “outputs.” According to Cooper et al. (2011):

“*DEA is a relatively new “data-oriented” approach for evaluating the performance of a set of peer entities called Decision Making Units (DMUs) which convert multiple inputs into multiple outputs. The definition of a DMU is generic and flexible. Recent years have seen a great variety of applications of DEA for use in evaluating the performances of many kinds of entities engaged in many different activities in many different contexts in many different countries. These DEA applications have used DMUs of various forms to evaluate the performance of entities, such as hospitals, US Air Force wings, universities, cities, courts, business firms, and others, including the performance of countries, regions, etc. Because it requires few assumptions, DEA has also opened possibilities for use in cases resistant to other approaches because of the complex (often unknown) nature of the relations between the multiple inputs and outputs involved in DMUs.*”

Performance Metrics Classified as Inputs and Outputs

The DEA methodology requires that performance measures be classified into inputs and outputs. However, it is important to ensure that the selected measures properly reflect the process under study. Inputs and outputs are generally well-defined in a production or service process but may not be so in benchmarking. The efficient DMUs, as defined by DEA, may not necessarily form a "production frontier" but rather lead to a "best-practice frontier." One needs to classify performance measures into inputs and outputs for use in DEA. DEA minimizes inputs and maximizes outputs, but exceptions exist, such as pollutants from a production process. In certain circumstances, a factor can simultaneously play a dual role of input and output. If the underlying DEA problem represents a production process, then inputs and outputs can be more clearly identified. However, suppose the DEA problem is a general benchmarking problem. In that case, the inputs are usually the "less-the-better" type of performance measures, and the outputs are usually the "more-the-better" type. Cook et al. (2014) also point out that we can also have mixed use of ratio data, percentage data, and raw data as inputs and outputs.

Number of DMUs vs. Number of Inputs and Outputs

It is well known that large numbers of inputs and outputs compared to the number of DMUs may diminish the discriminatory power of DEA. A suggested “rule of thumb” is that the number of DMUs is at least twice the number of inputs and outputs combined (see Golany and Roll 1989). On the other hand, Banker et al. (1989) state that the number of DMUs should be at least three times the number of inputs and outputs combined. However, such a rule is neither imperative nor has a statistical basis, but rather is often imposed for convenience. Otherwise, one indeed loses discrimination power. It is not suggested, however, that such a rule must be satisfied. There are situations where a significant number of DMUs are, in fact, efficient. Sometimes, the population size is small and does not permit one to add actual DMUs beyond a certain point. However, if the user wishes to reduce the number or proportion of efficient DMUs, various DEA models can help; for example, weight restrictions may be useful in such cases.

Cook et al. (2014) point out that while in statistical regression analysis, sample size can be a critical issue, as it tries to estimate the average behavior of a set of DMUs, DEA, when used as a benchmarking tool, focuses on individual DMU performance. In that sense, the sample size or the number of DMUs under evaluation may be immaterial. For example, if there are only ten firms in a particular market and many inputs and outputs must be used if deemed necessary by the management, then the DEA benchmarking results can still be valuable. One fact remains that whatever form the production frontier takes, it is beyond the best practice frontier. It is also true that if one adds DMU to an existing set, that DMU will be either inefficient or efficient. In the former case, the best practice frontier does not shift, and nothing new is learned about the production frontier. In the latter situation, the frontier may shift closer to the actual (but unknown) production frontier.

In summary, DEA is not a form of regression model but a frontier-based linear programming-based optimization technique. Applying a sample size requirement to DEA is meaningless, which should be viewed as a benchmarking tool focusing on individual performance. A significant portion of DMUs will likely be deemed as efficient.

3.3.2. Traditional DEA Model

We use decision-making units (DMUs) to represent business operations or processes. Each DMU is evaluated based on a set of multiple performance measures that are classified as "inputs" and "outputs." Suppose we have a set of observations on n DMUs. Each observation consists of values of performance measures related to a DMU_j (j=1, …, n). The selected performance measures are classified as m inputs x_{ij} (i=1, 2, …, m) and s outputs y_{rj} (r=1, 2, …, s).

DEA uses linear programming techniques to identify the (empirical) efficient frontier or best-practice frontier for these n observations. The following two properties ensure we can develop a piecewise linear approximation to the efficient frontier and the area dominated by the frontier.

Property 1.1 *Convexity*. $\sum_{j=1}^{n} \lambda_j x_{ij}$ $(i = 1,2, \dots, m)$ and $\sum_{j=1}^{n} \lambda_j y_{rj}$ $(r = 1,2, \dots, s)$ are possible input and output levels achievable by the DMU_j, where λ_j $(i = 1,2, \dots, n)$ are nonnegative scalers such that $\sum_{j=1}^{n} \lambda_j = 1$.

Property 1.2 *Inefficiency*. The same y_{rj} can be obtained by using $\hat{x}_{ij}$, where $\hat{x}_{ij} > x_{ij}$ (i.e., the same output levels can be achieved by using more inputs). The same x_{ij} can be used to achieve $\hat{y}_{ij}$, where $\hat{y}_{ij} \leq y_{ij}$ (i.e., the same input levels can be used to achieve fewer outputs).

The next step is to estimate the empirical (piecewise linear) efficient frontier characterized by **Equation (2)**. DEA uses linear programming to estimate the tradeoffs inherent in the efficient empirical frontier implicitly.

For specific x_i (i = 1,2,…, m) and y_i (r = 1,2,…,s), we have

$$\begin{cases} \sum_{j=1}^{n} \lambda_j x_{ij} \leq x_i & i = 1,2, \dots, m \\ \sum_{j=1}^{n} \lambda_j y_{rj} \geq y_r & r = 1,2, \dots, s \\ \sum_{j=1}^{n} \lambda_j = 1 & \end{cases} \quad (2)$$

Consider **Figure 3.3,** where 5 DMUs (A, B, C, D, and H) have one input and output. One possible best-practice frontier consists of DMUs A, B, C, and D. AB exhibits increasing RTS (IRS), BC exhibits constant RTS (CRS), and CD exhibits decreasing RTS (DRS). As a result, this best-practice frontier is called Variable RTS (VRS) frontier.

DMU H is inefficient (or best practice) because it uses too much input and/ or does not produce enough output. There are two ways to improve the performance of H. One is to reduce its input to reach H' on the frontier, and the other is to increase its output to reach H" on the frontier. As a result, DEA models will have two orientations: input-oriented and output-oriented.

Input-oriented models test if a DMU under evaluation can reduce its inputs while keeping the outputs at their current levels. Output-oriented models test if a DMU under evaluation can increase its outputs while keeping the inputs at their current levels.

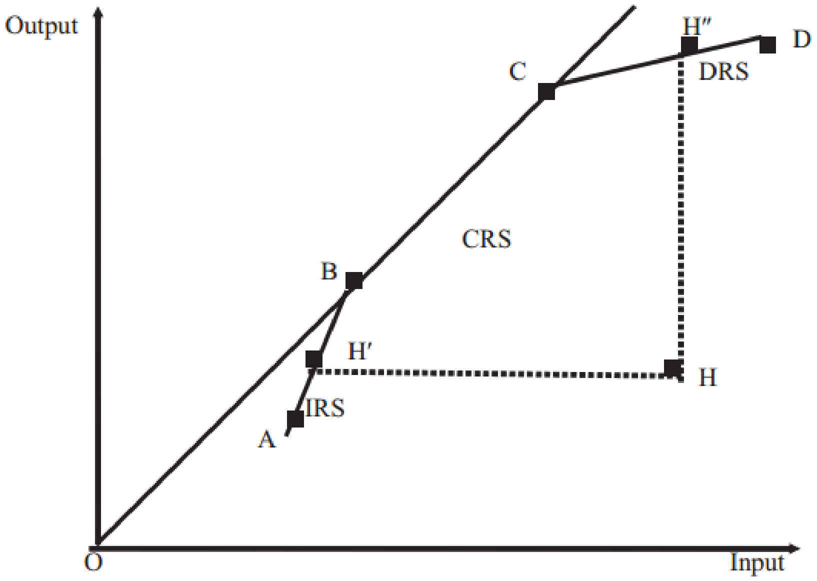

Figure 3.3. Variable returns-to-scale (VRS) frontier

3.3.3. Super-SBM Model

The Super-SBM model, developed by Tone (2001), calculates the efficiency of an efficient DMU by comparing it to the nearest point on the frontier, excluding itself.

Let the set of DMUs be $j = (1, \dots, n)$ and each DMU_j has m input factors and g output factors. We denote the vectors of inputs and outputs for DMU_j by $X_j = (x_{1j}, x_{2j}, \dots, x_{mj})^T$ and $Y_j = (y_{1j}, y_{2j}, \dots, y_{gj})^T$, respectively.

We define input and output matrices X and Y by $X = (x_1, x_2, \dots, x_n) \in R^{m\times n}$ and $Y = (y_1, y_2, \dots, y_n) \in R^{g\times n}$, respectively. We assume all data are positive, i.e., $X > 0$, $Y > 0$.

While λ is a non-negative vector, $\lambda = (\lambda_1, \lambda_2, \dots, \lambda_n)^T$ is called the intensity vector in R^n, the vectors $s^- = (s^-{}_1, s^-{}_2, \dots, s^-{}_m)^T \in R^m$ and $s^+ = (s^+{}_1, s^+{}_2, \dots, s^+{}_g)^T \in R^g$ represent the expression's excessive input and insufficient output, called slacks. In fractional form, the SBM-DEA model evaluates the efficiency of DMU_k is as follows:

$$min\rho = \frac{1 + \frac{1}{m}\sum_{i=1}^{m} s_i^- / x_{ik}}{1 - \frac{1}{g}\sum_{i=1}^{g} s_i^+ / y_{ik}} \quad (3)$$

Subject to:

- $x_{k0} = X + s^-$,
- $y_{k0} = Y - s^+$, and
- $s^- \geq 0 \; and \; s^+ \geq 0$.

In this study, the authors consider the super-efficiency problem under the assumption of $\rho^* = 1$, $S^{-*} = 0$ and $S^{+*} = 0$; the inputs are guaranteed, and the output is constant in the optimal solution; the DMU (x_{k0}, y_{k0}) is defined as the SBM efficient model. The efficiency with which the SBM is estimated ranges from 0 to 1.

The Super-SBM model was introduced by Tone (2001) to separate and rank these efficient DMUs. If $\rho^* = 1$, then the DMU (x_{k0}, y_{k0}) is efficient, the Super-SBM model can be described as follows:

$$min\delta = \frac{\frac{1}{m}\sum_{i=1}^{m} \bar{x_\iota} / x_{ik}}{\frac{1}{g}\sum_{i=1}^{g} \bar{y_\iota} / y_{ik}} \quad (4)$$

Subject to:

- $\bar{x} \geq \sum_{j=1, j\neq k}^{n} \lambda_j \, x_j$;
- $\bar{y} \leq \sum_{j=1, j\neq k}^{n} \lambda_j \, y_j$;
- $\bar{x} \geq x_k$, $0 \leq \bar{y} \leq y_k$, $\lambda \geq 0$.

Suppose $y_{rk} \leq 0$. $\bar{y}_r^+$, and $\bar{y}_{-r}^+$ will be defined by:

- $\bar{y}_r^+ = \max_{j=1,\dots,n} \{ y_{rj} | y_{rj} > 0 \}$, and
- $\bar{y}_{-r}^+ = \min_{j=1,\dots,n} \{ y_{rj} | y_{rj} > 0 \}$.

If the output r has no positive factors, then it is denoted as $\bar{y}_r^+ = \bar{y}_{-r}^+ = 1$. The elements in the objective function are replaced by s_r^+ / y_{rk} as follows, whereas the value y_{rk} never changes.

If $\bar{y}_r^+ > \bar{y}_{-r}^+$, subjected to: $\frac{s_r^+}{\frac{y_{-r}^+(\bar{y}_r^+ - y_{-r}^+)}{\bar{y}_r^+ - y_{rk}}}$

If $\bar{y}_r^+ = \bar{y}_{-r}^+$, subjected to: $\frac{s_r^+}{\frac{(\bar{y}_{-r}^+)^2}{B(\bar{y}_r^+ - y_{rk})}}$

DEA-solver is assigned a B-Score of 100, indicating that the recommendations it provides are always helpful and have a high level of precision y_{-r}^+. B-Score is influenced by the size of the unsupported output and the distance between the actual value and target value $\underline{y}_r^+ - y_{rk0}$. Importantly, the B-Score is independent of the unit of measurement used.

For inefficient provinces to attain full efficiency, the DEA projection analysis quantifies how much reduction in inputs and undesirable outputs would have been required and how much increase in desirable outputs. The improvement ratio is calculated by dividing the slack by the original value (i.e., (original value − projected value)/original value). A positive ratio indicates the need to increase the corresponding input/output, and a negative ratio indicates the need to decrease the corresponding input/output.

3.3.4. DEA Malmquist

The MPI was proposed by Caves, Christensen, and Diewert (1982) to determine each DMU's efficiency change in two periods. In the research, the authors assessed the dynamic productivity trend of provinces' FDI using the original and expanded MPI by Färe et al. (1994). MPI is a tool used to analyze productivity and comprises two major parts: efficiency change (EC) and technical change (TC). The efficiency change is also known as the CU effect, representing the change in DMU's efficiency. In contrast, the technical change is known as the FS effect, exhibiting the fluctuation in the efficient frontier.

The change in total factor productivity from period *t* to period *t* + 1 is calculated as the following **Equation (5)**:

$$MPI_t^{t+1} = \sqrt{\frac{\rho_0^t\,(x^{t+1}, y^{t+1})}{\rho_0^t\,(x^t, y^t)} \times \frac{\rho_0^{t+1}(x^{t+1}, y^{t+1})}{\rho_0^{t+1}(x^t, y^t)}} \quad (5)$$

MPI_t^{t+1} > 1 indicates positive DMU performance growth in the period between *t* and *t* + 1, whereas MPI_t^{t+1} = 1 and MPI_t^{t+1} < 1 correspondingly indicates that the performance has no change and negative growth.

The MPI index can be decomposed into the product of two components:

$$MPI(x^{t+1}, y^{t+1}, x^t, y^t) = \frac{\rho_0^{t+1}(x^{t+1}, y^{t+1})}{\rho_0^t\,(x^t, y^t)} \sqrt{\frac{\rho_0^t\,(x^{t+1}, y^{t+1})}{\rho_0^{t+1}(x^t, y^t)} \times \frac{\rho_0^t\,(x^t, y^t)}{\rho_0^{t+1}(x^t, y^t)}} \quad (6)$$

= Catch-up effect (CE) × Frontier shift (FS)

A CE score larger than one in the context of productivity analysis indicates that a province is making attempts to close the gap and get closer to the frontier. On the other hand, the FS value is a measure of a province’s overall improvement or deterioration in efficiency, which can push the frontier outward or inward and affect all DMUs. A rise in the CE value is viewed as proof of approaching the frontier, but an increase in the FS value is regarded as evidence of innovation.

3.4. Conclusion

In this third chapter, the authors explain the methodology and the final proposed model utilized in the research study. The chapter is divided into three main parts: the research process, the Grey Delphi method, and the DEA method.

The study presents a hybrid technique that combines the Grey Delphi, Super-SBM, and DEA Malmquist to assess the efficacy of FDI in Vietnam. The Grey Delphi method focuses on obtaining a consensus among experts on the topic of FDI to formulate a set of Competitive Index. Through this method, the experts can provide their opinions and expertise to the research, contributing to a comprehensive analysis of FDI's effectiveness in Vietnam.

On the other hand, the DEA method is a data-driven approach that enables the analysis of the relative efficiency of different units by comparing their inputs and outputs. The authors provide a comprehensive overview of the DEA method, including its origin, meaning, and traditional model. In this research study, the authors utilize two high-end DEA models: the DEA Super-SBM and DEA Malmquist. These models are effective tools that can provide insights into the performance of different units regarding efficiency and productivity.

The findings and data analysis process will be provided in the next chapter.

CHAPTER 4: FINDINGS AND ANALYSIS

4.1. Results of the Grey Delphi Technique

The Delphi panel participants will receive an invitation to participate in all Delphi rounds unless they opt out of the study. By continuing to participate in the survey, it will be assumed that the participant consents to the study. Questionnaires were sent to experts using Google Forms. Although there is no set standard for the sample size of a panel, a higher number of panel members generally increases the reliability of group judgments. Experts have suggested that a minimum of 10 to 18-panel members per area of expertise is required *(Santaguida* et al.*, 2018)*. Given the complexity of the criteria and the possibility of having multiple areas of expertise among various FDI professionals, we obtained 11 valid participants.

The experts selected for this study include individuals from both academic and industrial backgrounds. Industrial professionals with at least eight years of experience in FDI management and business development are chosen to provide data. The selection of academic experts specializing in FDI, Business Management, or International Business in reputable academic institutions is based on their proficiency and expertise in FDI. The survey had 11 participants who completed it. Out of the 11, 6 were male, and five were female.

Regarding age, 2 participants were under 25, 7 were between 25 to 40 years old, two were between 40 to 60 years old, and none were over 60 years old. Regarding education, three participants held a professor position, one held a bachelor's degree, four held a master's degree, and three held a doctorate. Regarding occupation, six participants were scholars, three were policymakers, and two were managers. Finally, regarding experience in the field, two had less than five years of experience, four had 5 to 10 years of experience, and five had 10 to 20 years of experience. Overall, the participants had diverse demographic and professional characteristics, which provided valuable insights and perspectives on the research topic.

Following the expert group's responses, we transformed the linguistic value into grey numbers using **Table 4.1.** To calculate the overall grey weight, **Equation (1.1)** is utilized. The resulting grey weight is converted into a crisp number using **Equation (1.2).** These crisp numbers are then used to determine which CIFs should be included or excluded from the analysis. The threshold value is the average of all crisp values; a value greater than this threshold indicates that the CIF is relevant and should be included. Conversely, the CIF is excluded if the value is below the threshold. The overall grey and crisp weights and the decision are presented in **Table 4.2**.

Table 4.1. Linguistic scale and grey number.

Linguistic Scale	**Grey Number**
No important (NI)	[0,0]
Low important (LI)	[0,1]
Medium important (MI)	[1,2]
High important (HI)	[2,3]
Very high important (VH)	[3,4]

Table 4.2. Results of the Grey Delphi method.

CIFs	**Overall Grey Weight**		**Crisp Weight**	**Decision**	**Decode**
EC	2,3	3,3	2,8	Accept	CIF1
ED	0,8	1,6	1,2	Reject	
FIN	0,9	1,7	1,3	Reject	
LS	2,0	3,0	2,5	Accept	CIF2
TR	2,0	3,0	2,5	Accept	CIF3
IC	2,1	3,1	2,6	Accept	CIF4
GL	0,8	1,4	1,1	Reject	
LT	2,2	3,2	2,7	Accept	CIF5
PB	2,1	3,1	2,6	Accept	CIF6

IN	0,6	1,1	0,9	Reject	
PL	2,2	3,2	2,7	Accept	CIF7
SS	2,1	3,1	2,6	Accept	CIF8
UE	1,3	2,2	1,8	Reject	
LA	2,3	3,3	2,8	Accept	CIF9
SD	1,0	1,8	1,4	Reject	
LI	2,3	3,2	2,8	Accept	CIF10

The results of the grey Delphi show ten qualified CIFs in FDI evaluation. Surprisingly, the factors include all of Vietnam's PCIs, indicating that the PCI is an appropriate set of competitive indexes to assess the effectiveness of Vietnamese provinces in attracting FDI. These ten CIFs are important for FDI investors and the government to effectively evaluate Vietnam provinces' competency and competitiveness.

4.2. Data Collection

In this analysis, each DMU represents a distinct Vietnamese province. The investigation utilizes information from 63 provinces. This paper uses data from the General Statistics Office of Vietnam regarding the number of FDI cases and capital. In addition, CIFs data are extracted from the annual business survey, evaluation, and classification conducted by the Vietnam Chamber of Commerce and Industry. As in **Figure 4.1**, 10 selected inputs and output factors (FDI by capital and FDI by cases) are defined as follows.

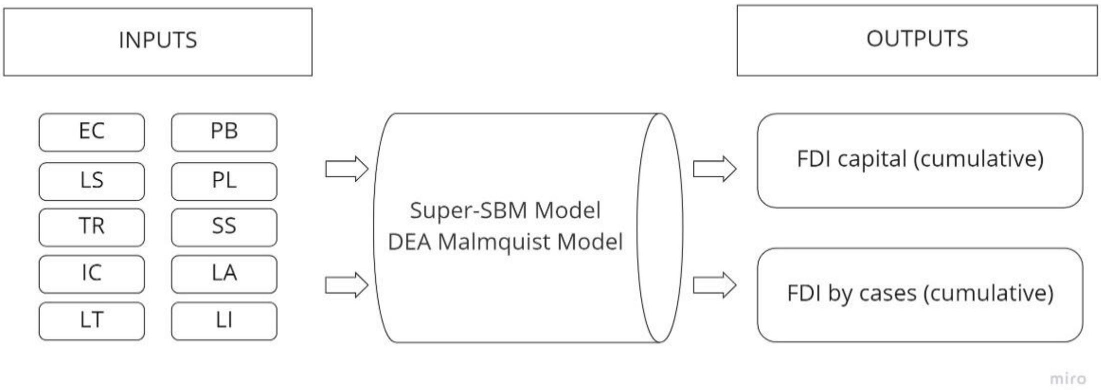

Figure 4.1. The DEA structure for evaluation of FDI attractiveness in Vietnam.

4.3. Efficiency Analysis

Initially, the authors employed the Super-SBM model to assess the FDI efficiency of 63 provinces in Vietnam from 2017 to 2021. The results of the static evaluation are presented in **Table 4.3**. In the super-SBM model, the DMU is inefficient when the score is less than 1 and efficient when the score is equal to or greater than 1. As seen from **Table 4.3**, the FDI efficiency of Vietnam's provinces in 2017–2021 was not high; most of the FDI efficiency scores in the provinces were less than 1, except for Ho Chi Minh City. The average efficiency score obtained throughout the years is merely 0.1225 to 0.1376, indicating a need to enhance the FDI efficiency of most of Vietnam's provinces.

Table 4.3. FDI attractiveness efficiency scores and ranking of provinces (2017–2021).

