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Greetings from Editor-in-Chief: Supply Chain and Sustainability Review (SCSR)

Jirasek Trimetsoothorn

The application of sustainability issues to supply chain management, logistics, transportation, and various optimization methods has been increasingly popular in recent years. One of the numerous issues that supply chain management encounters on an ongoing basis is operating in a sustainable manner. The goal of the SCSR is to investigate the use of sustainability in supply chain management, operation management, logistics, transportation, healthcare management, and fuzzy sets theory. The first issue of SCSR is to serve this purpose as how sustainable development must go hand in hand with logistics and supply chain management.

We invite academics from a variety of management-related disciplines to submit original, high-quality research papers that primarily address sustainability-management-related challenges and contribute to the SCSR's mission. The articles in the SCSR will emphasize both theoretical and empirical research. Literature reviews, conceptual theory development, qualitative survey research, such as case studies, and quantitative empirical methodologies may all be included in academic papers. SCSR rules must be adhered to by all submitted papers.

In view of current disruptions in global supply chains (e.g., chip crisis), the implications of supply chains for the climate and biodiversity discourse, new supply chain laws to increase social responsibility, and technological innovations (e.g., blockchain), supply chain management has become an imperative for global business.

In this inaugural issue, 6 research papers are presented (1) Impacts of the COVID-19 Pandemic on Supply Chains of the German Automotive Industry (2) Implementing Industry 4.0 Concepts to a Media Content Supply Chain and a Food Processing Business: Case Studies from Finland (3) A New Supply Chain and Sustainable Development Mechanism of Guangdong under the Framework of RECP (4) A Study of India's Role and Importance in Future Global Supply Chains (5) Performance Evaluation on the Promotion of Rural Health Teaching Strategy based on DEA Analysis in China (6) One Solution for Good? Systematic Analysis of Industrial Human Resource Supply Chain: Study on the Educational Dilemma and Countermeasures of Declining Birth Rate in Taiwan

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In addition, we would like to inform you about our next issues (Volume 2) in 2023. Recent announcement of the call for papers is accessible on the SCSR website. This issue marks the debut of the SCSR and its birth. It is my pleasure to address you on this occasion. I would like to express a warm welcome to the SCSR readership on behalf of the SCSR Editorial Team. I would like to thank our authors, editors, and anonymous reviewers, who have all voluntarily contributed to the journal's success. Without your participation, this initial issue would not exist.

We look forward to receiving your contributions.

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Impacts of the COVID-19 Pandemic on Supply Chains of the German Automotive Industry

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Abstract

The COVID-19 pandemic has dramatically changed our daily lives in a very short time. International supply chains, such as those of the German automotive industry, have experienced major disruptions. Measures such as border closures or production stops caused these supply chains to collapse due to increasing globalization on both on supply and demand side and the associated dependency on the global flows of goods. This in turn has led to bottlenecks, fluctuations in demand as well as delays along the entire value chain. The aim of this paper is to illustrate the impacts of the COVID-19 pandemic along the supply chains of the German automotive industry. Based on the literature review, potentials were identified to be able to react more effectively against crises in the future. The solution of previous thesis, various articles of management consultancies and statements of German car manufacturers were consulted. The obvious impact of the COVID-19 pandemic could be seen in the border closures and government measures such as home office obligations and lack of materials. There was a drop in demand in the automotive sector due to a limited processing time. Significantly, fewer vehicles were produced, and companies had to deal with immense drops in sales. The theoretical findings identified four major factors that influence the disruption of supply chains. These include complexity, communication, risk management and geopolitical factors. Due to the low vertical integration of the German automotive industry and the resulting high dependency on suppliers, the optimization of these factors is essential in order to react better to crises in the future. A fundamental step could be the digitalization of supply chains and the transparency of communication between all parties. Furthermore, adjustment of inventories and procurement at national level should be taken into consideration for the disruption of supply chains in the future.

Keywords: Supply Chain, German Automotive Market, COVID-19 Impact

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Introduction

Research Background

The coronavirus, also known as COVID-19, has spread worldwide after its initial discovery in China in December 2019. Within months, the virus has become a global pandemic and affects all areas of daily life. These include, for example, exit restrictions, contact bans, compulsory masking, border controls or lockdowns. The supply chains of the German automotive industry have not been spared either. With annual sales of over 438 billion euros in 2019, the cornerstone of the German economy is the automotive industry. Almost two-thirds of annual sales came from abroad in this regard (Reichert, 2020). The automotive industry represents a very dynamic environment with constant changes. For example, virtually all automobile manufacturers are diversifying their product ranges in order to conquer additional market niches. Examples are cabriolets, or SUV's. Globalization also has a strong impact on the automotive industry. Cost pressure is leading to a reduction in vertical integration in many cases. This means that the production of components and parts is outsourced and purchased from supplier. Through this outsourcing, supply chains develop into a global affair. These supply chains were also affected by the COVID-19 pandemic (Kropik, 2009).

Research Problem

Globalization has led to the development of mostly international and highly complex supply chains in recent decades, particularly in the automotive industry, which has been highly affected by the COVID-19 pandemic (Deloitte, 2020). But what does this mean? The effects can be observed on the supply side as well as on the demand side (Janßen et al., 2020).

Border closures, production stops and transport bottlenecks have affected the supply side. (GTAI, 2021). These factors resulted in supply shortages of materials or products and political measures. However, the impact of Corona is much more profound. When we talk about supply chains, all supply relationships and all suppliers are involved. In the automotive industry, we are talking about a gigantic number of suppliers. The external procurement rate is often over 75%. If the supply of just one material fails, for example the supply of leather for car seats, it can lead to the production lines in Germany coming to a stop. The costs of this are enormous (Eßig, 2020). In addition, there was a demand-related disruption. (Janßen et al., 2020). As described above, there was a decline in the economy. The first half of 2020 was characterized by an historic decline in the international automotive markets. The European market was hit hardest. 39% fewer vehicles were registered than in the same period of the previous year (VDA, 2020a).

The long-term consequences for supply chains are not yet foreseeable at this point in time. Nevertheless, companies are already increasingly considering whether processes should be adapted with the aim of being able to react effectively in crises (Deloitte, 2020).

Objective of the study

This research aims to show how the COVID-19 pandemic effected the supply chains of the German automotive industry. In order to understand the impacts, the structure of supply chains will be illustrated and the short-term and long-term effects along the entire chain will be explained. In this context, the four main factors influencing supply chain disruption will be used. These include complexity, communication, risk management and geopolitical factors. Finally, potential changes in the supply chain management process will be elaborated to be able to react more effectively in future crises.

Literature Review

In this chapter, the theoretical foundations of the supply chain are explained. This is followed by a description of the German automotive industry. Finally, the COVID-19 pandemic is discussed in order to define its impact on the supply chain.

Supply Chain

Due to advancing globalization and changes in sales markets, the value-adding processes (products are processed or refined in order to obtain a higher value) are no longer limited to the company's own boundaries. In fact, they extend from the raw material supplier to the end customer (Baumgarten, 2004). This also implies that there is a global and wide-ranging view and companies have formed an entire corporate network. The term supply chain has become established for this network. Despite this, many different definitions of the term can be found in the literature (Werner, 2004).

The following definition by Göpfert (2004), Corsten and Gössinger (2001) seems to be relevant for this work. A supply chain is a cross-company value chain that includes the stages from the upstream supplier (tier 1: component supplier, tier 2: parts supplier, tier 3: raw material supplier) through logistics service providers, distribution centers and the original equipment manufacturer (OEM) to retailers and end customers. The chain consists of material, information, and financial flows.

The idea of a value chain was first mentioned by Porter in his book “competitive advantage: creating and sustaining superior performance” (Porter, 1985). Also according to the early logistics, the physical flow, i.e., of a material, was clearly divided into procurement, production and distribution operations. However, regarding a single company (Pfohl, 2004). Over the years, companies have discovered that a cross-company perspective and planning can achieve much better optimization results than an isolated view of a single company (Kuhn & Hellingrath, 2002). The following figure illustrates the network in a simplified way.