Provinces	2017	2018	2019	2020	2021	2017	2018	2019	2020	2021
	Efficiency Scores					Ranking				
An Giang	0.0045	0.0044	0.0054	0.0055	0.0058	47	49	47	50	49
Bac Lieu	0.0016	0.0097	0.0115	0.0993	0.0967	58	45	43	21	21
Bac Giang	0.1003	0.1079	0.1259	0.1479	0.1740	17	16	14	14	13
Bac Kan	0.0005	0.0005	0.0005	0.0004	0.0004	61	61	61	61	61
Bac Ninh	0.3662	0.3789	0.3581	0.4010	0.4044	6	7	7	7	7
Ben Tre	0.0180	0.0210	0.0206	0.0308	0.0314	35	35	35	36	37
Binh Duong	0.6533	0.6742	0.7030	0.6928	0.7224	3	3	2	3	3

Binh Dinh	0.0150	0.0175	0.0161	0.0224	0.0228	37	37	37	38	40
Binh Phuoc	0.0495	0.0562	0.0614	0.0702	0.0799	29	27	27	27	24
Binh Thuan	0.0805	0.0763	0.0771	0.0805	0.0790	23	23	24	24	25
Ba Ria Vung Tau	0.6118	0.6464	0.6426	0.6777	0.6363	5	4	5	4	5
Ca Mau	0.0017	0.0016	0.0031	0.0093	0.0032	57	58	54	46	56
Cao Bang	0.0043	0.0028	0.0021	0.0019	0.0019	49	55	57	58	58
Can Tho	0.0139	0.0147	0.0145	0.0151	0.0405	41	39	39	42	34
Da Nang	0.0945	0.1075	0.1089	0.1083	0.1127	21	17	17	19	19
Dak Lak	0.0044	0.0034	0.0033	0.0033	0.0124	48	52	51	53	44
Dak Nong	0.0025	0.0034	0.0032	0.0065	0.0064	54	51	52	48	48
Dien Bien	0.0001	0.0001	0.0001	0.0001	0.0001	63	62	63	63	63
Dong Nai	0.6170	0.6259	0.6514	0.6686	0.6592	4	5	4	5	4
Dong Thap	0.0034	0.0030	0.0031	0.0031	0.0043	52	54	53	54	54
Gia Lai	0.0007	0.0006	0.0007	0.0007	0.0007	60	60	60	59	59
Ha Giang	0.0013	0.0010	0.0007	0.0006	0.0006	59	59	59	60	60
Ha Nam	0.0547	0.0628	0.0774	0.0878	0.0964	26	26	23	23	22
Ha Noi	0.6592	0.7410	0.6942	0.7514	0.7347	2	2	3	2	2
Ha Tinh	0.2795	0.2651	0.2466	0.2519	0.2351	9	9	9	9	10
Hai Duong	0.1883	0.1717	0.1759	0.1967	0.1672	10	10	10	10	14
Hai Phong	0.3417	0.3940	0.3838	0.4028	0.4479	7	6	6	6	6
Hau Giang	0.0179	0.0098	0.0107	0.0106	0.0137	36	44	45	44	43
Hoa Binh	0.0140	0.0164	0.0152	0.0160	0.0168	39	38	38	41	42
Hung Yen	0.0985	0.1015	0.1046	0.1100	0.1209	18	19	18	18	16

Kien Giang	0.0970	0.1022	0.0987	0.1083	0.1027	19	18	20	20	20
Kon Tum	0.0020	0.0021	0.0020	0.0021	0.0056	56	57	58	57	50
Khanh Hoa	0.0949	0.0924	0.0905	0.0898	0.0955	20	21	21	22	23
Lai Chau	0.0004	0.0001	0.0001	0.0001	0.0001	62	62	62	62	62
Lang Son	0.0059	0.0054	0.0050	0.0052	0.0049	46	47	49	51	51
Lao Cai	0.0128	0.0123	0.0123	0.0122	0.0116	43	43	42	43	45
Lam Dong	0.0146	0.0123	0.0109	0.0106	0.0101	38	42	44	45	46
Long An	0.1416	0.1481	0.1523	0.1581	0.2425	12	12	12	12	9
Nam Dinh	0.0723	0.0720	0.0691	0.0759	0.0722	24	24	26	26	27
Ninh Binh	0.0290	0.0279	0.0293	0.0313	0.0343	33	34	34	35	36
Ninh Thuan	0.0295	0.0379	0.0353	0.0324	0.0365	32	32	32	34	35
Nghe An	0.0429	0.0415	0.0443	0.0487	0.0502	30	29	29	30	30
Phu Tho	0.0248	0.0280	0.0331	0.0395	0.0491	34	33	33	33	31
Phu Yen	0.1171	0.0395	0.0429	0.0415	0.0422	15	31	30	32	32
Quang Binh	0.0135	0.0178	0.0164	0.0244	0.0256	42	36	36	37	39
Quang Nam	0.1242	0.1280	0.1189	0.1223	0.1189	13	13	15	16	18
Quang Ninh	0.1188	0.1231	0.1167	0.1244	0.1422	14	15	16	15	15
Quang Ngai	0.0334	0.0397	0.0391	0.0416	0.0409	31	30	31	31	33
Quang Tri	0.0023	0.0022	0.0021	0.0025	0.0044	55	56	56	56	53
Soc Trang	0.0029	0.0052	0.0051	0.0063	0.0047	53	48	48	49	52
Son La	0.0036	0.0031	0.0029	0.0029	0.0029	51	53	55	55	57
Tay Ninh	0.1111	0.1241	0.1379	0.1553	0.1755	16	14	13	13	12
Tien Giang	0.0504	0.0483	0.0547	0.0591	0.0597	28	28	28	29	29
HCMC	1.5429	1.5914	1.6109	1.5499	1.5985	1	1	1	1	1

TT-Hue	0.0544	0.0785	0.0788	0.0794	0.0771	27	22	22	25	26
Tuyen Quang	0.0038	0.0041	0.0042	0.0047	0.0042	50	50	50	52	55
Thai Binh	0.0140	0.0145	0.0145	0.0161	0.0275	39	40	40	39	38
Thai Nguyen	0.1629	0.1695	0.1683	0.1754	0.1798	11	11	11	11	11
Thanh Hoa	0.3166	0.3136	0.3041	0.3117	0.3033	8	8	8	8	8
Tra Vinh	0.0681	0.0715	0.0692	0.0691	0.0701	25	25	25	28	28
Vinh Long	0.0116	0.0126	0.0138	0.0160	0.0175	44	41	41	40	41
Vinh Phuc	0.0889	0.0993	0.1027	0.1103	0.1202	22	20	19	17	17
Yen Bai	0.0104	0.0088	0.0082	0.0085	0.0092	45	46	46	47	47
Average	0.1225	0.1269	0.1272	0.1335	0.1376					

According to **Table 4.3**, among the 63 provinces in Vietnam, Ho Chi Minh City, Ha Noi, Binh Duong, Ba Ria Vung Tau, and Dong Nai are the top five provinces with the highest efficiency scores. Having scores greater than 1.5, Ho Chi Minh City was ranked first for all five years from 2017 to 2021, with the highest score of 1.6109 in 2017. Investment capital from the state budget is concentrated in Ho Chi Minh City because this is the economic center of the south (congthuong.vn, 2022). However, to achieve such an achievement, the People's Committee of these two provinces had to use capital sources and utilize resources to attract FDI effectively. The first is Ho Chi Minh City; in 2022 alone, Ho Chi Minh City attracted 3.94 billion USD in FDI, the highest in the country (hanoimoi.com.vn, 2023). People's Committee of Ho Chi Minh City has focused on investing in infrastructure projects such as Thu Thiem 2 bridge, with a total investment of nearly 3100 billion VND, promulgating preferential policies for foreign-invested projects (thuvienphapluat.vn, 2004); promoting human resource training; ensuring a stable political and economic environment (hcmcpv.org.vn, 2021).

The second province under the FDI attractiveness efficiency ranking is Hanoi despite being inefficient with scores around 0.7. Like Ho Chi Minh City, Hanoi is also prioritized by the state to focus on investment because Hanoi is the capital of the country. The province has focused on key investment areas and has made significant achievements. As the economic-political center of the country, Hanoi actively expands international cooperation relations, improves the efficiency of external activities, contributes to trade promotion, and attracts foreign investment. After more than 23 years of being awarded the title of City for Peace by UNESCO, many major international events have been successfully organized by Hanoi, such as “The 2019 North Korea–United States Hanoi Summit” or “Hanoi 2020—Investment and Development Cooperation” (tapchicongsan.org.vn, 2021). These conferences have symbolic meaning, affirming Hanoi’s capacity and prestige in major events. Thanks to the peaceful and stable environment, investors have chosen Hanoi as an important destination for FDI. However, the investment licensing procedures in Ha Noi are still complicated for FDI. The time to consider and approve some projects is still long, and the coordination between the city's government agencies, central ministries, and branches is ineffective. The planning and introduction of construction sites for investment projects are still slow. In addition, several mechanisms and policies have not been adjusted in time to suit the conditions of international economic integration (tapchicongsan.org.vn, 2020).

The next three provinces that effectively attract FDI are Binh Duong, Ba Ria Vung Tau, and Dong Nai, with the average efficiency scores respectively 0.7224, 0.6363 and 0.6592. Although, it has yet to reach the level of effectiveness. Besides the advantage of being adjacent to key economic regions, these three provinces have new points to attract FDI. The first is Binh Duong, which impresses with its relatively good transport infrastructure and industrial infrastructure. In particular, Binh Duong always promotes the administrative reform process, creating favorable conditions for foreign enterprises to carry out legal procedures for business investment (laodong.vn, 2023). Next is Ba Ria Vung Tau. With many advantages of a deep-water seaport, industrial development, tourism, and convenient transportation infrastructure in the dynamic economic zone of the Southeast region, Ba Ria Vung Tau is creating a good image of a potential and promising land for foreign direct investors. This helps ensure smooth traffic, exploits the province’s strengths, and connects with other regional localities (Vietnamplus, 2022). Finally, Dong Nai province. Dong Nai province has achieved many important achievements in attracting foreign investment in 2017–2021. However, by 2022, FDI attraction in this province showed signs of slowing down and was very low (baotintuc.vn, 2022). This situation is because Dong Nai has carefully selected investment projects in the locality, prolonging the appraisal time. Therefore, Dong Nai must develop appropriate policies to remove limitations, increase competitiveness and attract FDI. Through the models in the above province, policymakers in other provinces can learn to optimize resources and exploit their strengths to attract more FDI.

On the other hand, Dien Bien, Lai Chau, Bac Kan, Ha Giang, and Gia Lai are the most inefficient provinces from 2017 to 2021. Among them, Dien Bien has the lowest efficiency score of 0.0001, making it the least effective province in the country during this period. To attract efficiently FDI, provinces need to establish a stable economic, political, and social environment, enhance the local government's role, improve the legal framework for investment activities, and provide investors with incentives to invest in new-oriented industries and fields (tapchitaichinh.vn, 2017). However, this should be done while demonstrating national interests and local economic and technical efficiency and avoiding attracting low-quality FDI just for the sake of movement. Moreover, it is essential to invest in material and technical infrastructure to create favorable conditions for foreign investors and improve the quality of human resources. These are innovative regulations for attracting FDI that top provinces such as Ho Chi Minh City and Binh Duong have successfully implemented.

While most provinces' scores were stable, four provinces, consisting of Bac Lieu, Can Tho, Dak Lak, and Phu Yen, experienced significant fluctuations. Bac Lieu's score exhibited an upward trend, increasing from 0.0016 in 2017 to 0.0967 in 2021, improving their ranking from 58th to 21st. Can Tho's ranking has remained relatively stable in efficiency scores between 2017 and 2020, but by 2021, the province's efficiency score improved, leading to an increase in rank from 42nd to 34th. Dak Lak also experienced a similar trend. It is worth noting that Phu Yen held a high ranking of 15th in 2017 but subsequently fell to 32nd place from 2018 to 2021.

Regarding various socio-economic regions in Vietnam, **Table 4.4** provides the FDI attractiveness efficiency indexes. Concurrently, **Chart 4.1** plots the FDI attractiveness evolution paths of these regions. As shown in **Chart 4.1**, all regions had stable efficiency trends in attracting FDI over 2017–2021. Specifically, the Southeast region stands out as the most efficient in attracting FDI, followed by the Red River Delta and North Central Coast and Central Coast regions.

The provinces in the Southeast region have been actively preparing the necessary conditions in terms of infrastructure, procedures, and human resources to welcome the new wave of FDI (baodautu.vn, 2023). The Southeast provinces are better prepared to receive investors than in the past. The first noticeable improvement is the investment in regional connectivity infrastructure. Construction of Ring Road 3, which will pass through four localities, including Ho Chi Minh City, Binh Duong, Dong Nai, and Long An, is set to commence in the second quarter of this year. This route is considered a driving force for the development of the entire region as it will reduce freight time and costs for businesses. In parallel with the investment in Ring Road 3, provinces and cities are actively investing in expanding national highways, linking each other to create momentum for economic development. Notably, Ho Chi Minh City has recently begun to expand National Highway 50, connecting with Long An, and commenced the construction of the An Phu intersection to alleviate congestion on the Ho Chi Minh City - Long Thanh - Dau Giay expressway. Furthermore, Binh Duong province is expanding National Highway 13, connecting Ho Chi Minh City and Binh Phuoc, as well as the road connecting Phu Giao district to Dong Phu district in Binh Phuoc province. Dong Nai and Ba Ria - Vung Tau provinces are also preparing the necessary conditions for constructing the Bien Hoa - Vung Tau expressway, which is planned to start in the middle of this year.

According to Mr. Watanabe Nobuhiro, the Consulate General of Japan in Ho Chi Minh City, the Southeast provinces' ability to attract investment is expected to increase soon. This is due to the construction of important infrastructure projects such as the Bien Hoa - Vung Tau highway, Ring Road 3, and Ring Road 4, enhancing connectivity between provinces and cities in the Southern Key Economic Zone. Mr. Watanabe believes that once these projects are completed, the Southeast provinces will become even more appealing to investors.

After the most critical infrastructure issue has been solved, the Southeast provinces focus on expanding new industrial parks to accommodate potential investors. In particular, Ho Chi Minh City, a significant economic hub, promotes investment in the 668-hectare Pham Van Hai Industrial Park. Binh Duong is investing in developing the 1,000-hectare VSIP III Industrial Park as a green industrial park. Immediately after investing in this industrial park, Binh Duong attracted a project from LEGO Group with an investment capital of 1.3 billion USD. Dong Nai is collaborating with various government ministries to accelerate the establishment of eight newly approved industrial parks, which will provide more than 7,000 hectares of industrial land for investment. Similarly, Ba Ria - Vung Tau province plans to expand eight other industrial parks by 2030, with a total land area of over 8,000 hectares to cater to the demands of potential investors. Upon completion, these industrial parks will offer a considerable land fund for potential investors seeking to expand their operations in these provinces.

In 2023, the Southeastern provinces will expand their industrial parks and further enhance the investment environment. Specifically, Ho Chi Minh City plans to reinstate the "Single Door" mechanism in its industrial parks, allowing businesses to evaluate the operational capacity of departments and branches. Binh Duong province will implement all online procedures related to businesses from 2023. Similarly, Dong Nai and Ba Ria - Vung Tau will prioritize improvements to their investment environment and administrative reforms to expedite business-related procedures. The Southeastern provinces have also established a model that links the state, enterprises, and schools to train high-quality human resources and foster a startup ecosystem. With careful preparation and the necessary conditions in place, the Southeastern provinces are expected to remain the leading destination for foreign direct investment in the years to come.

The Red River Delta region not only ranks second in Vietnam in terms of its effectiveness in attracting FDI, but it also possesses diverse potentials, exceptional opportunities, and competitive advantages (baotainguyenmoitruong.vn, 2023). The strength of this region lies in its composition of 11 provinces and centrally-run cities, accounting for 6.42% of the country's area, which equates to approximately 21,278 km2. This strategically significant political and economic region is the northern gateway to Vietnam and ASEAN, facilitating trade with China, the world's largest market. Furthermore, the region boasts a well-integrated transportation system that synchronously connects all five modes of transportation, namely road, railway, river, air, and seaport, and is linked to four inter-regional and international economic corridors, providing favorable conditions for the development of logistics. As of 2020, the region had 496 km of highways and 2,133 km of national highways, the country's highest density of highways and national highways.

The Red River Delta region has exhibited a robust economic growth rate that exceeds the national average from 2005 to 2020. Specifically, the region's economic growth rate has averaged 7.94% per year, whereas the national average is 6.36%. As of 2020, the economic scale of the region has increased by 7.75 times compared to 2005, contributing to 29.4% of the country's Gross Domestic Product (GDP). Moreover, the region's Gross Regional Domestic Product (GRDP) has reached 103.6 million VND per year, which is 1.3 times higher than the national average. Notably, the structure of the region's economy has rapidly shifted towards increasing the proportion of the industrial and service sectors, which accounted for 40.62% and 40.64%, respectively, in 2020. The spearhead industries develop in the direction of modernity, large scale, less labor-intensive, and high technology content. The marine economy has experienced significant development, particularly in Hai Phong and Quang Ninh, which have gradually become the center of the sea economy and primary seaport services.

In recent years, the North Central Coast and Central Coast provinces have made significant progress in attracting FDI by prioritizing the completion of current and integrated infrastructure projects to facilitate connectivity with other regions and countries. Additionally, these provinces have demonstrated investment promotion efforts and issued attractive investment incentive policies. In contrast, the Central Highlands region has been the least efficient in attracting FDI due to shortcomings and difficulties, such as underdeveloped infrastructure, lacking human resources, transparency, and administrative procedures. Consequently, the provinces in this region must focus on developing and implementing effective strategies and solutions to improve the investment environment, enabling them to attract FDI sustainably and successfully in the future.

Table 4.4. FDI attractiveness efficiency trend of six socio-economic regions (2017–2021).

Key Economic Region	2017-2018	2018-2019	2019-2020	2020-2021	Average
Northern Midlands and Mountain	0.024	0.025	0.027	0.029	0.032
Red River Delta	0.184	0.198	0.193	0.210	0.215
North Central and Central Coast	0.092	0.089	0.087	0.089	0.088
Central Highlands	0.004	0.004	0.003	0.004	0.007
South East	0.597	0.619	0.634	0.635	0.645
Mekong River Delta	0.033	0.034	0.035	0.045	0.053

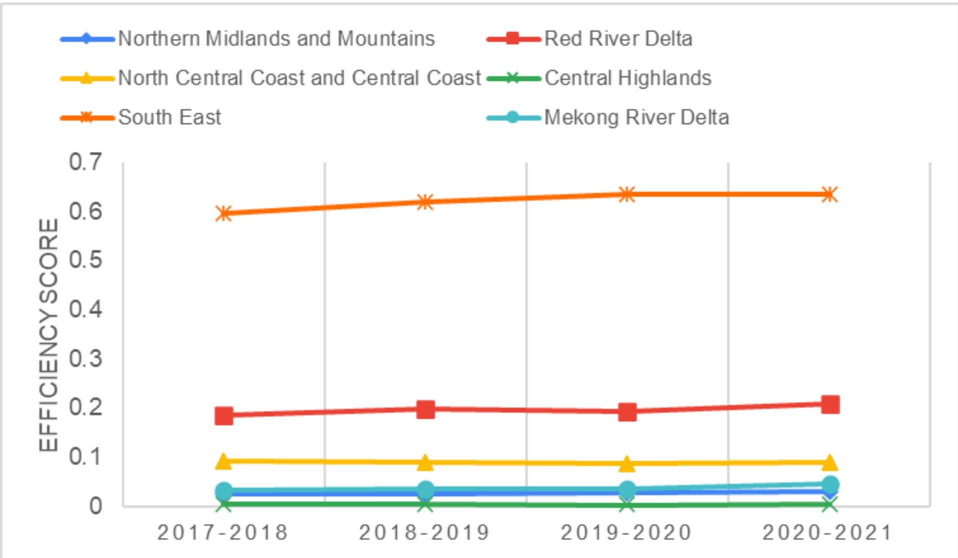

Chart 4.1. Trend of efficiency in each socio-economic region of Vietnam (2017–2021).

A projection analysis of inputs and outputs was conducted for inefficient provinces to identify directions for improving their performance. **Table 4.5** includes input and output improvement ratios for identifying input redundancy and reducing the shortfall of desirable outputs. From an input standpoint, all inputs conducted have a redundancy of approximately 80%. On the other hand, the shortage of expected outputs is a more serious issue. The most demanding need is an increase in the number of FDI cases, up to four times the current level, to reach an efficient state. Following that, the capital amount of FDI must be increased by 20%.

Table 4.5. Input-output projection rate (%) of provinces' FDI efficiency over years.

Variables		2017	2018	2019	2020	2021	Average
Inputs	CIF1	−88.24	−87.19	−86.61	−87.48	−86.97	−87.30
	CIF2	−88.22	−88.66	−87.72	−86.81	−86.38	−87.56
	CIF3	−87.67	−87.15	−86.96	−86.76	−87.21	−87.15
	CIF4	−86.85	−86.91	−87.14	−86.46	−86.12	−86.69
	CIF5	−88.44	−87.88	−87.90	−86.57	−86.91	−87.54
	CIF6	−88.40	−86.90	−87.77	−86.42	−86.21	−87.14
	CIF7	−88.49	−87.73	−88.16	−87.06	−86.91	−87.67
	CIF8	−86.05	−85.73	−85.86	−86.06	−84.06	−85.55
	CIF9	−86.79	−86.60	−86.49	−85.92	−84.92	−86.15
	CIF10	−88.73	−88.60	−88.44	−87.11	−87.00	−87.98
Outputs	FDI by cases	323.37	335.11	350.36	486.52	501.29	399.33
	FDI by capital	20.60	20.17	22.63	19.31	19.38	20.42

4.4. The Malmquist Productivity Changes

4.4.1. Technical Efficiency Change

Table 4.6. Catch-up index (2017–2021)

Catch-Up	2017–2018	2018–2019	2019–2020	2020–2021	Average
An Giang	0.9953	1.2200	1.0257	1.0391	1.0700
Bac Lieu	6.0015	1.1863	8.6488	0.9735	4.2025
Bac Giang	1.0752	1.1676	1.1741	1.1767	1.1484
Bac Kan	1.1417	0.8711	0.9275	0.9393	0.9699
Bac Ninh	1.0347	0.9450	1.1197	1.0085	1.0270
Ben Tre	1.1682	0.9832	1.4930	1.0204	1.1662
Binh Duong	1.0320	1.0428	0.9855	1.0427	1.0258
Binh Dinh	1.1674	0.9219	1.3905	1.0169	1.1242
Binh Phuoc	1.1351	1.0933	1.1428	1.1384	1.1274
Binh Thuan	0.9485	1.0103	1.0437	0.9811	0.9959
Ba Ria Vung Tau	1.0566	0.9941	1.0545	0.9389	1.0110
Ca Mau	0.9394	1.9849	2.9946	0.3383	1.5643
Cao Bang	0.6606	0.7265	0.9327	0.9931	0.8282
Can Tho	1.0623	0.9839	1.0439	2.6792	1.4423
Da Nang	1.1370	1.0128	0.9950	1.0403	1.0463
Dak Lak	0.7655	0.9773	1.0080	3.7020	1.6132
Dak Nong	1.3774	0.9297	2.0389	0.9855	1.3329
Dien Bien	0.9079	0.8522	0.9434	0.9792	0.9207
Dong Nai	1.0143	1.0408	1.0265	0.9858	1.0168
Dong Thap	0.8857	1.0423	0.9984	1.3839	1.0776
Gia Lai	0.8466	1.0729	1.0827	0.9481	0.9875
Ha Giang	0.8028	0.6447	0.9564	0.9668	0.8427
Ha Nam	1.1481	1.2328	1.1340	1.0979	1.1532
Ha Noi	1.1242	0.9368	1.0825	0.9777	1.0303
Ha Tinh	0.9486	0.9302	1.0214	0.9335	0.9584

Hai Duong	0.9115	1.0248	1.1180	0.8502	0.9761
Hai Phong	1.1530	0.9741	1.0494	1.1120	1.0721
Hau Giang	0.5491	1.0918	0.9870	1.2942	0.9805
Hoa Binh	1.1745	0.9275	1.0519	1.0487	1.0507
Hung Yen	1.0306	1.0308	1.0517	1.0990	1.0530
Kien Giang	1.0546	0.9655	1.0966	0.9485	1.0163
Kon Tum	1.0567	0.9389	1.0350	2.7239	1.4386
Khanh Hoa	0.9732	0.9794	0.9923	1.0639	1.0022
Lai Chau	0.3007	0.8838	0.9229	1.0148	0.7805
Lang Son	0.9176	0.9172	1.0325	0.9499	0.9543
Lao Cai	0.9607	0.9998	0.9921	0.9496	0.9755
Lam Dong	0.8435	0.8811	0.9746	0.9560	0.9138
Long An	1.0460	1.0281	1.0380	1.5341	1.1615
Nam Dinh	0.9955	0.9601	1.0986	0.9512	1.0014
Ninh Binh	0.9623	1.0487	1.0678	1.0982	1.0442
Ninh Thuan	1.2849	0.9308	0.9173	1.1262	1.0648
Nghe An	0.9671	1.0698	1.0991	1.0301	1.0415
Phu Tho	1.1308	1.1820	1.1939	1.2413	1.1870
Phu Yen	0.3374	1.0860	0.9679	1.0155	0.8517
Quang Binh	1.3222	0.9195	1.4922	1.0461	1.1950
Quang Nam	1.0310	0.9291	1.0283	0.9726	0.9902
Quang Ninh	1.0367	0.9479	1.0662	1.1429	1.0484
Quang Ngai	1.1915	0.9830	1.0661	0.9825	1.0558
Quang Tri	0.9447	0.9550	1.1974	1.7526	1.2124
Soc Trang	1.8120	0.9819	1.2364	0.7521	1.1956
Son La	0.8682	0.9122	1.0227	0.9774	0.9451
Tay Ninh	1.1171	1.1106	1.1267	1.1302	1.1211
Tien Giang	0.9565	1.1334	1.0798	1.0115	1.0453
HCMC	1.0314	1.0122	0.9621	1.0313	1.0093

Thua Thien Hue	1.4437	1.0041	1.0070	0.9719	1.1067
Tuyen Quang	1.0771	1.0162	1.1222	0.9034	1.0297
Thai Binh	1.0371	1.0012	1.1140	1.7027	1.2137
Thai Nguyen	1.0401	0.9931	1.0421	1.0250	1.0251
Thanh Hoa	0.9905	0.9698	1.0248	0.9733	0.9896
Tra Vinh	1.0510	0.9681	0.9976	1.0147	1.0079
Vinh Long	1.0893	1.0901	1.1610	1.0920	1.1081
Vinh Phuc	1.1176	1.0339	1.0736	1.0904	1.0789
Yen Bai	0.8449	0.9264	1.0401	1.0803	0.9730
Average	1.0957	1.0097	1.2351	1.1420	1.1206
Max	6.0015	1.9849	8.6488	3.7020	4.2025
Min	0.3007	0.6447	0.9173	0.3383	0.7805
SD	0.6653	0.1604	0.9930	0.4787	0.4232

In the previous stage, the authors used the Super SBM model to determine the effective and inefficient rankings of 63 provinces in Vietnam from 2017 to 2021. In this part, the DEA Malmquist model is applied to show FDI performance in 63 provinces of Vietnam by analyzing the total change in productivity. The provinces' MI, CU, and FS values are displayed in **Tables 4.6 - 4.8**.

From the point of view of the Catch-up index (**Table 4.6**), most provinces are greater than 1, which also happened to be a key part of making MI more productive. More specifically, the average level of CU performance is highest in Bac Lieu, Ca Mau, Can Tho, Dak Lak, and Kon Tum. Their FDI efficiency is improving due to increasing their technical work, not because of FS. Oppositely, provinces with an average CU of less than 1, such as Bac Kan, Binh Thuan, Cao Bang, Dien Bien, Gia Lai, Ha Giang, Ha Tinh, Hai Duong, Hau Giang, Lai Chau, Lang Son, Lao Cai, Lam Dong, Phu Yen, Quang Nam, Son La, Thanh Hoa, and Yen Bai, are not achieving CU efficiency.

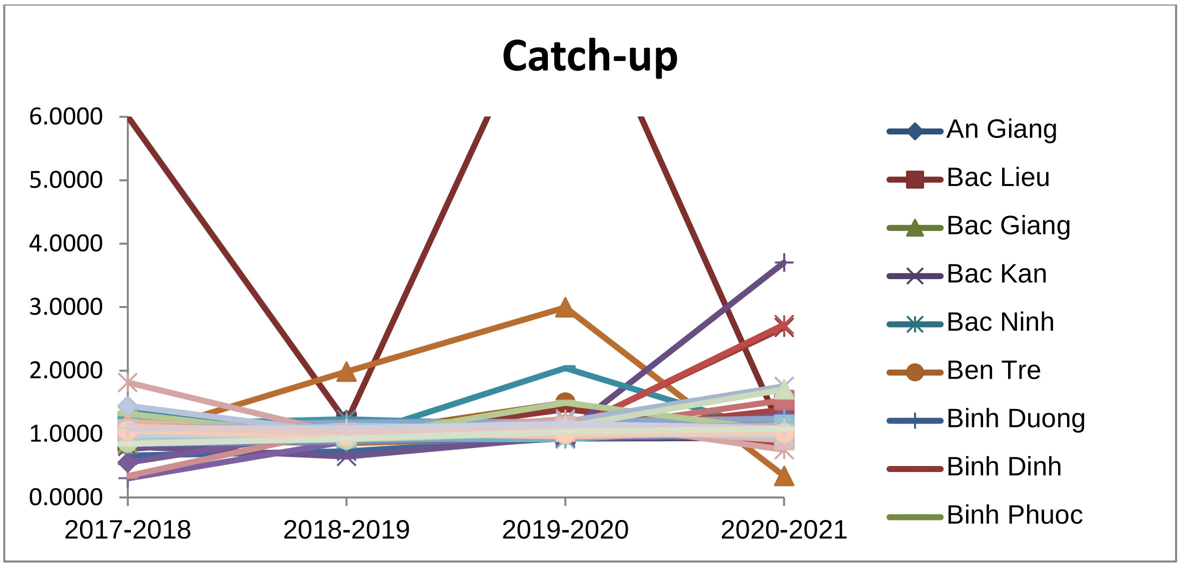

Chart 4.2. Catch-up Effect

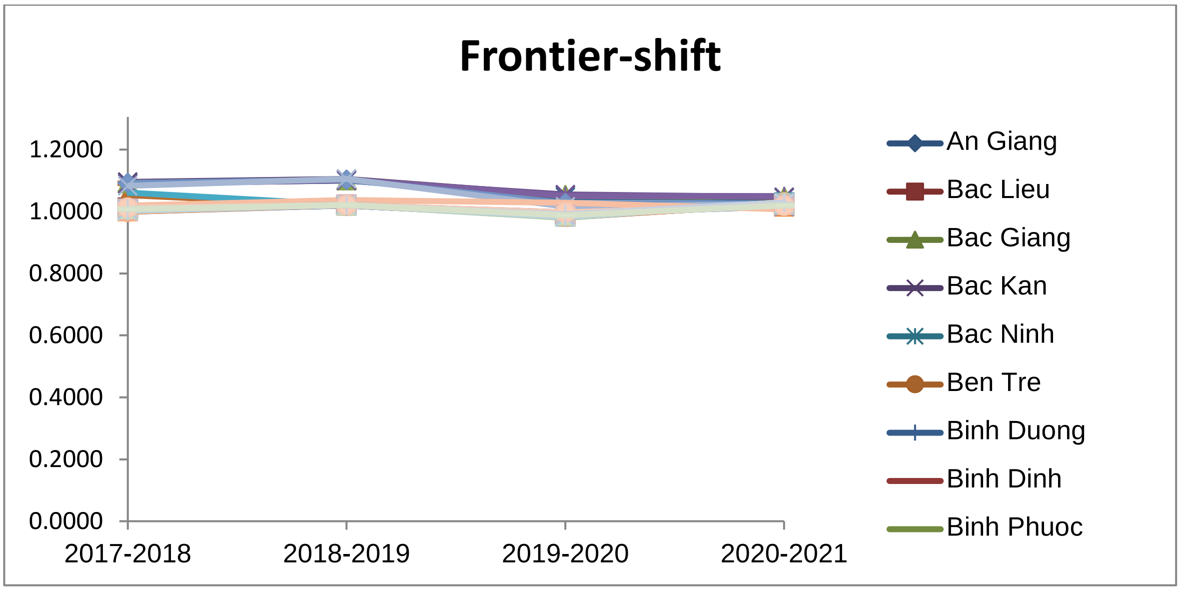

Chart 4.3. Frontier-shift Effect

4.4.2. Technological Efficiency Change

Table 4.7. Frontier-shift Index (2017–2021).

Frontier	2017–2018	2018–2019	2019–2020	2020–2021	Average
An Giang	1.0094	1.0223	0.9906	1.0271	1.0124
Bac Lieu	1.0127	1.0213	0.9914	1.0240	1.0124
Bac Giang	1.0051	1.0223	0.9904	1.0215	1.0098
Bac Kan	1.0956	1.1050	1.0516	1.0443	1.0741
Bac Ninh	1.0020	1.0213	0.9926	1.0268	1.0107

Ben Tre	1.0120	1.0199	0.9956	1.0257	1.0133
Binh Duong	1.0062	1.0223	0.9844	1.0285	1.0104
Binh Dinh	1.0087	1.0225	0.9897	1.0238	1.0112
Binh Phuoc	1.0056	1.0217	0.9849	1.0323	1.0111
Binh Thuan	1.0100	1.0197	0.9878	1.0282	1.0114
Ba Ria Vung Tau	1.0046	1.0209	0.9887	1.0266	1.0102
Ca Mau	1.0529	1.0195	0.9852	1.0264	1.0210
Cao Bang	1.0916	1.1000	1.0471	1.0450	1.0709
Can Tho	1.0067	1.0209	0.9906	1.0263	1.0111
Da Nang	1.0029	1.0221	0.9858	1.0255	1.0091
Dak Lak	1.0107	1.0207	0.9839	1.0270	1.0106
Dak Nong	1.0067	1.0221	0.9885	1.0230	1.0101
Dien Bien	1.0909	1.1018	1.0512	1.0478	1.0729
Dong Nai	1.0057	1.0193	0.9873	1.0267	1.0097
Dong Thap	1.0109	1.0211	0.9954	1.0226	1.0125
Gia Lai	1.0924	1.1015	1.0532	1.0469	1.0735
Ha Giang	1.0906	1.1003	1.0554	1.0471	1.0734
Ha Nam	1.0001	1.0211	0.9839	1.0222	1.0068
Ha Noi	1.0009	1.0196	0.9835	1.0280	1.0080
Ha Tinh	0.9989	1.0204	0.9839	1.0252	1.0071
Hai Duong	1.0079	1.0221	0.9806	1.0255	1.0090
Hai Phong	1.0064	1.0218	0.9849	1.0268	1.0099
Hau Giang	1.0131	1.0200	0.9974	1.0229	1.0133
Hoa Binh	1.0061	1.0210	0.9845	1.0295	1.0103
Hung Yen	1.0059	1.0212	0.9939	1.0167	1.0094
Kien Giang	1.0106	1.0214	0.9919	1.0274	1.0128
Kon Tum	1.0071	1.0218	0.9856	1.0260	1.0101
Khanh Hoa	1.0076	1.0203	0.9914	1.0213	1.0101
Lai Chau	1.0924	1.1032	1.0507	1.0499	1.0741
Lang Son	1.0610	1.0216	0.9873	1.0241	1.0235
Lao Cai	1.0083	1.0224	0.9828	1.0230	1.0091
Lam Dong	1.0923	1.1026	1.0272	1.0255	1.0619
Long An	1.0100	1.0206	0.9933	1.0276	1.0129

Nam Dinh	1.0066	1.0210	0.9865	1.0220	1.0090
Ninh Binh	1.0039	1.0215	0.9933	1.0156	1.0086
Ninh Thuan	1.0085	1.0209	0.9897	1.0181	1.0093
Nghe An	0.9993	1.0213	0.9847	1.0302	1.0089
Phu Tho	1.0056	1.0216	0.9901	1.0231	1.0101
Phu Yen	1.0084	1.0196	0.9868	1.0232	1.0095
Quang Binh	1.0055	1.0213	0.9798	1.0303	1.0092
Quang Nam	1.0068	1.0214	0.9903	1.0231	1.0104
Quang Ninh	1.0094	1.0213	0.9896	1.0256	1.0115
Quang Ngai	1.0018	1.0216	0.9857	1.0217	1.0077
Quang Tri	1.0832	1.1054	1.0161	1.0237	1.0571
Soc Trang	1.0100	1.0218	0.9956	1.0230	1.0126
Son La	1.0087	1.0211	0.9879	1.0287	1.0116
Tay Ninh	1.0082	1.0212	0.9949	1.0243	1.0121
Tien Giang	1.0088	1.0204	0.9868	1.0276	1.0109
HCMC	1.0189	1.0371	1.0284	1.0071	1.0229
Thua Thien Hue	1.0041	1.0227	0.9908	1.0217	1.0098
Tuyen Quang	1.0085	1.0226	0.9887	1.0215	1.0103
Thai Binh	1.0081	1.0211	0.9882	1.0237	1.0103
Thai Nguyen	1.0076	1.0213	0.9890	1.0200	1.0095
Thanh Hoa	1.0023	1.0206	0.9817	1.0287	1.0083
Tra Vinh	1.0125	1.0207	0.9975	1.0190	1.0124
Vinh Long	1.0088	1.0203	0.9914	1.0290	1.0124
Vinh Phuc	1.0081	1.0205	0.9881	1.0202	1.0092
Yen Bai	1.0073	1.0210	0.9878	1.0195	1.0089
Average	1.0194	1.0317	0.9962	1.0264	1.0185
Max	1.0956	1.1054	1.0554	1.0499	1.0741
Min	0.9989	1.0193	0.9798	1.0071	1.0068
SD	0.0292	0.0273	0.0200	0.0078	0.0201

The frontier-shift index measures the technological improvements (efficiency frontiers) of DMUs during the period 2017–2021, reflecting their performance under a few variables, such as competitiveness, technological change, development, and political and regulatory environment, to highlight a few. **Table 4.7** summarizes the detailed frontier-shift values for the DMUs, and **Chart 4.3** illustrates the evolutionary trajectories of technical efficiencies for all DMUs.

Overall, the average FS of all provinces clustered around FS = 1, with an average FS slightly above 1 in 2017–2019. However, most provinces decreased below 1 during 2019–2020. More specifically, **Table 4.7** shows that only nine provinces, including Bac Kan, Cao Bang, Dien Bien, Gia Lai, Ha Giang, Lai Chau, Lam Dong, Quang Tri, and Ho Chi Minh City, meet the positive average frontier-shift indexes. Meanwhile, Ha Giang is the best technologically efficient operator in this period. However, all provinces' average FS increased during 2020-2021, with an average FS slightly above 1.

Because all the provinces have positive average frontier-shift indexes during the period 2017-2021, the overall average frontier-shift score during the research period is 1.0185 (efficiency increase). Compared to **Chart 4.2** (catch-up effect), **Chart 4.3** shows fewer fluctuating patterns of DMUs, which shows that FS does not play a major role in promoting change in their effectiveness. Especially, all provinces are only slightly changed in 2017–2021, clustered around FS = 1; this proves that all provinces are seen to have no technological change progression.

4.4.3. Total Productivity Change

Table 4.8 Malmquist productivity index (2017–2021).

Malmquist	2017–2018	2018–2019	2019–2020	2020–2021	Average
An Giang	1.0047	1.2472	1.0161	1.0672	1.0838
Bac Lieu	6.0780	1.2116	8.5744	0.9969	4.2152
Bac Giang	1.0806	1.1936	1.1629	1.2021	1.1598
Bac Kan	1.2509	0.9625	0.9754	0.9809	1.0424
Bac Ninh	1.0368	0.9652	1.1115	1.0355	1.0372
Ben Tre	1.1822	1.0028	1.4864	1.0467	1.1795
Binh Duong	1.0384	1.0660	0.9702	1.0725	1.0368
Binh Dinh	1.1776	0.9426	1.3762	1.0411	1.1344
Binh Phuoc	1.1414	1.1170	1.1255	1.1751	1.1398
Binh Thuan	0.9580	1.0302	1.0309	1.0088	1.0070
Ba Ria Vung Tau	1.0615	1.0149	1.0427	0.9639	1.0207
Ca Mau	0.9891	2.0237	2.9504	0.3472	1.5776

Cao Bang	0.7211	0.7992	0.9766	1.0379	0.8837
Can Tho	1.0694	1.0044	1.0341	2.7496	1.4644
Da Nang	1.1403	1.0351	0.9809	1.0668	1.0558
Dak Lak	0.7738	0.9975	0.9917	3.8019	1.6412
Dak Nong	1.3867	0.9503	2.0156	1.0082	1.3402
Dien Bien	0.9905	0.9390	0.9917	1.0260	0.9868
Dong Nai	1.0200	1.0609	1.0134	1.0121	1.0266
Dong Thap	0.8954	1.0643	0.9938	1.4152	1.0922
Gia Lai	0.9248	1.1817	1.1402	0.9925	1.0598
Ha Giang	0.8756	0.7094	1.0094	1.0123	0.9017
Ha Nam	1.1482	1.2588	1.1157	1.1222	1.1612
Ha Noi	1.1251	0.9551	1.0646	1.0051	1.0375
Ha Tinh	0.9475	0.9492	1.0049	0.9570	0.9647
Hai Duong	0.9187	1.0474	1.0963	0.8719	0.9836
Hai Phong	1.1603	0.9953	1.0335	1.1417	1.0827
Hau Giang	0.5564	1.1137	0.9844	1.3238	0.9946
Hoa Binh	1.1817	0.9470	1.0356	1.0797	1.0610
Hung Yen	1.0366	1.0527	1.0453	1.1173	1.0630
Kien Giang	1.0657	0.9862	1.0877	0.9745	1.0285
Kon Tum	1.0643	0.9593	1.0201	2.7946	1.4596
Khanh Hoa	0.9806	0.9992	0.9837	1.0865	1.0125
Lai Chau	0.3285	0.9751	0.9697	1.0654	0.8347
Lang Son	0.9736	0.9370	1.0193	0.9728	0.9757
Lao Cai	0.9687	1.0222	0.9750	0.9715	0.9844
Lam Dong	0.9214	0.9715	1.0012	0.9804	0.9686
Long An	1.0564	1.0493	1.0310	1.5765	1.1783
Nam Dinh	1.0021	0.9803	1.0837	0.9721	1.0096
Ninh Binh	0.9660	1.0712	1.0607	1.1153	1.0533
Ninh Thuan	1.2958	0.9502	0.9079	1.1466	1.0751

Nghe An	0.9664	1.0925	1.0822	1.0612	1.0506
Phu Tho	1.1372	1.2075	1.1821	1.2700	1.1992
Phu Yen	0.3402	1.1073	0.9551	1.0391	0.8604
Quang Binh	1.3295	0.9391	1.4620	1.0779	1.2021
Quang Nam	1.0380	0.9489	1.0184	0.9950	1.0001
Quang Ninh	1.0464	0.9680	1.0551	1.1722	1.0604
Quang Ngai	1.1936	1.0043	1.0509	1.0038	1.0631
Quang Tri	1.0233	1.0557	1.2167	1.7942	1.2724
Soc Trang	1.8300	1.0034	1.2309	0.7694	1.2085
Son La	0.8758	0.9314	1.0103	1.0054	0.9557
Tay Ninh	1.1262	1.1341	1.1209	1.1576	1.1347
Tien Giang	0.9649	1.1565	1.0655	1.0394	1.0566
HCMC	1.0509	1.0498	0.9894	1.0387	1.0322
Thua Thien Hue	1.4497	1.0269	0.9978	0.9929	1.1168
Tuyen Quang	1.0863	1.0392	1.1095	0.9228	1.0395
Thai Binh	1.0455	1.0223	1.1009	1.7430	1.2279
Thai Nguyen	1.0480	1.0143	1.0306	1.0455	1.0346
Thanh Hoa	0.9927	0.9898	1.0061	1.0013	0.9975
Tra Vinh	1.0641	0.9881	0.9951	1.0340	1.0203
Vinh Long	1.0989	1.1122	1.1509	1.1237	1.1214
Vinh Phuc	1.1266	1.0551	1.0608	1.1124	1.0887
Yen Bai	0.8511	0.9459	1.0274	1.1014	0.9815
Average	1.1140	1.0402	1.2287	1.1720	1.1387
Max	6.0780	2.0237	8.5744	3.8019	4.2152
Min	0.3285	0.7094	0.9079	0.3472	0.8347
SD	0.6711	0.1578	0.9826	0.4910	0.4215

Table 4.8 presents the average MI outcomes, which depict the extent of productivity alteration from 2017 to 2021. The data demonstrates that most provinces, specifically 49 out of 63, have registered an average MI greater than 1, implying that most provinces have

experienced a positive productivity increase over the given timeframe. The remaining provinces have an average MI less than 1, such as Cao Bang, Dien Bien, Ha Giang, Ha Tinh, Hai Duong, Hau Giang, Lai Chau, Lang Son, Lao Cai, Lam Dong, Phu Yen, Son La, Thanh Hoa, Yen Bai, which is not performing well in terms of productivity. It is particularly important to mention Bac Lieu, the province with the highest average MI and the most fluctuated during the study period. Bac Lieu received the highest average CU between 2017 and 2018, then experienced a severe drop in efficiency during 2018–2019. However, its average CU increased significantly in 2019–2020, with a score of 8.649, but recorded a sharp decline in the final period of 2020–2021, resulting in an average CU decrease. Its FS was around 1 in the whole period, demonstrating its drastically decreased rate of productivity change because of the decreasing technical efficiency change.