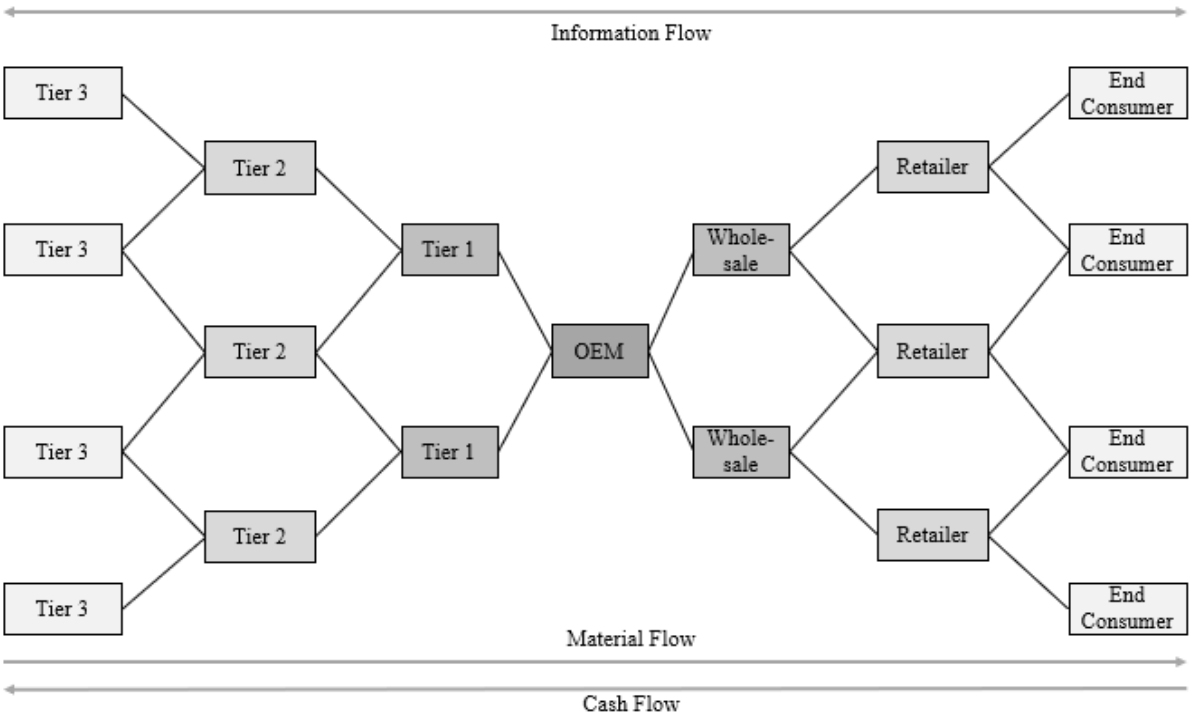

Figure 1 Example of a supply chain and the components (adapted from Hieronimus, 2006, p. 49.)

The figure illustrates different participants of the supply chain by squares, which are connected with edges. These connections show the relationships of the actors. The arrows symbolize the flow of materials, information, and cash flow. Direct relationships can also exist, for example, between raw material suppliers and OEMs or any other combination. There are no limits.

There is also some controversy in the literature about the term supply chain since it refers to a complex network. Sydow (2002) defines the term as a logistics network. An enterprise network with tasks to the operational and strategic logistics management. However, the previous definition of a supply chain goes far beyond the logistics chain as individual participants cannot make decisions in isolation, instead the entire chain is controlled by a collaborative management (Corsten & Gössinger, 2001).

Supply Chain Management

In theory and in practice, there is no standard definition of the term supply chain management. Based on the definition of a supply chain in the previous chapter, Kugeler (2002) defines the supply chain management as the planning, management, execution, and control of the entire value chain from raw material extraction to the end customer, taking into account material, information and financial flows. Werner and Thorn (2003) define supply chain management similarly, but in more detail. Here, the terms order acquisition, order processing and product delivery are used. The two authors also define the term supply chain planning. This includes all planning tasks that occur in the supply chain management and therefore represents a field of activities. The supply chain management also focuses on interfaces between companies. For this reason, it is also referred as interface

management (Kloth, 1999). Internally, this refers to interfaces between different departments. Intercompany interfaces are between suppliers and customers (Melzer-Ridinger, 2005).

The customer demands nearly every product should be available at any time and any place. This is due to the increasing demands of society as well as technological progress (Böhnlein, 2005). Here is one motivation to join forces and align supply chain as efficiently as possible with customer demand (Baumgarten, 2004). Companies are also increasingly focusing on international procurement markets. Value creation is decreasing, while networking between companies is increasing. The complexity of supply chains is increasing as a result of the relocation of work steps to foreign (often Asian or Eastern European) locations. The functioning of the supply chain depends on successful cooperation (Geimer, 2005).

Most goals in supply chain management can be achieved by connecting all actors and synchronizing development, manufacturing, delivery, and information. One of the most frequently mentioned goals is to increase delivery service and to react quickly to changing customer needs. In this context, an improved market position against competing supply chain is targeted (Böhnlein, 2005). To achieve the goals, a constant balance between effort or cost and the benefits of savings associated with the goals is required. For example, the goals of responding quickly to customer needs and market changes while achieving profitable growth are in conflict. The conflicting competitive factors of quality, cost, time, and flexibility must be realized (Keller & Krol, 2004).