4.4.4. Comparative Analysis

Chart 4.4 shows the relationship between the average FS, CU, and MI of DMUs. Although a few provinces have achieved breakthroughs in FS and CU, the changing trend of CU is similar to MI with slow-changing improvement. The similarity between the trends of MI and CU suggests that technical efficiency change played a big role and may be the main reason why FDI changed in the provinces of Vietnam. On the other hand, it was observed that most provinces are clustered around FS = 1, with an average FS slightly above 1, which shows that FS does not play a major role in promoting change in their effectiveness. Hence, the results indicate the need for much improvement in existing related technologies (mostly policy and practical innovations) to make FDI much more efficient in the future.

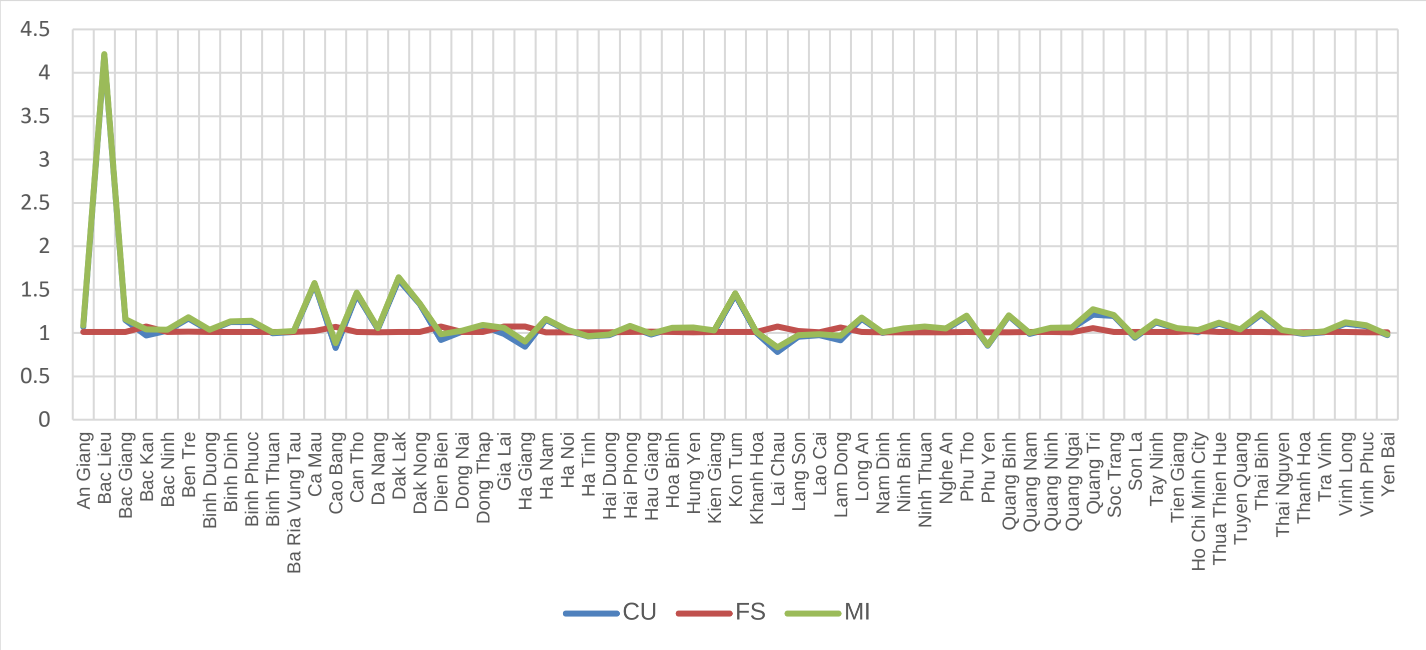

Chart 4.4. Comparison of catch-up (CU), frontier-shift (FS), and Malmquist index (MI).

Besides, this study found that CU was the main factor influencing dynamic change and that slow change in FS might be the main reason for low FDI efficiency. This means the foundation for attracting FDI in Vietnam remains insufficient and requires significant improvement. The government of Vietnam should continue to improve the investment climate, enhance infrastructure and human resources, and diversify investment promotion strategies to attract more high-quality and sustainable FDI. Furthermore, the research on FDI in Vietnam should focus on the impact of FDI on social and environmental sustainability, the role of local enterprises in FDI value chains, and the potential of technology transfer and innovation spillovers (mof.gov.vn, 2021). Addressing these issues can help Vietnam maximize the benefits of FDI and achieve its goals of becoming a modern, industrialized, and innovative nation.

4.5. Discussion

This finding is consistent with previous studies about FDI in Vietnam for academics. This article is like Diep's (2014), arguing that PCI is an important indicator in assessing the efficiency of FDI investment across provinces. The top effective and under-effective provinces were also mentioned in Le and Dang's findings (Le and Dang, 2022). Additionally, this study provides new insights into the FDI performance evaluation in Vietnam, particularly regarding the complementarity of the super-SBM model and MI. The study shows that combining these two methods provides a better understanding of FDI performance by measuring the dynamic decomposition of efficiency and finding out the root cause of efficiency change. The findings also suggest that future research on FDI in Vietnam should focus on the impact of FDI on social and environmental sustainability, the role of local enterprises in FDI value chains, and the potential of technology transfer and innovation spillovers. Addressing these issues can further enhance the understanding of FDI performance in Vietnam and provide a basis for more informed policymaking and investment decisions.

According to the Ministry of Planning and Investment, as of August 2021, Vietnam had attracted 34,424 FDI projects with a total registered capital of US$405.9 billion, with most of the investment coming from countries such as South Korea, Japan, Singapore, and China (https://fia.mpi.gov.vn/, 2021). Vietnam's investment incentives, for example, have been a major factor in attracting FDI. The country has offered various incentives to foreign investors. Such as Decree 01/2021/ND-CP (thuvienphapluat.vn, 2021a) outlines regulations for investment in construction projects to simplify administrative procedures and encourage investment in infrastructure projects. Decree 118/2015/ND-CP (thuvienphapluat.vn, 2015) and Decree 22/2018/ND-CP (thuvienphapluat.vn, 2018) have streamlined foreign investors' process to obtain investment licenses, reducing the time and costs of starting a business in Vietnam. In particular, Law on Investment 2020 (thuvienphapluat.vn, 2020b) includes a range of investment procedures, incentives, and promotion provisions. It aims to promote sustainable development, attract high-quality investment, and improve the investment environment. Accordingly, Decree 31/2021/ND-CP (thuvienphapluat.vn, 2021b) and Decree 52/2021/ND-CP (thuvienphapluat.vn, 2021c) provide guidelines for implementing the Investment Law, particularly regarding investment procedures, investment incentives, and investment promotion. In addition, Resolution 50/NQ-CP (thuvienphapluat.vn, 2020a) outlines a series of measures to improve the business environment and enhance national competitiveness.

CHAPTER 5: CONCLUSION

5.1. Summary of findings & answer the research questions

To assess how the competitive index affects FDI attractiveness, the research has answered the following questions, which were given in chapter one. The research questions are addressed as follows:

Question 1: Is the PCI an appropriate set of competitive indexes to assess the effectiveness of Vietnamese provinces in attracting FDI?

FDI has played a crucial role in the economic development of Vietnam. With an open-door policy and various incentives offered to foreign investors, Vietnam has attracted a large amount of FDI, contributing significantly to the country’s economic growth, job creation, technology transfer, and export expansion. However, in terms of provinces in Vietnam, there will be different indicators to evaluate each province's capacity to attract FDI. Learning about previous studies, many indicators are used to evaluate the effectiveness. According to our research and research, we have collected 16 indicators from countries worldwide; we then use Grey Delphi, a popular survey method for synthesizing the opinion of experts on a particular issue to reach a consensus. At the same time, we asked for help from the assessment of experts, who are all highly experienced in different fields, to provide their opinions on a set of questions or statements related to our indicators. Ten competitive indicators are collected to give the most likely result; coincidentally, those ten are in the PCI index. Therefore, the PCI is an appropriate set of competitive indexes to assess the effectiveness of Vietnamese provinces in attracting FDI.

Question 2: Are Vietnam’s provinces effectively using resources to attract FDI?

In this thesis, the Super-SBM model is applied to compute the efficiency scores and rank the efficiency of 63 provinces in Vietnam from 2017 to 2021. **Table 4.3** presents the obtained scores and rankings of these provinces. As seen from **Table 4.3**, the FDI efficiency of Vietnam’s provinces in 2017–2021 was not high; most of the FDI efficiency scores in the provinces were less than 1, except for Ho Chi Minh City. The average efficiency score obtained throughout the years is merely 0.1225 to 0.1376, indicating that Vietnam’s provinces are inefficient in using resources to attract FDI.

There is huge potential to improve the performance of provinces in using resources to attract FDI by learning from successful models. Throughout the research periods, Ho Chi

Minh City, Ha Noi, Binh Duong, Ba Ria Vung Tau, and Dong Nai are the top five provinces with the highest efficiency scores. At the same time, Dien Bien, Lai Chau, Bac Kan, Ha Giang, and Gia Lai are provinces with the most inefficient scores.

Due to its efforts to improve its investment environment, vigorously implementing the goals of improving the quality of FDI inflows, along with many open mechanisms and policies and a series of practical solutions, the Southeast Region achieved the best FDI attractiveness. Within economic circles, policymakers in other provinces should learn from successful provinces with high FDI attractiveness. Provinces need to establish a stable economic, political, and social environment, enhance the local Government's role, and improve the legal framework for investment activities. Moreover, it is essential to invest in material and technical infrastructure and improve the quality of human resources.

Especially, Government should emphasize the development of knowledge-intensive industries, high-technology, advanced manufacturing and information technology, energy-saving, new energy, and modern service industries, to obtain investors' attention and continue developing toward the goal of sustainability.

Question 3: Over the years, how has there been a change in optimizing the resources of Vietnamese provinces?

The catch-up index, shown in **Table 4.6**, analyzes the performance of 63 provinces in Vietnam based on the Technical Efficiency Change of DMUs from 2017 to 2021. From 2021 to 2023, the average catch-up score of most provinces was greater than 1, which also happened to be a key part of making MI more productive. Notably, the province with the highest average level of CU performance is Bac Lieu. It showed progressive technical efficiency between 2017 and 2021, with average catch-up indexes of more than 4. On the other hand, eighteen provinces are less efficient than average when they have catch-up indexes of less than 1.

The technological frontier-shift index analyzes DMUs' technology frontiers (efficiency frontiers) from 2017 to 2021 to represent their performance shown in **Table 4.7**. Overall, the average frontier-shift indexes of most provinces are clustered around FS = 1, with an average FS slightly above 1, which shows that FS does not play a major role in promoting change in their effectiveness. However, for 2019-2020, most provinces have failed to meet the advancement frontier-shift indexes with indexes less than 1; only nine provinces have more than 1. For 2021-2022, thirteen DMUs have failed to meet the advancement frontier-shift indexes with indexes less than 1; five DMUs have frontier-shift indexes plus than 1. In 2022-2023, only ten DMUs failed to meet the advancement frontier shift indexes. Four DMUs had frontier-shift indexes of more than 1, and four DMUs with constant technological efficiency change.

Several provinces in Vietnam have made progress in FDI and competitiveness, with some achieving breakthroughs in FS and CU. However, the slow-changing improvement in CU is similar to that of MI, implying that efficiency change plays a critical role and may be the primary driver of changes in FDI across provinces. Additionally, most provinces have FS values clustered around 1, indicating that it does not significantly contribute to enhancing effectiveness.

Therefore, the findings suggest a need for considerable improvements in existing technologies, primarily policy and practical innovations, to enhance future FDI efficiency. This study also highlights CU as the primary factor influencing dynamic change and the slow change in FS as the primary reason for low FDI efficiency. As a result, the foundation for attracting FDI in Vietnam needs to be improved and requires significant improvements. In general, the research findings give the Vietnamese government, policymakers, and managers complete information about the performance of all provinces in Vietnam, allowing them to design appropriate policies and strategies for enhancing performance. Besides, the research results also help investors in determining future investment strategies. They may use a strategy of increasing investment in provinces with significant increases in operational efficiency to capitalize on the gains.

5.2. Conclusion

FDI has played a crucial role in the economic development of Vietnam. With an open-door policy and various incentives offered to foreign investors, Vietnam has attracted a large amount of FDI, contributing significantly to the country's economic growth, job creation, technology transfer, and export expansion. However, to have a solid basis and an overview of Vietnam's business environment, it is very important to evaluate the competitive performance of each province. So, this is the first study of Vietnam's provincial FDI performance using PCI sub-indexes using an innovative integrated approach that combines three techniques: Grey Delphi, Super-SBM model, and DEA Malmquist. The Grey Delphi model was employed to establish input and output metrics. The Super SBM model evaluated the effectiveness and inefficiency of FDI in Vietnam’s provinces, while the DEA Malmquist model measured productivity changes from 2017 to 2021 for each DMU.

This thesis provides a comprehensive evaluation of the FDI attractiveness of

Vietnamese provinces from 2017 to 2021, using an integrated model of Grey Delphi, Super SBM, and DEA Malmquist. By measuring ten dimensions of provincial performance affecting the total number of FDI and FDI capital accumulation, the authors have developed a series of indicators that can be used to evaluate the effectiveness of provinces in Vietnam in attracting FDI. This study's findings provide insights into the efficiency and optimization level of FDI attraction in each province over time, aiding policymakers and investors in making informed decisions regarding FDI in Vietnam. Overall, this study highlights the importance of strategic planning and policy implementation in attracting FDI and promoting economic growth in Vietnam.

5.3. Implication

The thesis on FDI performance evaluation in Vietnam has important implications for various stakeholders, including policymakers, investors, and academics. As a result of this analysis, the following implications have been reached.

For policymakers, the thesis reveals the low FDI efficiency and the significant difference in FDI attractiveness in Vietnam's provinces. The findings suggest that policymakers in the provinces with low FDI attractiveness should learn from successful models and improve administrative and legal management. It provides that proactiveness and the continued efforts of top provincial leaders in implementing central policy and designing the initiatives are necessary for developing the business sector. It shows that business support services benefit local firms. Further local services for private-sector trade promotion, provision of regulatory information to firms, provision of industrial zones, and technological services are required to support the business of the local firms. The research results argue that easier land access and better security of tenure are thus seen as essential property policies that can contribute to the success of the local business sector. Foreign investment enterprises are willing to invest in the regions or provinces where they can easily access the market at the lowest costs. The research result also aligns with the argument that reducing informal charges, time costs and regulatory compliance in doing business will lead to better firm economic performance. The high transparency in accessing the proper planning and legal documents necessary to run the businesses and the lack of policy bias in privileges to the state-owned economic group positively impact FDI attractiveness. Legal institutions and labor training are also important factors, as foreign investors usually have a long-term perspective in their investment decisions. In summary, the study offers policy implications and recommendations for regional governments to focus on the most appropriate governance packages for better market-supporting mechanisms and institutions that help the development of the business sector.

The study provides insights into the FDI performance evaluation, which can help investors make informed decisions about investing in Vietnam. The study shows that Ho Chi Minh City is the most efficient province in attracting FDI. Moreover, the Southeast region of Vietnam has the highest level of attractiveness for FDI. These provinces will have an appropriate investment environment with favorable administrative and legal procedures, implement transparent policies, and adopt practical solutions. Therefore, investors should seize the opportunity to exploit provinces with potential markets.

The thesis has theoretical implications for academics for the literature on FDI performance evaluation. The study's results show that the efficiency of FDI varies significantly across provinces in Vietnam, which implies that FDI performance should not be evaluated based on national-level data alone. Instead, evaluating FDI performance at the sub-national level is essential to gain a more nuanced understanding of FDI's impact on local economies. Additionally, the study highlights the importance of administrative and legal quality in building a favorable and effective investment environment to attract FDI.

5.4. Limitations and suggestions for further research

This thesis has several limitations that must be considered. While the study provides valuable insights into FDI attractiveness in Vietnam, it has certain limitations and challenges. These limitations include the impact of COVID-19 on FDI performance, a limited set of indicators, the use of a single method for performance evaluation, the focus on Vietnam alone, and the absence of consideration of FDI’s distributional effects.

First, the study did not fully consider the impact of COVID-19 on FDI performance. While the study recognizes the negative impact of COVID-19 on FDI, it did not examine how the pandemic affected FDI performance or the potential effects of government responses to the pandemic on FDI. Second, the study only considers limited indicators in evaluating FDI attractiveness. In addition to its active contributions to researchers and policymakers, future researchers could use additional indicators or more valid methods to measure the impact of other factors, such as education, financial market, innovation, integration into the global economy, and socio-demographic and urban-environmental factors. However, the thesis only uses the DEA method for performance evaluation, which has certain limitations. Future research could integrate the DEA method with other techniques, such as machine learning predictive techniques or MCDM based on different Fuzzy sets, such as Spherical Fuzzy sets to investigate undesirable input/output factors in FDI performance evaluation. Furthermore, the thesis only focuses on FDI attractiveness in Vietnam and does not compare it to other countries or regions. Future research could compare FDI attractiveness across different countries or regions to identify commonalities and differences in the factors that affect FDI performance. Finally, the thesis only focuses on the efficiency of FDI without considering its distributional effects. Future research could examine the distributional effects of FDI, including its impact on local communities, employment, and income distribution.

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APPENDICES

Table A1. LIST OF EXPERTS

No	Gender	Age	Education	Position	Seniority
1	Male	Under 25	Bachelor	Scholar	Less than 5 years
2	Male	From 40 to 60 years old	Professor	Policy Maker	From 10 to 20 years
3	Female	From 25 to 40 years old	Master graduate	Scholar	From 5 to 10 years
4	Male	From 25 to 40 years old	Master graduate	Managers	From 5 to 10 years
5	Female	From 25 to 40 years old	Master graduate	Scholar	Less than 5 years
6	Male	From 25 to 40 years old	Doctor	Scholar	From 10 to 20 years
7	Female	From 25 to 40 years old	Master graduate	Policy Maker	From 5 to 10 years
8	Female	From 25 to 40 years old	Professor	Managers	From 5 to 10 years
9	Female	From 25 to 40 years old	Doctor	Policy Maker	From 10 to 20 years
10	Male	From 40 to 60 years old	Professor	Policy Maker	From 10 to 20 years
11	Female	Under 25	Master graduate	Managers	Less than 5 years

DELPHI SURVEY

Research project: "How does the Competitiveness Index promote Foreign Direct Investment at the provincial level in Vietnam? A non-parametric approach. "

Purpose: The main aim of this project is to explore and formulate a series of indicators that can be utilized to assess FDI attractiveness at the provincial level

SECTION 1. General Knowledge

The respondent is asked to consider the following definitions/descriptions and express his/her opinion and level of agreement on these. (Please select your answer with an 'x')

1.1. Foreign direct investment (FDI) is an ownership stake in a foreign company or project from another country by an investor, company, or government. The term describes a business decision to acquire a substantial stake in a foreign business or buy it outright to expand operations to a new region. The term usually does not describe a stock investment in a foreign company alone. FDI is a key element in international economic integration because it creates stable and long-lasting links between economies

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
(1)	(2)	(3)	(4)	(5)

1.2. Provincial Competitiveness Index (PCI) is designed to measure and evaluate the ease of doing business, economic governance, and administrative reform efforts by local governments to promote the development of the private sector in 63 provinces and cities in Vietnam. In short, the PCI augments the collective voice of private entrepreneurs in Vietnam regarding the business environment in provinces and cities in Vietnam.

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
(1)	(2)	(3)	(4)	(5)

SECTION 2. Competitive Index Assessment

Rate the level of importance of the following factors affecting the attraction of FDI according to the scale: No important = NI, Low important = LI, Medium important = MI, High important = HI, Very high important = VH

No	Competitive Index	Rate
1	Entry costs (EC): the entry costs for new firms of a province	
2	Land access and security (LS): how easy it is to access land and the security of tenure once the land is acquired	
3	Transparency (TR): a measure of whether firms have access to the proper planning and legal documents necessary to run their businesses	
4	Informal charges (IC): how much of an obstacle the extra fees pose for the firm's business operations	
5	Time Costs and Regulatory Compliance (LT): how much time firms waste on bureaucratic compliance, how often and for how long firms must shut their operations down for inspections by local regulatory agencies	
6	Policy Bias (PB): measure privileges to the state-owned economic group, corporations, causing difficulties to your business	

7	The proactivity of provincial leadership (PL): the measure of the creativity and cleverness of provinces in implementing central policy, designing their initiatives for private sector development, and working within sometimes unclear national regulatory frameworks to assist and interpret in favor of local private firms	
8	Business support service (SS): a measure of provincial services for private sector trade promotion, provision of regulatory information to firms, business partner matchmaking, provision of industrial zones or industrial clusters, and technological services for firms	
9	Labor training (LA): the efforts to promote vocational training and skills development for local industries and to assist in the placement of local labor	
10	Legal institution (LI): a measure of the private sector's confidence in provincial legal institutions	
11	Education (ED): a measure of the skilled and educated workforce	
12	Financial market (FIN): the strength and stability of a country's financial market	
13	Innovation factor (IN): measures new opportunities for growth and competitiveness, which helps companies stay ahead of the curve in a rapidly changing global economy.	
14	Integration into the global economy (GL): a country's level of integration into the global economy, measured by the volume of trade and investment flows, is a key factor that attracts FDI.	
15	Sociodemographic (SD): demographic factors such as population size, age structure, and income levels	
16	Urban-environmental (UE): the measure of the quality of a country's urban and environmental infrastructure	

SECTION 3. Respondent's Profile

1. Please indicate what age you are in:
   - ☐ Under 25
   - ☐ From 25 - 40 years old
   - ☐ From 40 - 60 years old
   - ☐ Over 60 years old
2. Please indicate your gender:
   - ☐ Male
   - ☐ Female
   - ☐ Other
3. Please indicate your current level of Education Qualification:
   - ☐ Professor
   - ☐ Bachelor
   - ☐ Master graduate
   - ☐ Doctor
   - ☐ Others: …………………………………………………………………
4. Please indicate what is your current position occupation :
   - ☐ Scholar
   - ☐ Policy Maker
   - ☐ Managers
   - ☐ Other: …………………………………………………………………..
5. Please indicate your experience in this field:
   - ☐ Less than 5 years
   - ☐ From 5 to 10 years
   - ☐ From 10 to 20 years
   - ☐ Over 20 years
6. Please indicate how much your monthly income is:
   - ☐ Under 1000 dollars
   - ☐ From 1000 to 2000 dollars
   - ☐ From 2000 to 3000 dollars
   - ☐ From 3000 to 4000 dollars
   - ☐ Over 4000 dollars

mathematics

Article

How Does the Competitiveness Index Promote Foreign Direct Investment at the Provincial Level in Vietnam? An Integrated Grey Delphi–DEA Model Approach

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Abstract: Foreign direct investment (FDI) is an important factor in building a strong economy for a country, particularly in developing and emerging markets. Both domestic enterprises and policy makers have been motivated to attract FDI for the benefits of FDI, such as technological transfers, spillover benefits, and rising competition. There is a need for a functional model to assess how the competitive index affects FDI attractiveness. Therefore, in this study, the authors use an integrated model of Grey Delphi, the Data Envelopment Analysis Super Slack-Based Measure Model (DEA–Super SBM), and the Malmquist Model (DEA–Malmquist) to evaluate the FDI attractiveness of Vietnamese provinces from 2017 to 2021. Firstly, ten critical dimensions of the provincial competitive index (PCI) affecting the number of FDI by cases and amount of FDI capital were validated via the Grey Delphi method. Secondly, the Super-SBM model is applied to assess the FDI efficiency of 63 provinces in Vietnam from 2017 to 2021. Then, the DEA–Malmquist model is employed to analyze the total change in the productivity of 63 provinces' FDI performance in Vietnam. The findings of this study revealed that the efficiency of FDI in Vietnam's provinces is relatively low, and there is a significant variation in the attractiveness of FDI among the provinces. This study can provide valuable insights for policy makers and other stakeholders in developing effective strategies to attract FDI and foster economic development.