German Automotive Market

According to the definition of the German Association of the Automotive Industry (VDA), the automotive industry consists of the production of motor vehicles of all types that are necessary for the transportation of people and goods. This includes the automobile manufacturers and the supplier industry, which produces car parts and equipment (VDA, 2007). Automotive manufacturers (OEMs) are enterprises that combine components, modules and other similar items produced in-house or by third parties into complete vehicles and offer them to the end consumer. The externally sourced components are purchased from suppliers. This includes all economic units that supply intermediate products or provide services for a company downstream in the value chain as part of the inter-company distribution of activities (Wallentowitz et al., 2009). The structure of the actors is shown in Figure 1.

The value chain in the automotive industry is highly diversified. Parts, components, and raw materials are largely purchased for vehicle production. The supplier industry benefits as a result. These include material and parts supplies from the chemical industry, mechanical engineering, or the electrical industry. Furthermore, car dealers, repair shops and gas stations are directly or indirectly dependent on the automotive industry. As mentioned in the research background chapter, the automotive industry has a major significance for the German economy. The German Federal Ministry for Economic Affairs and Energy (BMWi) defines the automotive industry as the largest sector of the manufacturing industry and the most important industrial sector in Germany in terms of sales. This is reflected in the fact that almost 833,000 employees earn their living in this sector. (BMWi, 2021). The largest employers in Germany and in the automotive field are the Daimler AG with

approximately 166,500 employees (Kaleta, 2021), Volkswagen Group with approximately 120,000 employees (Volkswagen AG, 2021) and the BMW Group with approximately 90,000 employees (Manager Magazin, 2020).

German automotive production is ranked among the world's largest manufacturer. In terms of vehicle sales, Volkswagen sells the most vehicles after Toyota (Japan) with 9.16 million vehicles in 2020. Daimler with 2.84 million. and BMW with 2.33 million vehicles are also among the 12 largest manufacturers worldwide (Kords, 2021a). The export sector is the most important for the German automotive industry. Most recently, around two-thirds of passenger cars produced in Germany were exported to other countries. The most important buyer countries include China, USA, England, and France (Kords, 2021b). For this reason, access to foreign markets is a key issue for the automotive industry (BMWi, 2021).

COVID-19 Impacts on Global Supply Chains

The impact of the COVID-19 pandemic on global supply chains has been enormous. National and international restrictions such as strict border controls caused a negative impact on supply chains (Kumar & Managi, 2020). In recent years, companies have aligned their supply chains according to different strategies. For example, lean or flexible systems have been introduced to better coordinate or visualize them in order to identify weaknesses and save costs. However, the implementation of the strategies has not been sufficient to avoid the negative impact of the pandemic (Oloruntoba, 2020).

The rapid spread of the virus disrupted supply chains. Supply shocks, demand shocks, the bullwhip effect (fluctuations in demand in the supply chain), transportation requirements and costs are the major effects (Zhu et al., 2020). The main influence on these effects is the possibility for companies to buy supplies. Border closures have strongly influenced business activities or the transportation of goods. In China, government measures have shut down the production of entire industries. Since many supplies in the automotive industry also come from China, companies were no longer able to receive the required supplies, therefore their production also had to be stopped. In this context, upstream and downstream supply chain partners were also disrupted. Due to the lack of materials, production had to be stopped here as well (Barter, 2020). This resulted in shortages for end consumers and surpluses for suppliers or manufacturers. These effects are related to the bullwhip effect, which occurs when swings in inventories increase due to demand fluctuations. The main reason is the lack of transparency in the supply chain. Changes in demand are partly due to panic buying and stockpiling. This shifted demand, which many companies were not prepared for. Large companies were able to manage this shift in demand, while smaller companies were forced to stop production (Parson, 2020). Border closures significantly increased transportation costs. Some of the raw materials are requested by air. Due to the pandemic, many flights could not take place and new ways of procurement were needed. This resulted in a worldwide increase in costs. In addition, new safety measures and regulations affected costs and delivery times (Zhu et al., 2020).

Past Research

Researchers have examined the coronavirus impact on global supply chains. According to Taleb (2012), global supply chains are designed for high efficiency and cost reduction, which is why they have become vulnerable to disruption. This thesis is supported by Pedersen and Nylænder (2021). The two authors were able to gather insights from different companies through interviews and illustrate the impact on companies, such as delays or financial impact. The impact was also confirmed by a global survey that interviewed more than 173 business managers and leaders from various industries about the negative impact of the COVID-19 pandemic on their supply chains (Mazareanu, 2021). Another focus of the research so far is on factors that influence the disruption of global supply chains by COVID-19. Factors were identified that influence disruption and therefore can be prevented under certain circumstances. These are complexity, communication, risk management and geopolitical factors (Pedersen & Nylænder, 2021).

Pató and Herczeg (2020) were able to show that the automotive industry was extremely challenged. They took a slightly different approach. In their work, which is based on a case study, solution paths were defined based on the challenges, which focused on trouble-free production. In their opinion, inventory choice and organizational strategy are key aspects in the crisis. Köllner (2020) mentioned the sales losses due to the pandemic in Germany. Furthermore Humphrey & Lechowski (2020) examined the structural changes that emerge from the pandemic-induced demand crisis in the automotive sector. In particular, the disparate impact on small firms or the influence of national governments on governance processes in the industry.

Regarding to the German automotive industry, no scientific work could be found at the present time. The German Association of the Automotive Industry has regularly disclosed positions. For example, the industry association speaks of historic sales declines, particularly due to the lack of exports (VDA, 2020a; VDA, 2020b). There have also been various analyses by consulting firms. Deloitte, for example, has shown through a survey that the automotive industry could already see positive signals in 2020. The dependence on components and process steps is defined here as an elementary obstacle. Nevertheless, the export business could be seen as a rescuing link, in particular due to sales numbers in China (Proff, 2020). Until today, there have also been regular press releases from the German automotive industry. This revealed how the individual manufacturers are dealing with the COVID-19 pandemic. The focus was on production stoppages and financial aspects (Sattler, 2020; Volkswagen, 2020).

Finding

The following findings were obtained from the literature review of the coronavirus impact to the supply chains of German automotive market. Figure 2 illustrates a conceptional framework established based on the findings of the research.

Figure 2 Conceptual Framework Model

(Kumar & Managi, 2020); (Oloruntoba, 2020); (Parsons, 2020); (Zhu et al., 2020); (Werner, 2004); (Corsten & Gössinger 2001); (Melzer-Ridinger, 2005); (Pfohl, 2004); (Kugeler, 2002); (Geimer, 2005); (Keller & Krol, 2004); (VDA, 2007); (Wallentowitz et al., 2009); (BMWi, 2021); (Kords, 2021a)

The Coronavirus Impact to Supply Chains

The COVID-19 pandemic had many impacts on supply chains. However, the following impacts have had the greatest impact. As a result of restrictions, delays occurred. The largest delay was found in inventory. This category also includes postponements of projects, which has affected the entire value chain. The type of work has also changed in the form of home office. These changes can be positively attributed to the fact that employees are more flexible in their work. Negative effects, on the other hand, could be seen in the customer relationship or in the reduction of social interaction. A major impact can certainly be attributed to the financial impact. Sales decreased, prices for raw materials increased and, in some cases, production had to be reduced. Another impact was the travel restriction on the supply chains. International travel bans affected production and thus international supply chains. But also, third party verifiers had negative influences. Overall, it can also be observed that smaller firms experienced more delays and sales decline than large firms. Large firms, in turn, have downsized their employees rather than smaller firms (Pedersen & Nylænder, 2021).

Impact to the German Automotive Market

The above-mentioned reasons have a direct impact on the supply chains of the German automotive industry. Plant closures and production stops to protect employees, supply bottlenecks due to interrupted supply chains and a lack of supplier parts. In addition, there was a drop in demand (Köllner, 2020). All these factors can be seen in the sales figures. There was significant drop in automobile production due to corona measures, especially at the beginning of the pandemic, 1st half of 2020. In Germany, over 600,000 fewer motor vehicles were produced as planned by June 1, 2020 (Kords, 2020). According to the German Association of the Automotive Industry, sales fell by approximately a quarter in 2020. Although the Chinese sales market recovered comparatively quickly, the level was still below that of the previous year (VDA, 2021). This is also reflected in the sales figures for the German automotive industry. With sales of €378.17 billion in 2020, that's about €58 billion less than the previous year and the worst figures since 2014 (Kords, 2021c). All manufacturers were affected in addition to production stops of closed registration authorities as well as the decrease in demand of the consumers. Nevertheless, the development of the various car manufacturers was quite different. Daimler and BMW (sales down 7.8%) showed a much lower sales decline than Volkswagen, for instance, with 15.1%

(Autozeitung, 2021). Due to the very complex structure of the supply chain, a large number of automotive suppliers have also been affected. They cover around 70 – 80% of the value chain. They have also been forced to shut down or stop production (Köllner, 2020).