Keywords: efficiency; inefficiency; foreign direct investment; grey Delphi; Data Envelopment Analysis; Malmquist; Super Slack-Based Measure

MSC: 97M30; 91B02; 62P05; 91B84

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1. Introduction

In many developing countries, foreign direct investment (FDI) has become the primary source of external financing, surpassing aid, remittances, and portfolio investment. To achieve the Sustainable Development Goals, a significant increase in capital flows to developing countries is necessary, and private-sector investment is the only way to accomplish this on the necessary scale. FDI not only provides funding but also helps developing economies integrate into global markets and improves productivity through competition and knowledge transfer across borders. Therefore, countries focus on attracting FDI, and understanding the key elements influencing investment decisions is essential for implementing policies attracting investors [1]. In the long run, FDI can benefit the home and host countries in various important aspects, including facilitating greater access to international markets, generating much-needed foreign currency, boosting human capital development, transferring cutting-edge technologies, and increasing competition in domestic markets. These contributions can lead to economic growth, job creation, and living standards for people in homes and host countries. It can also help to modernize industries and allow small- and medium-sized businesses to participate in global value chains [2].

In 1986, Vietnam initiated a set of reform measures called "Doi Moi," which marked a significant departure from the planned economic system towards a market-oriented one after prolonged economic hardship. Since then, Vietnam has emerged as an attractive location for FDI in Southeast Asia, offering a wide range of benefits to the host country, including capital injection, finished products, components, advanced technology, organizational and managerial skills, distribution channels, and market access. Over the past three decades, has a consistent rise in the inflow of FDI from multinational companies in Vietnam, making it a significant contributor to the country's domestic economic expansion. In 2015, there was a significant increase in FDI, with newly registered and additional capital reaching 24.11 billion USD and an actual capital of 14.5 billion USD, a 17.4% increase from the previous year. The following year, 2016, saw an even higher increase in FDI, with a newly registered and additional capital of 26.69 billion USD and an actual capital of 15.8 billion USD. In 2019, the total registered capital reached 38.02 billion USD, with an actual capital of 20.38 billion USD, a 6.7% increase from the previous year [3]. FDI projects in Vietnam have been established by 129 countries and territories, spanning all provinces, and covering 19 economic sectors [4]. Unlike other Southeast Asian countries, Vietnam's FDI inflows remained unaffected by the COVID-19 pandemic in 2020, while Singapore, Thailand, Indonesia, and Malaysia experienced a sharp decline in FDI [5]. Vietnam's impressive performance in attracting FDI is evident as it was ranked 19th globally, among the top 20 countries in 2020 [6].

However, there has been a recent shift in the form of direct investment in Vietnam, with an increasing number of investors choosing to engage in mergers and acquisitions rather than greenfield investments. This change in investment patterns has important implications for Vietnam's FDI policy framework and incentive system, which may need to be revised to maintain the country's attractiveness to foreign investors. Furthermore, Vietnam's current system of investment incentives is distributed across various laws, locations, and regulations, which can create difficulties for both authorities and businesses in understanding and applying them effectively. This lack of transparency can also increase the risk of corruption and rent seeking. In this study, we aim to examine the factors that influence FDI in Vietnam, including the impact of the changing investment landscape and the effectiveness of existing investment incentives.

Despite Vietnam's commendable efforts in attracting FDI, it is observed that the inflow of FDI into the country needs to be more evenly distributed across its various provinces. There has been a severely unequal distribution of FDI among provinces, a remarkable aspect of Vietnam's FDI inflow distribution. While others fall behind, certain provinces can attract FDI [7]. In Vietnam, there is a concentration of FDI in major economic centers such as Hanoi, Ho Chi Minh, and Da Nang. In contrast, regions such as the northern mountainous provinces and the Central Highlands receive minimal FDI, resulting in substantial disparities in development between different areas. The localities that attract a significant amount of FDI experience fast growth and modernization, characterized by urbanization. At the same time, other regions remain undeveloped and primarily depend on agriculture and resource extraction [8]. In Vietnam, as in many other countries, disparities exist between regions regarding natural and social conditions. The capital, Hanoi, and the southern economic hub of Ho Chi Minh City have received a significant amount of investment capital due to specific policies and mechanisms. Meanwhile, cities such as Hai Phong, Da Nang, and Can Tho that fall directly under the Central Government have experienced relatively synchronous development in terms of technical and social infrastructure. Proximity to major economic centers has proven advantageous for neighboring provinces, attracting more FDI and fostering higher levels of development. However, unequal distribution of FDI across industries, sectors, and regions can negatively impact the country's overall economic sustainability, including reliance on technology and markets and domestic pressure businesses [9]. Thus, assessing the efficiency of a specific region in drawing in FDI is vital for comprehending the reasons for differences among regions and offers policy makers a basis for consistently improving FDI appeal.

Regarding competitiveness indicators, many countries have employed distinct regional competitiveness indexes to foster a sustained enhancement in business efficiency and the quality of life for the region's residents [10]. Similarly, Vietnam has also implemented the Provincial Competitiveness Index (PCI), which incorporates ten sub-indexes that reflect various aspects of economic governance affecting the development of the private sector. The PCI measures and evaluates the quality of economic management, the degree of favorability and friendliness of the business environment, and the efforts of administrative reform of the government of provinces and cities in Vietnam, thereby promoting the development of the private economic sector [11]. Specifically, the index is carried out by the Vietnam Chamber of Commerce and Industry (VCCI) with the support of the United States Agency for International Development (USAID) in Vietnam. Built from the largest-scale annual enterprise survey data, conducted most meticulously in Vietnam today, the PCI is the "collection of voices" of the business community about the business environment in provinces and cities in Vietnam. The PCI is not intended for purely scientific research purposes or to praise or criticize provinces with high or low PCI scores. Instead, the PCI aims to investigate and explain why some provinces or cities are surpassing others in private economic development, job creation, and economic growth.

Given the PCI's importance, the first research question arises: "Is the PCI an appropriate set of competitive indexes to assess the effectiveness of Vietnamese provinces in attracting FDI?" The authors have applied the Grey Delphi method to answer this question by considering the comparative regional indexes among different countries. The Delphi method has been widely used to determine industry performance indicators [12]. Multiple investigations are required to ensure the consistency of expert opinions and agreements to reach the mean value of all opinions. As a result, the authors obtained an agreement among FDI specialists. The authors' objective has been achieved based on this method, giving a complete and accurate set of competition indicators.

In evaluating efficiency from an operational standpoint, two main methodologies are used for measurement: parametric and non-parametric. The parametric method is a statistical method that demands the formulation of a special function to describe the statistical distribution of a sample using a particular set of parameters that need estimation. Certain presumptions, including normality, homoscedasticity, independence, and identical stochastic distribution of errors, must be fulfilled for this technique [13]. However, these hypotheses can often be difficult to justify, and the distribution model may be unknown. In contrast, Data Envelopment Analysis (DEA) is a non-parametric technique considering various outputs and inputs. This method has become popular in recent decades for its ability to test various aspects of FDI, perform multidimensional comparisons, and process multiple input and output variables concurrently, leading technical software development [14].

Due to the significance of FDI, the second and third research questions arose: "Are Vietnam's provinces effective in using resources to attract FDI?"; and "Over the years, how has there been a change in optimizing the resources of Vietnamese provinces?". The authors use the two-stage DEA approach to answer these two questions, which combines the Super Slacks-Based Measure (SBM) and DEA Malmquist models. As a result, the authors' purposes were achieved. Using the Super SBM model, this paper assessed the efficiency and inefficiency of Vietnamese provinces in using resources to attract FDI. The provinces with the most room for growth and those with the best practices are identified using projection analysis of inputs and outputs. Moreover, with the DEA Malmquist model, the authors have measured Vietnamese provinces' change in resource optimization.

In this study, the proposed model was assessed using data from all 63 provinces in Vietnam, compiled from the General Statistics Office of Vietnam's website and the Provincial Competitiveness Index Vietnam from 2017 to 2021. After consulting the expert board, we apply the following variables. The inputs are: (1) entry costs; (2) land access and security; (3) transparency; (4) informal charges; (5) time costs and regulatory compliance;

(6) policy bias; (7) proactivity of provincial leadership; (8) business support service; (9) labor training; and (10) legal institution. The outputs are FDI by capital (cumulative) and FDI by cases (cumulative).

The key contributions of this study are briefed as follows: (i) This is the first research that ranks Vietnam's provincial FDI performance using PCI sub-indexes using an innovative integrated approach that combines three techniques: Grey Delphi, Super-SBM model, and DEA Malmquist. (ii) The Grey Delphi model was employed to establish input and output metrics. The Super SBM model evaluated the effectiveness and inefficiency of FDI in Vietnam's provinces, while the DEA Malmquist model measured productivity changes from 2017 to 2021 for each decision-making unit (DMU). (iii) The findings of this research have important impacts on local policy makers and government officials eager to improve their region's attractiveness to FDI. These outcomes can guide the formulation of sustainable strategies that encourage sustained growth in FDI over the long term.

The rest of this research is presented as follows. Section 2 covers the literature review. In Section 3, the research process and methods are provided. Section 4 presents the empirical analysis, results and discussion. Finally, Conclusion is presented in Section 5.

2. Literature Review

2.1. Literature Review on the Competitiveness Index

Competitiveness has several definitions, but one commonly used by the World Economic Forum is the "set of institutions, policies, and factors" that affect a country's productivity and determine the level of prosperity it can achieve [15]. From the similar perspective, the World Bank developed the concept of Global Investment Competitiveness (GIC) to measure a country's ability to attract and retain FDI. It involves evaluating a country's investment climate, including the quality of institutions, regulatory frameworks, infrastructure, and human capital. The GIC framework aims to provide policy makers with a comprehensive and data-driven approach to attract more FDI and improve the country's competitiveness in the global market [16].

As earlier stated, the term "regional" pertains to the territorial segmentation of a nation, which can be established based on multiple criteria such as demographics, historical background, cultural identity, economic conditions, and climatic factors, to name a few. As part of resource and capability management, each country has employed distinct regional competitiveness indexes to foster a sustained enhancement in business efficiency and the quality of life for the region's residents. For instance, Vukmirović et al. [17] highlighted the significance of FDI and competitiveness of emerging and developing countries, with a particular focus on Serbia. They examined the correlation between FDI, GDP, unemployment rate, and GCI, and compares FDI inflows from China, Russia, and EU countries. Several South American countries have different methods to evaluate the competitiveness of their regions [18]. Peru and Chile have their own regional competitiveness indexes, while Colombia has two sets of indicators: the Structural Departmental Competitiveness Index and the Revealed Departmental Competitiveness Index. Mexico also has two sets of State Competitiveness indexes and a Competitiveness of Mexican cities index [19]. Similarly, Vietnam has implemented the PCI since 2005 to assess the ability of each region to attract foreign investment [20].

Elkomy et al. [21] found that the effects of FDI on growth are influenced by the level of human capital and political development, with political development suppressing FDI effects on growth in authoritarian countries and enhancing them in hybrid democracies. The study also found that domestic investment is a more important driver of growth in more democratic countries. Similarly, Liu et al. [22] conducted a study on the location choice for outward foreign direct investment (OFDI) by Chinese companies, focusing on the ASEAN region. Specifically, among institutional quality factors, rule of law and corruption control significantly promote market-seeking, resource-seeking, and efficiency-seeking investments, while regulatory quality and government effectiveness significantly promote market-seeking and efficiency-seeking investments. Le et al. [23] argued that policies should focus on improving economic governance, investing in public education and human capital, and addressing the negative impact of urbanization on income inequality.

However, the competition among countries in the region has intensified, making it increasingly difficult for countries such as Vietnam to attract and retain foreign investors. To address this challenge, policy makers need to understand how the competitive index affects FDI attractiveness and identify the most effective policies and incentives for promoting FDI. Several studies have examined the relationship between the competitive index and FDI attractiveness in Vietnam. For example, Le and Dang [24] highlighted FDI's importance for sustainable socio-economic growth and international economic integration by employing five crucial indicators, including labor force, gross regional domestic product, the provincial competitiveness index, FDI by capital, and FDI by cases.

Furthermore, there have been several recent changes in Vietnam's FDI policy and incentives that are relevant to our study. For example, Vietnam introduced a new Law on Investment and a Law on Enterprises in 2020, which aim to simplify investment procedures and create a more favorable business environment for foreign investors [25]. In addition, Vietnam has signed several free trade agreements with other countries, including the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP) and the EU–Vietnam Free Trade Agreement (EVFTA), which are expected to increase Vietnam's attractiveness as an investment destination [26]. Moreover, Vietnam has been implementing a series of reforms to improve the transparency and efficiency of its legal system, including the adoption of a new Civil Code and a new Law on Competition [27]. These reforms are expected to reduce barriers to entry for foreign investors and enhance the protection of their intellectual property rights. However, there are still some challenges that Vietnam needs to address to improve its FDI attractiveness. According to Vietnam Briefing's recent report in 2022, Vietnam's infrastructure and logistics systems are still underdeveloped compared to other countries in the region, which can create bottlenecks and increase transaction costs for foreign investors. In addition, there are concerns about the quality and availability of skilled labor in Vietnam, which can also deter foreign investment [28].

After thorough research, we realized that not all indicators are suitable for assessing performance for each region of each country. Research in diverse domains may not necessarily generate cohesive outcomes when dealing with many indicators at distinct strategic, tactical, and operational levels [12]. Adapt from various provincial/regional competitive index, we extracted 16 potential inputs for our evaluation as shown in Table 1: (1) entry costs (EC); (2) land access and security (LS); (3) transparency (TR); (4) informal charges (IC); (5) time costs and regulatory compliance (LT); (6) policy bias (PB); (7) proactivity of provincial leadership (PL); (8) business support service (SS); (9) labor training (LA); (10) legal institution (LI); (11) education (ED); (12) financial market (FIN); (13) innovation factor (IN); (14) integration into the global economy (GL); (15) socio-demographic (SD); and (16) urban-environmental (UE).

Table 1. Definitions of PCI indexes.

No	Competitive Index	Reference
1	Entry costs (EC): the entry costs for new firms of a province	[11]
2	Land access and security (LS): how easy it is to access land and the security of tenure once the land is acquired	[11]
3	Transparency (TR): a measure of whether firms have access to the proper planning and legal documents necessary to run their businesses	[11]
4	Informal charges (IC): how much of an obstacle the extra fees pose for the firm's business operations	[11]
5	Time Costs and Regulatory Compliance (LT): how much time firms waste on bureaucratic compliance, how often and for how long firms must shut their operations down for inspections by local regulatory agencies	[11]
6	Policy bias (PB): measure privileges to the state-owned economic group, corporations, causing difficulties to your business	[11]

Table 1. *Cont.*

No	Competitive Index	Reference
7	The proactivity of provincial leadership (PL): the measure of the creativity and cleverness of provinces in implementing central policy, designing their initiatives for private-sector development, and working within sometimes unclear national regulatory frameworks to assist and interpret in favor of local private firms	[11]
8	Business support service (SS): a measure of provincial services for private-sector trade promotion, provision of regulatory information to firms, business partner matchmaking, provision of industrial zones or industrial clusters, and technological services for firms	[11]
9	Labor training (LA): the efforts to promote vocational training and skills development for local industries and to assist in the placement of local labor	[11]
10	Legal institution (LI): a measure of the private sector's confidence in provincial le-gal institutions	[11]
11	Education (ED): a measure of skilled and educated workforce	[20]
12	Financial market (FIN): the strength and stability of a country's financial market	[20]
13	Innovation factor (IN): measure new opportunities for growth and competitiveness, which helps companies stay ahead of the curve in a rapidly changing global economy.	[20]
14	Integration into the global economy (GL): a country's level of integration into the global economy, measured by the volume of trade and investment flows, is a key factor that attracts FDI.	[20]
15	Socio-demographic (SD): demographic factors such as population size, age structure, and income levels	[20]
16	Urban-environmental (UE): measure of the quality of a country's urban and environmental infrastructure	[20]

2.2. Literature Review on Methods

2.2.1. The Delphi Method

The Delphi method, developed by Olaf Helmer and Norman Dalkey of the Rand Corporation in the 1950s, is a forecasting technique that involves multiple rounds of questionnaires administered to a group of experts [29]. Consistency of expert opinions is ensured through multiple rounds of investigation. Experts are required to adjust their opinions to match the mean value of all expert opinions, resulting in a consensus-building process that involves expert discussion and multiple rounds of questionnaires to achieve a shared understanding. For an example, Nong [30] measured the performance efficiency of 22 ports in Vietnam using a hybrid method of Delphi technique with KAMET principle and input and output-oriented DEA method. Additionally, Nong [31] assessed the performance efficiency of retail stores in the fashion industry, using the integrated approach of Delphi and DEA techniques. According to Sykianakis et al. [32], the Delphi method plays a crucial role in the initial stage of FDI decision-making process, which involves gathering in-formation about economic, political, and market environment to assess whether a project aligns with the company's expansion strategy and estimate the future demand for its products. The method helps in setting preferences for accepting FDI, such as having a local partner or maintaining full control of the investment and serves as a platform for individual and collective judgments to determine subsequent actions for the project. Therefore, the Delphi method plays a significant role in determining the attractiveness of FDI for a company. Huang et al. [33] combined Fuzzy Delphi and DEMATEL methods to identify the key factors and construct causal relationships among key factors of investment. Fazelian et al. [34] identified the obstacles to FDI in Iran and data gathered by questionnaires was analyzed by Fuzzy Delphi technique.

However, the Delphi method requires experts to modify their opinions to match the mean value of all expert opinions, resulting in a loss of individual expertise. Furthermore, the Delphi method does not consider the uncertainty and imprecision of data. On the other hand, the Fuzzy theory and Grey System Theory can handle uncertain, indistinct, and missing data [35]. Therefore, combination of the Fuzzy sets, Grey System Theory and the conventional Delphi method are applied to validate critical factors and select evaluation indicators using a grey whitening weight/defuzzying function based on questionnaires. Both Fuzzy theory and Grey System Theory can handle uncertain, indistinct, and missing data, but they have some differences in their advantages: Fuzzy theory is a mathematical framework that deals with uncertainty and imprecision by allowing variables to have partial membership in a set. This means that instead of using binary true/false values, Fuzzy theory allows for more nuanced and probabilistic descriptions of variables, which can be useful when dealing with complex or vague concepts. Fuzzy theory is particularly useful when dealing with linguistic variables, such as "high" or "low" levels of a certain factor, because it allows for degrees of membership in a set rather than forcing a binary classification [36]. On the other hand, Grey System Theory is a methodology that deals with data sets that are incomplete or have missing information [37]. It does this by using a limited amount of information to make predictions or draw conclusions. Grey System Theory is particularly useful when dealing with data sets that are limited in size or scope, or when there are gaps in the data. It can also be useful when dealing with data that is noisy or has a high degree of uncertainty.

In this study, the authors aim to enhance the decision-making process related to FDI by utilizing the Grey Delphi method, which combines the Delphi method and Grey System Theory. This method can address uncertainties and provide a more comprehensive understanding of the key factors affecting FDI. The outcome of this approach is the construction of competitiveness indexes that can effectively evaluate the performance of FDI in different provinces in Vietnam.

2.2.2. Data Envelopment Analysis (DEA) Methods

The DEA method is widely utilized for evaluating decision-making units' performance (DMUs). DEA can be traced back to Farrell's work in 1957. His concept of the production possibility frontier judges the effectiveness of businesses operating in the same industry, incorporating resource allocation efficiency and total technological efficiency [38]. However, input and output weighting are the main drawback of Farrell's efficiency. Charnes, Cooper, and Rhodes (CCR) addressed this issue and introduced an improved technique in 1978 [39]. The CCR approach utilized a non-parametric method to generate a production possibility frontier curve from DMU data and applied various mathematical programming techniques to calculate the efficiency of DMUs. Without using fixed weights or time series analysis, this method determines the relative efficacy of DMUs [40]. In 1984, Banker, Charnes, and Cooper (BCC) expanded upon the CCR model by determining variable returns to scale (VRS) scenarios, enabling a more thorough examination of DMU efficiency [41]. Incorporating dummy or categorical variables, discretionary and non-discretionary variables, and non-parametric Malmquist indices are just a few modifications made to the DEA approach over time [42]. Tone [43] later proposed the slacks-based measure of efficiency (SBM), which incorporated the slack's objective function to demonstrate a unit's input surplus and output shortage, transforming the model non-radial since inputs and outputs did not need to be verified simultaneously [44]. The DEA Malmquist model, an expansion of the original DEA model, is a very useful instrument for assessing the productivity of DMUs, with the Malmquist Productivity Index (MPI) being the result of the catch-up index (technical efficiency) and the frontier-shift index (technological efficiency) [45]. This study uses the MPI obtained from the Malmquist model to identify the provinces in Vietnam most effective at attracting FDI.

Table 2 summarizes the applications of DEA, with input and output factors in the literature to determine the relative efficiency of provinces in attracting FDI. Several notable studies have utilized this methodology in their analysis. Suyanto et al. [46] applied the generalized MPI to examine the spillover effects of FDI on Indonesian chemical and pharmaceutical companies. The Malmquist DEA model was used in the research article of Lei et al. [47]. They assessed the attractiveness of FDI for sustainable development using data from China from 1997 to 2008. This paper enriches the literature by delivering valuable input information for decision-makers in improving a framework to attract FDI in the host country. Thanh Tung (2014) [48] also applied the DEA Malmquist method to assess the influence of PCI factors on FDI in 63 provinces in Vietnam. While traditional DEA requires precise input and output data, most available data could be more precise and clearer. FDEA incorporates Fuzzy set theory into traditional DEA using Fuzzy sets to represent imprecise and ambiguous data. The research of Aydin et al. [49] considers applications of the FDEA method in FDI performance measurement to assess the efficiency of FDI in 12 transition economies that broke away from the USSR. Wang and Le [50] combined DEA Malmquist with the SBM model to evaluate the efficiency of FDI on the economic growth of 20 Asian and African developing countries during 2012–2017. The same year, Zhang et al. [51] conducted an output-oriented return-to-scale DEA model to calculate the efficiency of China's environmental protection spending. Liu et al. [52] published a study that is considered the first examination of China's industrial green competition through a panel dataset. The dataset encompasses 30 provinces and spans from the years 2001 to 2017. The study employs a super SBM model for evaluating the competition. In the paper by Le and Dang [24], five key indicators, including labor force, gross regional domestic product, the PCI, FDI by capital, and FDI by cases, were studied to see how they affect the efficiency of attracting FDI into provinces. The paper first uses a combination of Simple Moving Average (SMA) and Improved Fuzzy Time Series (IFTS) to predict the future values of the indicators from 2021 to 2022 using historical data from 2012 to 2020, combined with DEA window analysis to assess provinces' effectiveness in attracting FDI over the same period. However, this study has a limitation in not conducting a thorough examination of the surplus or shortage of inputs and outputs, resulting in a preliminary evaluation of the efficiency of each province. Starčević et al. [53] utilized the original DEA model to examine the effect of FDI on the sustainability of the economic system in Bosnia and Herzegovina and Serbia from 2005 to 2020. The findings affirm that DEA is an effective tool in evaluating the efficiency of FDI. Polloni-Silva et al. [54] conducted an excellent study on the environmental costs of FDI in Brazil. This group suggests using traditional panel data econometrics with the DEA model to study the environmental impact in regions with high foreign investment potential.

Table 2. List of related studies.

No.	Papers	Inputs	Outputs	Methods	Sample and Region
1	Suyanto et al. [46]	Spillovers from FDI	Productivity growth	Generalized Malmquist	Indonesian chemical and pharmaceutical firms
2	Lei et al. [47]	Material capital Human Capital Energy degree of openness	FDI performance index FDI potential index	CCR model, Malmquist	Chinese provinces
3	Thanh Tung [48]	Provincial Competitive Index (2012 version)	FDI and domestic investment	DEA Malmquist, bootstrapping	63 provinces of Vietnam
4	Aydin et al. [49]	Gross domestic product, population and global competitiveness index	FDI	FDEA	12 transition economies for 2011
5	Wang and Le [50]	FDI; exchange rate; CSR spending	Gross domestic product; GDP per capita	GM (1,1) model, DEA Malmquist, Super SBM	20 developing countries
6	Zhang et al. [51]	FDI	The efficiency of government expenditure on environmental protection	The output-oriented DEA scale return model	China

Table 2. *Cont.*

No.	Papers	Inputs	Outputs	Methods	Sample and Region
7	Liu et al. [52]	Land, capital, natural resources, labor	Air pollution, Water pollution, Solid Waste pollution, CO_2 Emissions, the added value of industrial output	Super SBM model	China
8	Le and Dang [24]	Labor force, gross regional product, and the PCI	FDI by capital (cumulative) and FDI by cases (cumulative)	IFTS, SMA DEA window	42 of Vietnam's 63 provinces
9	Starčević et al. [53]	FDI, RER, Inflation rate	GDP, RER, employment rate, import, export, inflation rate	DEA, PCA, IMF SWARA method, CRADIS method	Bosnia, Herzegovina, and Serbia
10	Polloni-Silva et al. [54]	Population density, GDP per capita, industry share of GDP, service's share of GDP, education level, productivity, and infrastructure	Intensity of FDI	Traditional panel data econometrics, DEA	All municipalities of the State of São Paulo, Brazil

According to the literature review mentioned earlier, no existing study has combined the novel Super-SBM and DEA Malmquist methods in assessing how effective FDI promotion is at the provincial level, particularly in a developing nation such as Vietnam.

The Super-SBM model will be applied to investigate the slacks of inputs-outputs of this case study. Slack refers to the potential improvement in the input and output variables for the inefficiency units compared to the benchmark objective [55]. The super-efficiency DEA model can process and further rank the DMUs whose efficiency value is 1 in the traditional model [56]. In performance evaluation, the frontier is held constant for DMUs with efficiency value $\theta < 1$, the frontier is maintained fixed, and the Super-SBM model is evaluated similarly to the SBM model. The Super-SBM model varies from the SBM model in that for a DMU with an efficiency value of $\theta = 1$, the Super-SBM model removes the DMU to be evaluated, reforms a new frontier, and then evaluates the distance of the DMU from the new frontier to determine its final ranking [57]. In other terms, the Super-SBM model can measure and compare the efficiency of DMUs by permitting a DMU's efficiency value to exceed 1. In addition, it is important to note that the DMU can still be ranked even if the efficiency value is less than 1 [58].

Furthermore, the outcomes of DEA–SBM efficiency evaluations enable projections analyses to assist inefficient DMUs in improving their efficiency and to provide quantitative and qualitative managerial recommendations by reducing excesses and increasing shortfalls [59–61]. Since the Super-SBM model provides more precise measurements than the conventional DEA model, it is chosen for performance evaluation analysis. The strength of the Super-SBM model has been exploited in many fields, e.g., green innovation performance [62], land usage [63] financial efficiency [64] and transportation [65].

However, the Super-SBM model has its limitations. It can only perform static analysis and not reflect the changes during the specified period. Malmquist Index (MI) can evaluate the relative growth in productivity between two time periods [66]. Malmquist's model is incredibly useful for assessing productivity. The DEA Malmquist model enhances the standard DEA model, useful for measuring DMU productivity over time. MPI equals the product of the catch-up index and the frontier-shift index [67]. The catch-up effect (CU) describes how close a DMU approaches the production frontier with the highest performance. The frontier-shift effect (FS) describes the technological advancement of the sample. Aspects of the MPI that have been deconstructed can determine how much of an increase in relative efficiency from period t to period t+1 can be attributed to individual effort and how much can be attributed to industry development. Efficiency change quantifies the degree to which a DMU's efficiency increases or decreases, whereas technological change quantifies the efficiency of FS between two periods [68]. There have been numerous Malmquist model applications in various fields over time. For example, Firsova [69] used DEA Malmquist to estimate direct and indirect innovation effects on Russian regions according to variables of the innovative product volume, the share of high-tech products in the gross regional product (GRP) structure, the number of used patents, and investment in innovation activity from 2006 to 2017. DEA was also employed to measure the Malmquist productivity of the driving forces of China's provincial energy intensity [70], the banking industry in Canada [71], and the computer industry [72]. The combination of DEA and MI, due to their mutual support, is widely used in jointly conducting static and dynamic performance evaluation in many research fields, e.g., the performance of semiconductor packaging and testing firms [73], export market selection and efficiency [74], road safety assessment [75].

Recognizing the methods' superiority and comprehensiveness over other efficiency evaluation methods, this study attempts to measure FDI performance in Vietnam provinces using the integrated super-SBM model and DEA Malmquist. First, Super-SBM offers a detailed comparison and recommendation between inefficient and efficient DMUs based on scores, rankings, and slack indicators. Then, DEA Malmquist is utilized to calculate the efficiency changes score for 2017–2021 based on output variables, including FDI by case and capital, and input variables, including Competitive Indexes. Input indicators that best match the characteristics of FDI evaluation will be well considered.

3. Methodology

3.1. Research Process

As stated in the preceding sections, this study presents a hybrid technique of Grey Delphi, Super-SBM, and DEA Malmquist to assess the efficacy of FDI in Vietnam. The Delphi method and DEA are research methods that can be used to investigate various aspects of a research problem or question. However, they differ in their approach to testing hypotheses. In the Delphi method, the focus is on obtaining consensus among experts on a particular topic or issue. The experts are usually chosen based on their knowledge and experience in the field and are asked to provide their opinions on a set of questions or statements related to the research problem. The method does not rely on pre-defined hypotheses, but rather seeks to gather insights and opinions from the experts that can be used to inform the research project. Similarly, in DEA, the focus is on measuring the efficiency and performance of a set of entities or decision-making units (DMUs) based on multiple inputs and outputs. The analysis does not rely on pre-defined hypotheses, but rather seeks to identify the most efficient DMUs and determine the factors that contribute to their performance. While both the Delphi method and DEA do not rely on pre-defined hypotheses, they can be used to generate insights and data that can inform and guide the development of hypotheses for further research. For example, the insights and opinions gathered through the Delphi method can be used to identify key areas of research or potential hypotheses to test, while the findings from DEA can be used to inform hypotheses about the factors that contribute to the efficiency and performance of DMUs.

Figure 1 depicts the research process for the technique. After defining the study aim, the competitiveness indices are investigated using the Grey Delphi approach. Super-SBM model is used to evaluate the efficiency and inefficiency of the DMUs. The Super-SBM model is a method used to assess the efficiency of DMUs and identify areas where improvements can be made. It helps to identify inefficient DMUs and guide them towards better efficiency by projecting potential improvements and highlighting areas for improvement. Projection analysis is used to predict the future performance of inefficient DMUs by projecting their performance towards the efficient frontier. Based on specified inputs and outputs, the Malmquist DEA model was used to estimate the change in total productivity caused by a change in CU and FS. Finally, research results are analyzed and discussed before managerial implications are proposed to improve the efficiency of the FDI attraction in Vietnam's provinces.

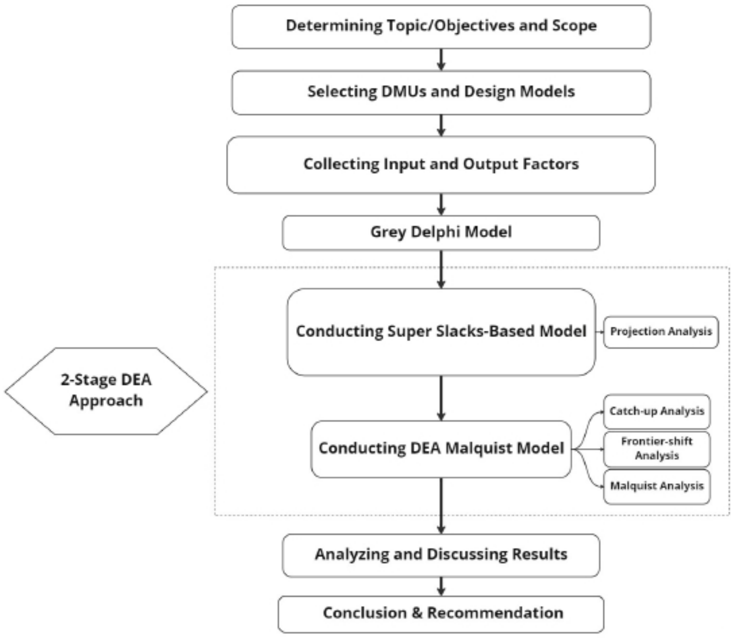

Figure 1. Research framework.

3.2. The Grey Delphi Method

Multi-criteria decision-making (MCDM) methods rely on expert judgments, which are often uncertain. To deal with this uncertainty, this study employs the grey systems theory. The Grey systems theory [76] categorizes information into fully certain (white), inadequate (grey), and unknown (black). This study employs Grey System Theory's concept of interval grey numbers. The Delphi method was proposed by Dalkey and Helmer [11]. It is a popular survey method for synthesizing the opinion of experts on a particular issue to reach a consensus. The conventional Delphi method has drawbacks, such as the need for multiple iterations to reach an agreement, subjectivity, and bias among experts. The grey theory integration could help surmount these limitations. Consequently, the Delphi and grey set theories are combined to form the Grey Delphi approach. The Grey Delphi approach involves several steps:

Step 1. Identification of competitive index factors (CIFs) of FDI

The literature review is used to identify potential CIFs of FDI in this step. Based on these CIFs, a questionnaire is created to gather data from the experts.

Step 2. Response collection from experts

The questionnaire prepared for this study is being delivered to specialists, who must respond using a linguistic scale. Table 2 shows the linguistic scales and their accompanying grey numbers.

Step 3. Overall evaluation using the grey number.

After referring to Table 1, the responses obtained from the experts have been converted to corresponding grey numbers. These grey numbers are then used to integrate the responses of the experts. Consider the case of an expert panel consisting of p members. The evaluation of the factor $\otimes G_i$ is as follows:

$$\otimes G_i = \frac{\left(G_i^1 + \otimes G_i^2 + \cdots + \otimes G_i^h + \cdots + \otimes G_i^p\right)}{p} \quad (1)$$

where $\otimes G_i$ is the overall evaluation of CIF's importance and $\otimes G_i^h$ denotes the hth expert's evaluation of CIF_i of FDI adoption.

Step 4. Whitening of the grey number

The grey number having the interval $\otimes G = \left[G^L, G^R\right] = \left[G' \in G \middle| G^L \leq G' \leq G^R \right|\right]$ Moreover, their equivalent whitenization value is $\otimes \sim$. The whitenization of grey numbers is obtained through Equation (2)

$$\tilde{\otimes} G = \alpha . G^L + (1-\alpha) . G^R, \alpha = [0,1] \tag{2}$$

Step 5. Setting threshold limit and CIFs selection

CIFs are selected and rejected in the Grey Delphi method's ultimate stage. To determine the importance of the factor, a total score is computed and compared to a threshold value (λ). If the value of $\otimes \sim \geq \lambda$, the factor is selected; otherwise, it is rejected.

3.3. Super-SBM Model

The Super-SBM model, developed by Tone [43] in 2022, calculates the efficiency of an efficient decision-making unit (DMU) by comparing it to the nearest point on the frontier, excluding itself.

Let the set of DMUs be $j = (1, \ldots, n)$ and each DMU_j has m input factors and g output factors. We denote the vectors of inputs and outputs for DMU_j by $X_j = \left(x_{1j}, x_{2j}, \ldots, x_{mj}\right)^T$ and $Y_j = \left(y_{1j}, y_{2j}, \ldots, y_{gj}\right)^T$, respectively.

We define input and output matrices X and Y by $X = (x_{1,} x_{2,\ldots,} x_n) \in R^{m \times n}$ and $Y = (y_1, y_{2,\ldots,} y_n) \in R^{g \times n}$, respectively. We assume that all data are positive, i.e., $X > 0$, $Y > 0$.

While λ is a non-negative vector, $\lambda = (\lambda_1, \lambda_2, \ldots, \lambda_n)^T$ is called the intensity vector in R^n, the vectors $s^- = \left(s^-{}_1, s^-{}_2, \ldots, s^-{}_m\right)^T \in R^m$ and $s^+ = \left(s^+{}_1, s^+{}_2, \ldots, s^+{}_g\right)^T \in R^g$ represent the expression's excessive input and insufficient output, called slacks. In fractional form, the SBM-DEA model evaluates the efficiency of DMU_k is as follows:

$$min\rho = \frac{1 + \frac{1}{m}\sum_{i=1}^{m} s_i^- / x_{ik}}{1 - \frac{1}{g}\sum_{i=1}^{g} s_i^+ / y_{ik}} \tag{3}$$

subject to:

- $x_{k0} = X + s^-$,
- $y_{k0} = Y - s^+$, and
- $s^- \geq 0 \; and \; s^+ \geq 0$.

In this study, the authors consider the super-efficiency problem under the assumption of $\rho^* = 1$, $S^{-*} = 0$ and $S^{+*} = 0$; the inputs are guaranteed, and the output is constant in the optimal solution; the DMU (x_{k0}, y_{k0}) is defined as the SBM efficient model. The efficiency with which the SBM is estimated ranges from 0 to 1.

The Super-SBM model was introduced to separate and rank these efficient DMUs. If $\rho^* = 1$, then the DMU (x_{k0}, y_{k0}) is efficient, the Super-SBM model can be described as follows:

$$min\delta = \frac{\frac{1}{m}\sum_{i=1}^{m} \overline{x_i} / x_{ik}}{\frac{1}{g}\sum_{i=1}^{g} \overline{y_i} / y_{ik}} \tag{4}$$

subject to:

- $\overline{x} \geq \sum_{j=1,\, j \neq k}^{n} \lambda_j x_j$;
- $\overline{y} \leq \sum_{j=1,\, j \neq k}^{n} \lambda_j y_j$;
- $\overline{x} \geq x_k, 0 \leq \overline{y} \leq y_k, \lambda \geq 0$.

Suppose $y_{rk} \leq 0$. $\overline{y}_r^+$, and $\overline{y}_{-r}^+$ will be defined by:

- $\overline{y}_r^+ = \max_{j=1,\ldots,n} \left\{ y_{rj} \middle| y_{rj} > 0 \right\}$, and
- $\overline{y}_{-r}^+ = \min_{j=1,\ldots,n} \left\{ y_{rj} \middle| y_{rj} > 0 \right\}$.

If the output r has no positive factors, then it is denoted as $\overline{y}_r^+ = \overline{y}_{-r}^+ = 1$. The elements in the objective function are replaced by s_r^+/y_{rk} as follows, whereas the value y_{rk} never changes.

If $\overline{y}_r^+ > \overline{y}_{-r}^+$, subjected to: $\frac{s_r^+}{\frac{y_{-r}^+\left(\overline{y}_r^+ - y_{-r}^+\right)}{\overline{y}_r^+ - y_{rk}}}$

If $\overline{y}_r^+ = \overline{y}_{-r}^+$, subjected to: $\frac{s_r^+}{\frac{\left(\overline{y}_{-r}^+\right)^2}{B\left(\overline{y}_r^+ - y_{rk}\right)}}$

DEA-solver is assigned a B-Score of 100, indicating that the recommendations it provides are always helpful and have a high level of precision y_{-r}^+. B-Score is influenced by the size of the unsupported output and the distance between the actual value and target value $\underline{y}_r^+ - y_{rk0}$. Importantly, the B-Score is independent of the unit of measurement used.

For inefficient provinces to attain full efficiency, the DEA projection analysis quantifies how much reduction in inputs and undesirable outputs would have been required and how much increase in desirable outputs. The improvement ratio is calculated by dividing the slack by the original value (i.e., (original value − projected value)/original value), where a positive ratio indicates the need to increase corresponding input/output and a negative ratio indicates the need to decrease corresponding input/output.

3.4. DEA Malmquist

The MPI was proposed by Caves et al. [77] to determine each DMU's efficiency change in two periods. In the research, the authors assessed the dynamic productivity trend of provinces' FDI using the original and expanded MPI by Färe et al. [78]. The MPI is a tool used to analyze productivity and comprises two major parts: efficiency change (EC) and technical change (TC). The efficiency change is also known as the CU effect, representing the change in DMU's efficiency, whereas the technical change is known as the FS effect, exhibiting the fluctuation in the efficient frontier.

The change in total factor productivity from period t to period $t+1$ is calculated as the following Equation [5]:

$$MPI_t^{t+1} = \sqrt{\frac{\rho_0^t\left(x^{t+1}, y^{t+1}\right)}{\rho_0^t\left(x^t, y^t\right)} \times \frac{\rho_0^{t+1}\left(x^{t+1}, y^{t+1}\right)}{\rho_0^{t+1}\left(x^t, y^t\right)}} \quad (5)$$

$MPI_t^{t+1} > 1$ indicates positive DMU performance growth in the period between t and $t+1$, whereas $MPI_t^{t+1} = 1$ and $MPI_t^{t+1} < 1$ correspondingly indicates that the performance has no change and negative growth.

The MPI index can be decomposed into the product of two components:

$$\begin{aligned} MPI\left(x^{t+1}, y^{t+1}, x^t, y^t\right) &= \frac{\rho_0^{t+1}\left(x^{t+1}, y^{t+1}\right)}{\rho_0^t\left(x^t, y^t\right)} \sqrt{\frac{\rho_0^t\left(x^{t+1}, y^{t+1}\right)}{\rho_0^{t+1}\left(x^t, y^t\right)} \times \frac{\rho_0^t\left(x^t, y^t\right)}{\rho_0^{t+1}\left(x^t, y^t\right)}} \\ &= \text{Catch-up effect (CE)} \times \text{Frontier shift (FS)} \end{aligned} \quad (6)$$

A CE score larger than one in the context of productivity analysis indicates that a province is making attempts to close the gap and get closer to the frontier. The FS value, on the other hand, is a measure of a province's overall improvement or deterioration in efficiency, which can push the frontier outward or inward and affect all DMUs. A rise in the CE value is viewed as proof of approaching the frontier, but an increase in the FS value is regarded as evidence of innovation.

4. Results and Discussions

4.1. Results of Grey Delphi Technique

The Delphi panel participants will receive an invitation to participate in all Delphi rounds unless they opt out of the study. By continuing to participate in the survey, it will be assumed that the participant consents to the study. Questionnaires were sent to experts by using Google form [79]. Although there is no set standard for the sample size of a panel, a higher number of panel members generally increases the reliability of group judgments. Experts have suggested that a minimum of 10 to 18 panel members per area of expertise is required [80]. Given the complexity of the criteria and the possibility of having multiple areas of expertise among various FDI professionals, we obtained 11 valid participants.

The experts selected for this study include individuals from both academic and industrial backgrounds. Industrial professionals with at least eight years of experience in FDI management and business development are chosen to provide data. The selection of academic experts specializing in FDI, Business Management, or International Business in reputable academic institutions is based on their proficiency and expertise in FDI. The survey had 11 participants who completed it. Out of the 11, 6 were male and 5 were female. In terms of age, 2 participants were under 25, 7 were between 25 to 40 years old, 2 were between 40 to 60 years old, and none were over 60 years old. Regarding education, three participants held a professor position, one held a bachelor's degree, four held a master's degree, and three held a doctorate degree. In terms of occupation, six participants were scholars, three were policy makers, and two were managers. Finally, regarding experience in the field, two had less than 5 years of experience, four had 5 to 10 years of experience, and five had 10 to 20 years of experience. Overall, the participants had a diverse range of demographic and professional characteristics, which provided valuable insights and perspectives on the research topic.

Following the expert group's responses [81], we transformed the linguistic value into grey numbers using Table 3. To calculate the overall grey weight, Equation (1) is utilized. The resulting grey weight is converted into a crisp number using Equation (2). These crisp numbers are then used to determine which CIFs should be included or excluded from the analysis. The threshold value is the average of all crisp values; a value greater than this threshold indicates that the CIF is relevant and should be included. Conversely, the CIF is excluded if the value is below the threshold. The overall grey and crisp weights and the decision are presented in Table 4.

Table 3. Linguistic scale and grey number.

Linguistic Scale	Grey Number
No important (NI)	[0,0]
Low important (LI)	[0,1]
Medium important (MI)	[1,2]
High important (HI)	[2,3]
Very high important (VH)	[3,4]

Table 4. Results of the Grey Delphi method.

CIFs	Overall Grey Weight		Crisp Weight	Decision	Decode
EC	2.3	3.3	2.8	Accept	CIF1
ED	0.8	1.6	1.2	Reject	
FIN	0.9	1.7	1.3	Reject	
LS	2.0	3.0	2.5	Accept	CIF2
TR	2.0	3.0	2.5	Accept	CIF3
IC	2.1	3.1	2.6	Accept	CIF4
GL	0.8	1.4	1.1	Reject	

Table 4. *Cont.*

CIFs	Overall Grey Weight		Crisp Weight	Decision	Decode
LT	2.2	3.2	2.7	Accept	CIF5
PB	2.1	3.1	2.6	Accept	CIF6
IN	0.6	1.1	0.9	Reject	
PL	2.2	3.2	2.7	Accept	CIF7
SS	2.1	3.1	2.6	Accept	CIF8
UE	1.3	2.2	1.8	Reject	
LA	2.3	3.3	2.8	Accept	CIF9
SD	1.0	1.8	1.4	Reject	
LI	2.3	3.2	2.8	Accept	CIF10

The results of the Grey Delphi method showed ten qualified CIFs in FDI evaluation. Surprisingly, the factors include all of Vietnam's PCIs, indicating that the PCI is an appropriate set of competitive indexes to assess the effectiveness of Vietnamese provinces in attracting FDI. These ten CIFs are important for FDI investors and the government to evaluate Vietnam provinces' competency and competitiveness effectively.

4.2. Data Collection

In this analysis, each DMU represents a distinct Vietnamese province. The investigation utilizes information from 63 provinces. This paper uses data from the General Statistics Office of Vietnam regarding the number of FDI cases and capital. In addition, CIFs data are extracted from the annual business survey, evaluation, and classification conducted by the Vietnam Chamber of Commerce and Industry. As in Figure 2, 10 selected inputs and output factors (FDI by capital and FDI by cases) are defined as follows.

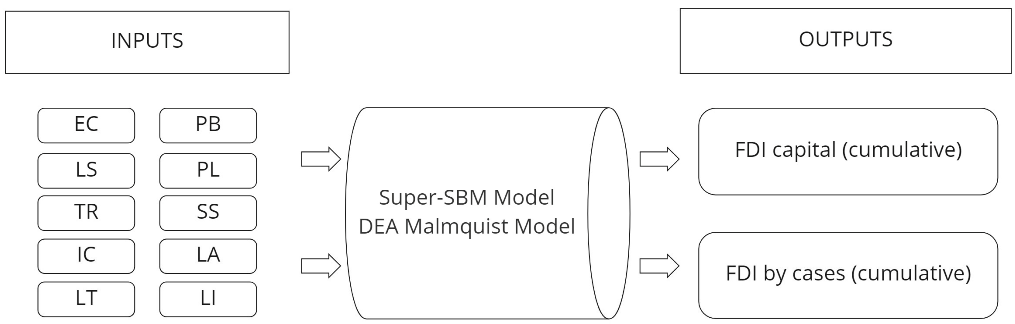

Figure 2. The DEA structure for evaluation of FDI attractiveness in Vietnam.

4.3. Efficiency Analysis

Initially, the authors employed the Super-SBM model to assess the FDI efficiency of 63 provinces in Vietnam from 2017 to 2021. The results of the static evaluation are presented in Table 5. In the super-SBM model, the DMU is inefficient when the score is less than 1 and efficient when the score is equal to or greater than 1. As seen from Table 4, the FDI efficiency of Vietnam's provinces in 2017–2021 was not high; most of the FDI efficiency scores in the provinces were less than 1, except for Ho Chi Minh City. The average efficiency score obtained throughout the years is merely 0.1225 to 0.1376, indicating a need to enhance the FDI efficiency of most of Vietnam's provinces.

Table 5. FDI attractiveness efficiency scores and ranking of provinces (2017–2021).

Provinces	2017	2018	2019	2020	2021	2017	2018	2019	2020	2021
	Efficiency Scores					Ranking				
An Giang	0.0045	0.0044	0.0054	0.0055	0.0058	47	49	47	50	49
Bac Lieu	0.0016	0.0097	0.0115	0.0993	0.0967	58	45	43	21	21
Bac Giang	0.1003	0.1079	0.1259	0.1479	0.1740	17	16	14	14	13
Bac Kan	0.0005	0.0005	0.0005	0.0004	0.0004	61	61	61	61	61
Bac Ninh	0.3662	0.3789	0.3581	0.4010	0.4044	6	7	7	7	7
Ben Tre	0.0180	0.0210	0.0206	0.0308	0.0314	35	35	35	36	37
Binh Duong	0.6533	0.6742	0.7030	0.6928	0.7224	3	3	2	3	3
Binh Dinh	0.0150	0.0175	0.0161	0.0224	0.0228	37	37	37	38	40
Binh Phuoc	0.0495	0.0562	0.0614	0.0702	0.0799	29	27	27	27	24
Binh Thuan	0.0805	0.0763	0.0771	0.0805	0.0790	23	23	24	24	25
BRVT	0.6118	0.6464	0.6426	0.6777	0.6363	5	4	5	4	5
Ca Mau	0.0017	0.0016	0.0031	0.0093	0.0032	57	58	54	46	56
Cao Bang	0.0043	0.0028	0.0021	0.0019	0.0019	49	55	57	58	58
Can Tho	0.0139	0.0147	0.0145	0.0151	0.0405	41	39	39	42	34
Da Nang	0.0945	0.1075	0.1089	0.1083	0.1127	21	17	17	19	19
Dak Lak	0.0044	0.0034	0.0033	0.0033	0.0124	48	52	51	53	44
Dak Nong	0.0025	0.0034	0.0032	0.0065	0.0064	54	51	52	48	48
Dien Bien	0.0001	0.0001	0.0001	0.0001	0.0001	63	62	63	63	63
Dong Nai	0.6170	0.6259	0.6514	0.6686	0.6592	4	5	4	5	4
Dong Thap	0.0034	0.0030	0.0031	0.0031	0.0043	52	54	53	54	54
Gia Lai	0.0007	0.0006	0.0007	0.0007	0.0007	60	60	60	59	59
Ha Giang	0.0013	0.0010	0.0007	0.0006	0.0006	59	59	59	60	60
Ha Nam	0.0547	0.0628	0.0774	0.0878	0.0964	26	26	23	23	22
Ha Noi	0.6592	0.7410	0.6942	0.7514	0.7347	2	2	3	2	2
Ha Tinh	0.2795	0.2651	0.2466	0.2519	0.2351	9	9	9	9	10
Hai Duong	0.1883	0.1717	0.1759	0.1967	0.1672	10	10	10	10	14
Hai Phong	0.3417	0.3940	0.3838	0.4028	0.4479	7	6	6	6	6
Hau Giang	0.0179	0.0098	0.0107	0.0106	0.0137	36	44	45	44	43
Hoa Binh	0.0140	0.0164	0.0152	0.0160	0.0168	39	38	38	41	42
Hung Yen	0.0985	0.1015	0.1046	0.1100	0.1209	18	19	18	18	16
Kien Giang	0.0970	0.1022	0.0987	0.1083	0.1027	19	18	20	20	20
Kon Tum	0.0020	0.0021	0.0020	0.0021	0.0056	56	57	58	57	50
Khanh Hoa	0.0949	0.0924	0.0905	0.0898	0.0955	20	21	21	22	23
Lai Chau	0.0004	0.0001	0.0001	0.0001	0.0001	62	62	62	62	62
Lang Son	0.0059	0.0054	0.0050	0.0052	0.0049	46	47	49	51	51
Lao Cai	0.0128	0.0123	0.0123	0.0122	0.0116	43	43	42	43	45
Lam Dong	0.0146	0.0123	0.0109	0.0106	0.0101	38	42	44	45	46
Long An	0.1416	0.1481	0.1523	0.1581	0.2425	12	12	12	12	9
Nam Dinh	0.0723	0.0720	0.0691	0.0759	0.0722	24	24	26	26	27
Ninh Binh	0.0290	0.0279	0.0293	0.0313	0.0343	33	34	34	35	36
Ninh Thuan	0.0295	0.0379	0.0353	0.0324	0.0365	32	32	32	34	35
Nghe An	0.0429	0.0415	0.0443	0.0487	0.0502	30	29	29	30	30
Phu Tho	0.0248	0.0280	0.0331	0.0395	0.0491	34	33	33	33	31
Phu Yen	0.1171	0.0395	0.0429	0.0415	0.0422	15	31	30	32	32
Quang Binh	0.0135	0.0178	0.0164	0.0244	0.0256	42	36	36	37	39
Quang Nam	0.1242	0.1280	0.1189	0.1223	0.1189	13	13	15	16	18
Quang Ninh	0.1188	0.1231	0.1167	0.1244	0.1422	14	15	16	15	15
Quang Ngai	0.0334	0.0397	0.0391	0.0416	0.0409	31	30	31	31	33
Quang Tri	0.0023	0.0022	0.0021	0.0025	0.0044	55	56	56	56	53
Soc Trang	0.0029	0.0052	0.0051	0.0063	0.0047	53	48	48	49	52
Son La	0.0036	0.0031	0.0029	0.0029	0.0029	51	53	55	55	57
Tay Ninh	0.1111	0.1241	0.1379	0.1553	0.1755	16	14	13	13	12
Tien Giang	0.0504	0.0483	0.0547	0.0591	0.0597	28	28	28	29	29
HCMC	1.5429	1.5914	1.6109	1.5499	1.5985	1	1	1	1	1
TT-Hue	0.0544	0.0785	0.0788	0.0794	0.0771	27	22	22	25	26
Tuyen Quang	0.0038	0.0041	0.0042	0.0047	0.0042	50	50	50	52	55
Thai Binh	0.0140	0.0145	0.0145	0.0161	0.0275	39	40	40	39	38

Table 5. *Cont.*

Provinces	2017	2018	2019	2020	2021	2017	2018	2019	2020	2021
	Efficiency Scores					Ranking				
Thai Nguyen	0.1629	0.1695	0.1683	0.1754	0.1798	11	11	11	11	11
Thanh Hoa	0.3166	0.3136	0.3041	0.3117	0.3033	8	8	8	8	8
Tra Vinh	0.0681	0.0715	0.0692	0.0691	0.0701	25	25	25	28	28
Vinh Long	0.0116	0.0126	0.0138	0.0160	0.0175	44	41	41	40	41
Vinh Phuc	0.0889	0.0993	0.1027	0.1103	0.1202	22	20	19	17	17
Yen Bai	0.0104	0.0088	0.0082	0.0085	0.0092	45	46	46	47	47
Average	0.1225	0.1269	0.1272	0.1335	0.1376					

According to Table 5, among the 63 provinces in Vietnam, Ho Chi Minh City, Ha Noi, Binh Duong, Ba Ria Vung Tau, and Dong Nai are the top five provinces with the highest efficiency scores. Having scores greater than 1.5, Ho Chi Minh City was ranked first for all five years from 2017 to 2021, with the highest score of 1.6109 in 2017. The efficiency scores of the remaining four provinces are significantly higher than the average performance scores, fluctuating between 0.6 to 0.75. However, it has yet to reach the level of effectiveness. These five provinces all had slight changes during the assessed period, which are considered insignificant. Investment capital from the state budget is concentrated in these two provinces because Hanoi is the country's capital, and Ho Chi Minh City is the economic center of the south [82]. However, to achieve such an achievement, the People's Committee of these two provinces had to use capital sources and utilize resources to attract FDI effectively. The first is Ho Chi Minh City; in 2022 alone, Ho Chi Minh City attracted 3.94 billion USD in FDI, the highest in the country [83]. People's Committee of Ho Chi Minh City has focused on investing in infrastructure projects such as Thu Thiem 2 bridge, with a total investment of nearly 3100 billion VND [84], promulgating preferential policies for foreign-invested projects [85]; promoting human resource training [86]; ensuring a stable political and economic environment [87]. A similar can be said for Hanoi, which has focused on key investment areas and has made significant achievements. In particular, as the economic-political center of the country, Hanoi actively expands international cooperation relations, improves the efficiency of external activities, contributes to trade promotion, and attracts foreign investment. After more than 23 years of being awarded the title of City for Peace by UNESCO, many major international events have been successfully organized by Hanoi, such as "The 2019 North Korea–United States Hanoi Summit" or "Hanoi 2020—Investment and Development Cooperation" [88]. These conferences have symbolic meaning, affirming Hanoi's capacity and prestige in major events. Thanks to the peaceful and stable environment, investors have chosen Hanoi as an important destination for FDI.

The next three provinces that effectively attract FDI are Binh Duong, Ba Ria Vung Tau, and Dong Nai. Besides the advantage of being adjacent to key economic regions, these three provinces have new points to attract FDI. The first is Binh Duong, which impresses with its relatively good transport infrastructure and industrial infrastructure. In particular, Binh Duong always promotes the administrative reform process, creating favorable conditions for foreign enterprises to carry out legal procedures for business investment [89]. Next is Ba Ria Vung Tau. With many advantages of a deep-water seaport, industrial development, tourism, and convenient transportation infrastructure in the dynamic economic zone of the Southeast region, Ba Ria Vung Tau is creating a good image of a potential and promising land for foreign direct investors. This helps ensure smooth traffic, exploits the province's strengths, and connects with other regional localities [90]. Finally, Dong Nai province. Dong Nai province has achieved many important achievements in attracting foreign investment in 2017–2021. However, by 2022, FDI attraction in this province showed signs of slowing down and was very low [91]. This situation is because Dong Nai has carefully selected investment projects in the locality, prolonging the appraisal time. Therefore, Dong Nai must develop appropriate policies to remove limitations, increase competitiveness and attract FDI. Through the models in the above province, policy makers in other provinces can learn to optimize resources and exploit their strengths to attract more FDI.

On the other hand, Dien Bien, Lai Chau, Bac Kan, Ha Giang, and Gia Lai are the most inefficient provinces from 2017 to 2021. Among them, Dien Bien has the lowest efficiency score of 0.0001, making it the least effective province in the country during this period. To attract and efficiently use FDI, provinces need to establish a stable economic, political, and social environment, enhance the local government's role, improve the legal framework for investment activities, and provide investors with incentives to invest in new-oriented industries and fields [92]. However, this should be done while demonstrating national interests and local economic and technical efficiency and avoiding attracting low-quality FDI just for the sake of movement. Moreover, it is essential to invest in material and technical infrastructure to create favorable conditions for foreign investors and improve the quality of human resources. These are innovative regulations for attracting FDI that top provinces such as Ho Chi Minh City and Binh Duong have successfully implemented.

While most provinces' scores were stable, four provinces, consisting of Bac Lieu, Can Tho, Dak Lak, and Phu Yen, experienced significant fluctuations. Bac Lieu's score exhibited an upward trend, increasing from 0.0016 in 2017 to 0.0967 in 2021, improving their ranking from 58th to 21st. Can Tho's ranking has remained relatively stable in efficiency scores between 2017 and 2020, but by 2021, the province's efficiency score improved, leading to an increase in rank from 42nd to 34th. Dak Lak also experienced a similar trend. It is worth noting that Phu Yen held a high ranking of 15th in 2017 but subsequently fell to 32nd place from 2018 to 2021.

A projection analysis of inputs and outputs was conducted for inefficient provinces to identify directions for improving their performance. Table 6 includes input and output improvement ratios for identifying input redundancy and reducing the shortfall of desirable outputs. From an input standpoint, all inputs conducted have a redundancy of approximately 80%. On the other hand, the shortage of expected outputs is a more serious issue. The most demanding need is an increase in the number of FDI cases, up to four times the current level, to reach an efficient state. Following that, the capital amount of FDI must be increased by 20%.

Table 6. Input-output projection rate (%) of provinces' FDI efficiency over the years.

Variables		2017	2018	2019	2020	2021	Average
Inputs	CIF1	−88.24	−87.19	−86.61	−87.48	−86.97	−87.30
	CIF2	−88.22	−88.66	−87.72	−86.81	−86.38	−87.56
	CIF3	−87.67	−87.15	−86.96	−86.76	−87.21	−87.15
	CIF4	−86.85	−86.91	−87.14	−86.46	−86.12	−86.69
	CIF5	−88.44	−87.88	−87.90	−86.57	−86.91	−87.54
	CIF6	−88.40	−86.90	−87.77	−86.42	−86.21	−87.14
	CIF7	−88.49	−87.73	−88.16	−87.06	−86.91	−87.67
	CIF8	−86.05	−85.73	−85.86	−86.06	−84.06	−85.55
	CIF9	−86.79	−86.60	−86.49	−85.92	−84.92	−86.15
	CIF10	−88.73	−88.60	−88.44	−87.11	−87.00	−87.98
Outputs	FDI by cases	323.37	335.11	350.36	486.52	501.29	399.33
	FDI by capital	20.60	20.17	22.63	19.31	19.38	20.42

4.4. The Malmquist Productivity Changes

In the previous stage, the authors used the Super SBM model to determine the effective and inefficient rankings of 63 provinces in Vietnam from 2017 to 2021. In this part, the DEA Malmquist I-C model is applied to show FDI performance in 63 provinces of Vietnam by analyzing the total change in productivity. The provinces' MI, CU, and FS values are displayed in Appendix A (Tables A1–A3.)

From the point of view of the catching-up Index (Table A1), most provinces are greater than 1, which also happened to be a key part of making MI more productive. More specifically, the average level of CU performance is highest in Bac Lieu, Ca Mau, Can Tho, Dak Lak, and Kon Tum. Their FDI efficiency is improving due to increasing their technical work, not because of FS. Oppositely, provinces with an average MI of less than 1, such as Bac Kan, Binh Thuan, Cao Bang, Dien Bien, Gia Lai, Ha Giang, Ha Tinh, Hai Duong, Hau Giang, Lai Chau, Lang Son, Lao Cai, Lam Dong, Phu Yen, Quang Nam, Son La, Thanh Hoa, and Yen Bai, are not achieving CU efficiency.

Table A3 presents the average MPI outcomes, which depict the extent of productivity alteration from 2017 to 2021. The data demonstrates that most provinces, specifically 49 out of 63, have registered an average MPI greater than 1, implying that most provinces have experienced a positive productivity increase over the given timeframe. The remaining provinces have an average MPI less than 1, such as Cao Bang, Dien Bien, Ha Giang, Ha Tinh, Hai Duong, Hau Giang, Lai Chau, Lang Son, Lao Cai, Lam Dong, Phu Yen, Son La, Thanh Hoa, Yen Bai, which is not performing well in terms of productivity. It is particularly important to mention Bac Lieu, the province with the highest average MPI and the most fluctuated during the study period. Bac Lieu received the highest average CU between 2017 and 2018, then experienced a severe drop in efficiency during 2018–2019. However, its average CU increased significantly in 2019–2020, with a score of 8.649, but recorded a sharp decline in the final period of 2020–2021, resulting in an average CU decrease. Its FS was around 1 in the whole period, demonstrating its drastically decreased rate of productivity change because of the decreasing efficiency change.

Figure 3 shows the relationship between the average FS, CU, and MI of DMUs. Although a few provinces have achieved breakthroughs in FS and CU, the changing trend of CU is similar to MI with slow-changing improvement. The similarity between the trends of MI and CU suggests that efficiency change played a big role and maybe the main reason why FDI changed in the provinces of Vietnam. On the other hand, it was observed that most provinces are clustered around FS = 1, with an average FS slightly above 1, which shows that FS does not play a major role in promoting change in their effectiveness. Hence, the results indicate the need for much improvement in existing related technologies (mostly policy and practical innovations) to make FDI much more efficient in the future.

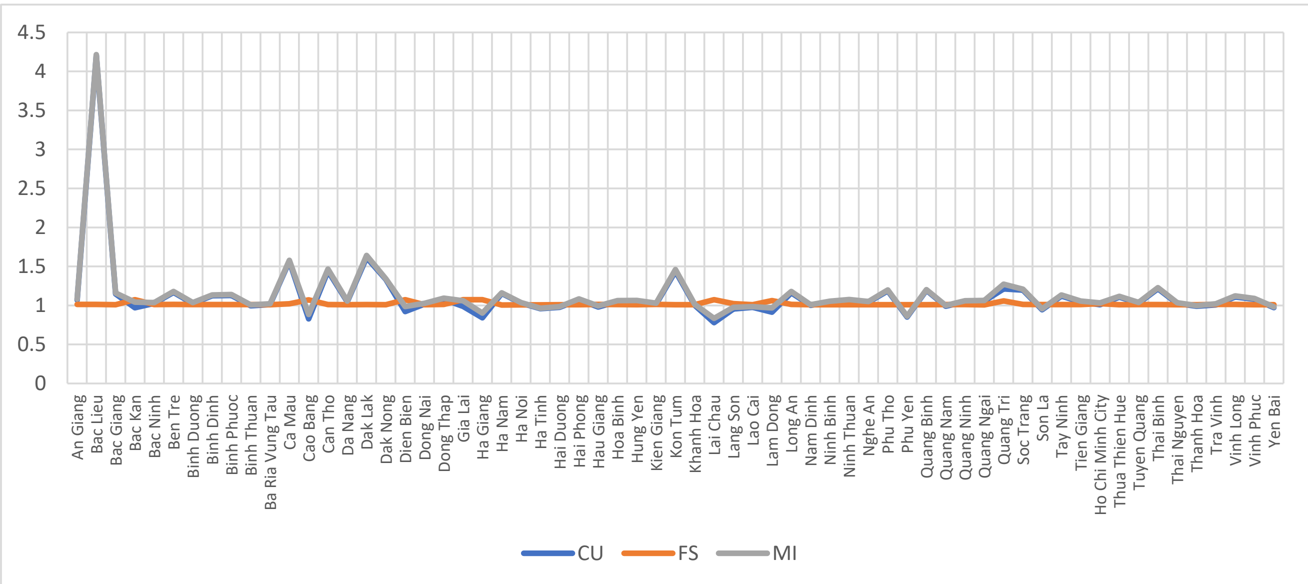

Figure 3. Comparison of catch-op (CU), frontier-shift (FS), and Malmquist index (MI).

Besides, this study found that CU was the main factor influencing dynamic change and that slow change in FS might be the main reason for low FDI efficiency. This means the foundation for attracting FDI in Vietnam remains insufficient and requires significant improvement. The government of Vietnam should continue to improve the investment climate, enhance infrastructure and human resources, and diversify investment promotion strategies to attract more high-quality and sustainable FDI. Furthermore, the research on FDI in Vietnam should focus on the impact of FDI on social and environmental sustainability, the role of local enterprises in FDI value chains, and the potential of technology transfer and innovation spillovers [93]. Addressing these issues can help Vietnam maximize the benefits of FDI and achieve its goals of becoming a modern, industrialized, and innovative nation.

This finding is consistent with previous studies about FDI in Vietnam for academics. This article is similar to results of [48], arguing that PCI is an important indicator in assessing the efficiency of FDI investment across provinces. The top effective and under-effective provinces were also mentioned in Le and Dang's findings [24]. Additionally, this study provides new insights into the FDI performance evaluation in Vietnam, particularly regarding the complementarity of the super-SBM model and MI. The study shows that combining these two methods provides a better understanding of FDI performance by measuring the dynamic decomposition of efficiency and finding out the root cause of efficiency change. The findings also suggest that future research on FDI in Vietnam should focus on the impact of FDI on social and environmental sustainability, the role of local enterprises in FDI value chains, and the potential of technology transfer and innovation spillovers. Addressing these issues can further enhance the understanding of FDI performance in Vietnam and provide a basis for more informed policymaking and investment decisions.

According to the Ministry of Planning and Investment, as of August 2021, Vietnam had attracted 34.424 FDI projects with a total registered capital of US$405.9 billion, with the majority of investment coming from countries such as South Korea, Japan, Singapore, and China [94]. Vietnam's investment incentives, for example, have been a major factor in attracting FDI. The country has offered various incentives to foreign investors. Such as Decree 01/2021/ND-CP [95] outlines regulations for investment in construction projects to simplify administrative procedures and encourage investment in infrastructure projects. Decree 118/2015/ND-CP [96] and Decree 22/2018/ND-CP [97] have streamlined foreign investors' process to obtain investment licenses, reducing the time and costs of starting a business in Vietnam. In particular, Law on Investment 2020 [98] includes a range of new provisions related to investment procedures, incentives, and promotion. It aims to promote sustainable development, attract high-quality investment, and improve the investment environment. Accordingly, Decree 31/2021/ND-CP [99] and Decree 52/2021/ND-CP [100] provide guidelines for implementing the Investment Law, particularly regarding investment procedures, investment incentives, and investment promotion. In addition, Resolution 50/NQ-CP [101] outlines a series of measures to improve the business environment and enhance national competitiveness.

The study's findings have significant implications for managers and investors seeking to invest in Vietnam. First, managers should conduct thorough due diligence to identify Vietnam's most attractive investment locations based on the province's FDI attractiveness ranking. Second, they should consider the infrastructure and human resource availability when selecting investment locations. Third, investors should diversify their investment promotion strategies to attract high-quality and sustainable FDI. Finally, investors should pay attention to the province's policies where they intend to invest, particularly the investment climate, to avoid the risk of investing in a low FDI attractiveness province. The study has theoretical implications for the literature on FDI performance evaluation. The study's results show that the efficiency of FDI varies significantly across provinces, which implies that FDI performance should not be evaluated based on national-level data alone. Rather, evaluating FDI performance at the sub-national level is essential to gain a more nuanced understanding of FDI's impact on local economies. Additionally, the study highlights the importance of infrastructure and human resource development in attracting high-quality and sustainable FDI. This finding suggests that future research should examine the role of infrastructure and human capital in FDI performance evaluation.

5. Conclusions, Limitations, and Future Works

5.1. Conclusions

FDI has played a crucial role in the economic development of Vietnam. With an open-door policy and various incentives offered to foreign investors, Vietnam has attracted a large amount of FDI, contributing significantly to the country's economic growth, job creation, technology transfer, and export expansion. Despite many achievements in attracting FDI, Vietnam must continue to promote its inherent advantages and overcome the remaining limitations. For example, the country does not have a foreign investment policy suitable to the fluctuations of the global economy, regulations to select qualified foreign investors, highly qualified workers, and a required infrastructure. To address these challenges, the government is improving the legal and regulatory environment and investing in education and training programs to develop a more skilled workforce. Furthermore, the unequal distribution of FDI across provinces may prevent provinces from realizing their full potential and capacity.

This study provides a comprehensive evaluation of the FDI attractiveness of Vietnamese provinces from 2017 to 2021, using an integrated model of Grey Delphi, Super SBM, and DEA Malmquist. By measuring ten dimensions of provincial performance affecting the total number of FDI and FDI capital accumulation, the authors have developed a series of indicators that can be used to evaluate the effectiveness of provinces in Vietnam in attracting FDI. This study's findings provide insights into the efficiency and optimization level of FDI attraction in each province over time, aiding policy makers and investors in making informed decisions regarding FDI in Vietnam. Overall, this study highlights the importance of strategic planning and policy implementation in attracting FDI and promoting economic growth in Vietnam.

The study on FDI performance evaluation in Vietnam has important implications for various stakeholders, including policy makers, investors, and academics. For policy makers, the study reveals the low FDI efficiency in Vietnam's provinces and the significant variation in FDI attractiveness among the provinces. The findings suggest that policy makers in the provinces with low FDI attractiveness should learn from successful models and take measures to improve the investment climate, enhance infrastructure and human resources, and diversify investment promotion strategies. By doing so, they can attract more high-quality and sustainable FDI and maximize the benefits of FDI capital. The study provides insights into the FDI performance evaluation, which can help investors make informed decisions about investing in Vietnam. The study identifies the most efficient provinces attracting FDI, such as Ho Chi Minh City, Ha Noi, Binh Duong, Ba Ria Vung Tau, and Dong Nai. The Southeast Region of Vietnam has been recognized for achieving the highest level of attractiveness for FDI. This achievement is attributed to the region's efforts to enhance its investment environment, prioritize attracting high-quality FDI inflows, implement transparent policies, and adopt practical solutions. Investors can learn from these successful models and identify potential investment opportunities in Vietnam.

5.2. Limitations and Future Works

While the study provides valuable insights into FDI attractiveness in Vietnam, it has certain limitations and challenges. These limitations include the impact of COVID-19 on FDI performance, a limited set of indicators, the use of a single method for performance evaluation, the focus on Vietnam alone, and the absence of consideration of FDI's distributional effects. First, the study did not fully consider the impact of COVID-19 on FDI performance. While the study recognizes the negative impact of COVID-19 on FDI, it did not examine how the pandemic affected FDI performance or the potential effects of government responses to the pandemic on FDI. Second, the study only considers limited indicators in evaluating FDI attractiveness. Future research could use additional indicators or more valid methods to measure the impact of other factors, such as education, financial market, innovation, integration into the global economy, and socio-demographic and urban-environmental factors. Third, the study only uses the DEA method for performance evaluation, which has certain limitations. Future research could integrate the DEA method with other techniques, such as machine learning predictive techniques or MCDM based on different Fuzzy sets, such as Spherical Fuzzy sets to investigate undesirable input/output factors in FDI performance evaluation. Fourth, the study only focuses on FDI attractiveness in Vietnam and does not compare it to other countries or regions. Future research could compare FDI attractiveness across different countries or regions to identify commonalities and differences in the factors that affect FDI performance. Finally, the study only focuses on the efficiency of FDI without considering its distributional effects. Future research could examine the distributional effects of FDI, including its impact on local communities, employment, and income distribution.

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

Appendix A

Table A1. Catch-up index (2017–2021).

Catch-Up	2017–2018	2018–2019	2019–2020	2020–2021	Average
An Giang	9.953	1.2200	1.0257	1.0391	1.0700
Bac Lieu	6.2015	1.1863	8.6488	9.735	4.2025
Bac Giang	1.0752	1.1676	1.1741	1.1767	1.1484
Bac Kan	1.1417	8.711	9.275	9.393	9.699
Bac Ninh	1.0347	9.450	1.1197	1.1985	1.0270
Ben Tre	1.1682	9.832	1.4930	1.0204	1.1662
Binh Duong	1.0320	1.0428	9.855	1.0427	1.0258
Binh Dinh	1.1674	9.219	1.3905	1.0169	1.1242
Binh Phuoc	1.1351	1.0933	1.1428	1.1384	1.1274
Binh Thuan	9.485	1.0103	1.0437	9.811	9.959
Ba Ria Vung Tau	1.0566	9.941	1.0545	9.389	1.0110
Ca Mau	9.394	1.9849	2.9946	3.383	1.5643
Cao Bang	6.606	7.265	9.327	9.931	8.282
Can Tho	1.0623	9.839	1.0439	2.6792	1.4423
Da Nang	1.1370	1.0128	9.950	1.0403	1.0463
Dak Lak	7.655	9.773	1.1980	3.7020	1.6132
Dak Nong	1.3774	9.297	2.0389	9.855	1.3329
Dien Bien	9.079	8.522	9.434	9.792	9.207
Dong Nai	1.0143	1.0408	1.0265	9.858	1.0168
Dong Thap	8.857	1.0423	9.984	1.3839	1.0776
Gia Lai	8.466	1.0729	1.0827	9.481	9.875
Ha Giang	8.028	6.447	9.564	9.668	8.427
Ha Nam	1.1481	1.2328	1.1340	1.0979	1.1532
Ha Noi	1.1242	9.368	1.0825	9.777	1.0303
Ha Tinh	9.486	9.302	1.0214	9.335	9.584
Hai Duong	9.115	1.0248	1.1180	8.502	9.761
Hai Phong	1.1530	9.741	1.0494	1.1120	1.0721
Hau Giang	5.491	1.0918	9.870	1.2942	9.805

Table A1. *Cont.*

Catch-Up	2017–2018	2018–2019	2019–2020	2020–2021	Average
Hoa Binh	1.1745	9.275	1.0519	1.0487	1.0507
Hung Yen	1.0306	1.0308	1.0517	1.0990	1.0530
Kien Giang	1.0546	9.655	1.0966	9.485	1.0163
Kon Tum	1.0567	9.389	1.0350	2.7239	1.4386
Khanh Hoa	9.732	9.794	9.923	1.0639	1.2022
Lai Chau	3.007	8.838	9.229	1.0148	7.805
Lang Son	9.176	9.172	1.0325	9.499	9.543
Lao Cai	9.607	9.998	9.921	9.496	9.755
Lam Dong	8.435	8.811	9.746	9.560	9.138
Long An	1.0460	1.0281	1.0380	1.5341	1.1615
Nam Dinh	9.955	9.601	1.0986	9.512	1.2014
Ninh Binh	9.623	1.0487	1.0678	1.0982	1.0442
Ninh Thuan	1.2849	9.308	9.173	1.1262	1.0648
Nghe An	9.671	1.0698	1.0991	1.0301	1.0415
Phu Tho	1.1308	1.1820	1.1939	1.2413	1.1870
Phu Yen	3.374	1.0860	9.679	1.0155	8.517
Quang Binh	1.3222	9.195	1.4922	1.0461	1.1950
Quang Nam	1.0310	9.291	1.0283	9.726	9.902
Quang Ninh	1.0367	9.479	1.0662	1.1429	1.0484
Quang Ngai	1.1915	9.830	1.0661	9.825	1.0558
Quang Tri	9.447	9.550	1.1974	1.7526	1.2124
Soc Trang	1.8120	9.819	1.2364	7.521	1.1956
Son La	8.682	9.122	1.0227	9.774	9.451
Tay Ninh	1.1171	1.1106	1.1267	1.1302	1.1211
Tien Giang	9.565	1.1334	1.0798	1.0115	1.0453
HCMC	1.0314	1.0122	9.621	1.0313	1.1993
Thua Thien Hue	1.4437	1.1941	1.1970	9.719	1.1067
Tuyen Quang	1.0771	1.0162	1.1222	9.034	1.0297
Thai Binh	1.0371	1.2012	1.1140	1.7027	1.2137
Thai Nguyen	1.0401	9.931	1.0421	1.0250	1.0251
Thanh Hoa	9.905	9.698	1.0248	9.733	9.896
Tra Vinh	1.0510	9.681	9.976	1.0147	1.1979
Vinh Long	1.0893	1.0901	1.1610	1.0920	1.1081
Vinh Phuc	1.1176	1.0339	1.0736	1.0904	1.0789
Yen Bai	8.449	9.264	1.0401	1.0803	9.730
Average	1.0957	1.1997	1.2351	1.1420	1.1206
Max	6.2015	1.9849	8.6488	3.7020	4.2025
Min	3.007	6.447	9.173	3.383	7.805
SD	6.653	1.604	9.930	4.787	4.232

Table A2. Frontier-shift Index (2017–2021).

Frontier	2017–2018	2018–2019	2019–2020	2020–2021	Average
An Giang	1.1994	1.0223	9.906	1.0271	1.0124
Bac Lieu	1.0127	1.0213	9.914	1.0240	1.0124
Bac Giang	1.1951	1.0223	9.904	1.0215	1.1998
Bac Kan	1.0956	1.1050	1.0516	1.0443	1.0741
Bac Ninh	1.2020	1.0213	9.926	1.0268	1.0107
Ben Tre	1.0120	1.0199	9.956	1.0257	1.0133
Binh Duong	1.1962	1.0223	9.844	1.0285	1.0104
Binh Dinh	1.1987	1.0225	9.897	1.0238	1.0112
Binh Phuoc	1.1956	1.0217	9.849	1.0323	1.0111
Binh Thuan	1.0100	1.0197	9.878	1.0282	1.0114
Ba Ria Vung Tau	1.1946	1.0209	9.887	1.0266	1.0102
Ca Mau	1.0529	1.0195	9.852	1.0264	1.0210
Cao Bang	1.0916	1.1000	1.0471	1.0450	1.0709
Can Tho	1.1967	1.0209	9.906	1.0263	1.0111

Table A2. *Cont.*

Frontier	2017–2018	2018–2019	2019–2020	2020–2021	Average
Da Nang	1.2029	1.0221	9.858	1.0255	1.1991
Dak Lak	1.0107	1.0207	9.839	1.0270	1.0106
Dak Nong	1.1967	1.0221	9.885	1.0230	1.0101
Dien Bien	1.0909	1.1018	1.0512	1.0478	1.0729
Dong Nai	1.1957	1.0193	9.873	1.0267	1.1997
Dong Thap	1.0109	1.0211	9.954	1.0226	1.0125
Gia Lai	1.0924	1.1015	1.0532	1.0469	1.0735
Ha Giang	1.0906	1.1003	1.0554	1.0471	1.0734
Ha Nam	1.2001	1.0211	9.839	1.0222	1.1968
Ha Noi	1.2009	1.0196	9.835	1.0280	1.1980
Ha Tinh	9.989	1.0204	9.839	1.0252	1.1971
Hai Duong	1.1979	1.0221	9.806	1.0255	1.1990
Hai Phong	1.1964	1.0218	9.849	1.0268	1.1999
Hau Giang	1.0131	1.0200	9.974	1.0229	1.0133
Hoa Binh	1.1961	1.0210	9.845	1.0295	1.0103
Hung Yen	1.1959	1.0212	9.939	1.0167	1.1994
Kien Giang	1.0106	1.0214	9.919	1.0274	1.0128
Kon Tum	1.1971	1.0218	9.856	1.0260	1.0101
Khanh Hoa	1.1976	1.0203	9.914	1.0213	1.0101
Lai Chau	1.0924	1.1032	1.0507	1.0499	1.0741
Lang Son	1.0610	1.0216	9.873	1.0241	1.0235
Lao Cai	1.1983	1.0224	9.828	1.0230	1.1991
Lam Dong	1.0923	1.1026	1.0272	1.0255	1.0619
Long An	1.0100	1.0206	9.933	1.0276	1.0129
Nam Dinh	1.1966	1.0210	9.865	1.0220	1.1990
Ninh Binh	1.1939	1.0215	9.933	1.0156	1.1986
Ninh Thuan	1.1985	1.0209	9.897	1.0181	1.1993
Nghe An	9.993	1.0213	9.847	1.0302	1.1989
Phu Tho	1.1956	1.0216	9.901	1.0231	1.0101
Phu Yen	1.1984	1.0196	9.868	1.0232	1.1995
Quang Binh	1.1955	1.0213	9.798	1.0303	1.1992
Quang Nam	1.1968	1.0214	9.903	1.0231	1.0104
Quang Ninh	1.1994	1.0213	9.896	1.0256	1.0115
Quang Ngai	1.2018	1.0216	9.857	1.0217	1.1977
Quang Tri	1.0832	1.1054	1.0161	1.0237	1.0571
Soc Trang	1.0100	1.0218	9.956	1.0230	1.0126
Son La	1.1987	1.0211	9.879	1.0287	1.0116
Tay Ninh	1.1982	1.0212	9.949	1.0243	1.0121
Tien Giang	1.1988	1.0204	9.868	1.0276	1.0109
HCMC	1.0189	1.0371	1.0284	1.1971	1.0229
Thua Thien Hue	1.1941	1.0227	9.908	1.0217	1.1998
Tuyen Quang	1.1985	1.0226	9.887	1.0215	1.0103
Thai Binh	1.1981	1.0211	9.882	1.0237	1.0103
Thai Nguyen	1.1976	1.0213	9.890	1.0200	1.1995
Thanh Hoa	1.2023	1.0206	9.817	1.0287	1.1983
Tra Vinh	1.0125	1.0207	9.975	1.0190	1.0124
Vinh Long	1.1988	1.0203	9.914	1.0290	1.0124
Vinh Phuc	1.1981	1.0205	9.881	1.0202	1.1992
Yen Bai	1.1973	1.0210	9.878	1.0195	1.1989
Average	1.0194	1.0317	9.962	1.0264	1.0185
Max	1.0956	1.1054	1.0554	1.0499	1.0741
Min	9.989	1.0193	9.798	1.1971	1.1968
SD	292	273	200	78	201

Table A3. Malmquist productivity index (2017–2021).

Malmquist	2017–2018	2018–2019	2019–2020	2020–2021	Average
An Giang	1.1947	1.2472	1.0161	1.0672	1.0838
Bac Lieu	6.0780	1.2116	8.5744	9.969	4.2152
Bac Giang	1.0806	1.1936	1.1629	1.2021	1.1598
Bac Kan	1.2509	9.625	9.754	9.809	1.0424
Bac Ninh	1.0368	9.652	1.1115	1.0355	1.0372
Ben Tre	1.1822	1.2028	1.4864	1.0467	1.1795
Binh Duong	1.0384	1.0660	9.702	1.0725	1.0368
Binh Dinh	1.1776	9.426	1.3762	1.0411	1.1344
Binh Phuoc	1.1414	1.1170	1.1255	1.1751	1.1398
Binh Thuan	9.580	1.0302	1.0309	1.1988	1.1970
Ba Ria Vung Tau	1.0615	1.0149	1.0427	9.639	1.0207
Ca Mau	9.891	2.0237	2.9504	3.472	1.5776
Cao Bang	7.211	7.992	9.766	1.0379	8.837
Can Tho	1.0694	1.1944	1.0341	2.7496	1.4644
Da Nang	1.1403	1.0351	9.809	1.0668	1.0558
Dak Lak	7.738	9.975	9.917	3.8019	1.6412
Dak Nong	1.3867	9.503	2.0156	1.1982	1.3402
Dien Bien	9.905	9.390	9.917	1.0260	9.868
Dong Nai	1.0200	1.0609	1.0134	1.0121	1.0266
Dong Thap	8.954	1.0643	9.938	1.4152	1.0922
Gia Lai	9.248	1.1817	1.1402	9.925	1.0598
Ha Giang	8.756	7.094	1.1994	1.0123	9.017
Ha Nam	1.1482	1.2588	1.1157	1.1222	1.1612
Ha Noi	1.1251	9.551	1.0646	1.1951	1.0375
Ha Tinh	9.475	9.492	1.1949	9.570	9.647
Hai Duong	9.187	1.0474	1.0963	8.719	9.836
Hai Phong	1.1603	9.953	1.0335	1.1417	1.0827
Hau Giang	5.564	1.1137	9.844	1.3238	9.946
Hoa Binh	1.1817	9.470	1.0356	1.0797	1.0610
Hung Yen	1.0366	1.0527	1.0453	1.1173	1.0630
Kien Giang	1.0657	9.862	1.0877	9.745	1.0285
Kon Tum	1.0643	9.593	1.0201	2.7946	1.4596
Khanh Hoa	9.806	9.992	9.837	1.0865	1.0125
Lai Chau	3.285	9.751	9.697	1.0654	8.347
Lang Son	9.736	9.370	1.0193	9.728	9.757
Lao Cai	9.687	1.0222	9.750	9.715	9.844
Lam Dong	9.214	9.715	1.2012	9.804	9.686
Long An	1.0564	1.0493	1.0310	1.5765	1.1783
Nam Dinh	1.2021	9.803	1.0837	9.721	1.1996
Ninh Binh	9.660	1.0712	1.0607	1.1153	1.0533
Ninh Thuan	1.2958	9.502	9.079	1.1466	1.0751
Nghe An	9.664	1.0925	1.0822	1.0612	1.0506
Phu Tho	1.1372	1.2075	1.1821	1.2700	1.1992
Phu Yen	3.402	1.1073	9.551	1.0391	8.604
Quang Binh	1.3295	9.391	1.4620	1.0779	1.2021
Quang Nam	1.0380	9.489	1.0184	9.950	1.2001
Quang Ninh	1.0464	9.680	1.0551	1.1722	1.0604
Quang Ngai	1.1936	1.1943	1.0509	1.1938	1.0631
Quang Tri	1.0233	1.0557	1.2167	1.7942	1.2724
Soc Trang	1.8300	1.1934	1.2309	7.694	1.2085
Son La	8.758	9.314	1.0103	1.1954	9.557
Tay Ninh	1.1262	1.1341	1.1209	1.1576	1.1347
Tien Giang	9.649	1.1565	1.0655	1.0394	1.0566
HCMC	1.0509	1.0498	9.894	1.0387	1.0322
Thua Thien Hue	1.4497	1.0269	9.978	9.929	1.1168
Tuyen Quang	1.0863	1.0392	1.1095	9.228	1.0395
Thai Binh	1.0455	1.0223	1.1009	1.7430	1.2279

Table A3. *Cont.*

Malmquist	2017–2018	2018–2019	2019–2020	2020–2021	Average
Thai Nguyen	1.0480	1.0143	1.0306	1.0455	1.0346
Thanh Hoa	9.927	9.898	1.1961	1.2013	9.975
Tra Vinh	1.0641	9.881	9.951	1.0340	1.0203
Vinh Long	1.0989	1.1122	1.1509	1.1237	1.1214
Vinh Phuc	1.1266	1.0551	1.0608	1.1124	1.0887
Yen Bai	8.511	9.459	1.0274	1.1014	9.815
Average	1.1140	1.0402	1.2287	1.1720	1.1387
Max	6.0780	2.0237	8.5744	3.8019	4.2152
Min	3.285	7.094	9.079	3.472	8.347
SD	6.711	1.578	9.826	4.910	4.215

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