Main Factors to Reduce Coronavirus-Related Supply Chain Disruptions.

Furthermore, due to the disruption of supply chains, factors can be defined that can lead to a resilient response to pandemics and disruptions in the future. Among the factors are complexity, communication, risk management and geopolitical factors. The complexity factor includes the size of supply chains, type of production (among others Lean and Just in Time) as well as the type of production (national or international). The communication factor includes, especially, the transparency within the supply chain. The type of information processing (manual or automatic) and the relationship with suppliers have a great influence. Risk management is characterized by resilience. The risk can be reduced due to redundancy in the form of multiple suppliers or extra resources. Robustness also belongs to this category. The financial situation of a company as well as safety inventory has a great influence in this context. The final factor, geopolitical factors, is very difficult for companies to manage. This category includes restrictions (domestic, international, travel bans, infection control rules and climate conventions) and governmental support (tax packages, support schemes and dispensation) (Pedersen & Nylaender, 2021).

Research limitations

This paper covers various aspects of COVID-19-related impacts on automotive supply chains. The issues are identified through documentary research in theses, journals, articles, books and more. Search engines such as ‘Google Scholar’ or ‘Emerald Insight’ and relevant websites are also used to bring together relevant information. The time period under analysis starts with the outbreak date of the pandemic, i.e., December 2019, until the completion of this paper. Potential future changes in supply chains may extend beyond this period.

Research Significance

In recent decades, the global supply chains of the automotive industry have been characterized by the outsourcing of production stages and the sourcing of pre-products from abroad as a profitable strategy. Currently, however, the question arises to what extent the associated risks caused by the pandemic can be justified (Kolev & Obst, 2020). This research study was anticipated to yield at least the following useful significance as following:

1. To provide an overview of the impacts caused by the pandemic. It shows the effects and can help provide more transparency in the supply chain.
2. To highlight the long-term actions. What can we learn from the pandemic to be better protected against crises in the future?

Conclusion and Recommendation

The aim of this paper was to show the short-term and long-term impacts of the COVID-19 pandemic on supply chains in the German automotive industry. Finally, potential changes should be presented in order to be able to handle crises better in the future.

It could be shown that the supply chains were massively affected by the short-term effects such as production stops or border closures. In addition, these effects and the decline in demand led to a huge drop in sales. In this context, the automotive industry was hit hard due to its low vertical range of manufacture and the resulting dependence on a large number of suppliers. The complex structure of the supply chains intensified this effect. This is why the focus on complexity, communication and risk management is essential in order to be able to resist crises in the long term. The implementation of lean principles has increased complexity. Efficiency is often the only focus, and risk management strategies remain on the side-lines. In particular, methods of resilience or robustness should be considered in order to be able to react better to disruptions in the future. Through risk management, potential risks can be identified at an early stage and corrective measures initiated (Chowdhury, Agarwal & Quaddus, 2019). Early communication throughout the supply chain can also significantly minimize vulnerability to disruption. In this context, companies should work to digitize supply chains. Digitized supply chains provide assistance and have many advantages. Among others, it can ensure the real-time tracking of goods as well as uninterrupted communication between all parties involved in the supply chain (Casey & Wong, 2007; Mansfield-Devine, 2017). Digitization also supports the objectives of supply chain management. Companies should also place a high priority on risk management. Plans should be created by all key suppliers and customer. Ivanov & Sokolov (2013) were able to show with their work that this allows a better response to disruption. In the best case, risk management should be digitized in the same way as the supply chains. By integrating a cross-enterprise supply chain monitoring system, companies can also become more flexible, organized, and responsive to disruptions. Another impact of the pandemic could also affect previously established lean management strategies such as keeping inventories as low as possible. Especially for critical materials, higher safety stock levels could compensate missing materials at least over a longer period. (Pató & Herczeg, 2020). However, companies should keep in mind economic factors as the costs due to increased inventories and develop an appropriate strategy. The currently dominating global sourcing of parts could also be affected as a result of the pandemic. In this context, companies could also consider producing critical materials locally, thereby decoupling geopolitical measures from governments such as border closures and avoiding production stoppages due to missing materials.

In the long term, the COVID-19 pandemic is likely to change the automotive industry in many facets. Structural changes in the nature of procurement and fundamental strategies are foreseeable. These measures are essential to ensure sustainable supply chains and procurement in the uncertain and likely more disruptive future (McKinsey Global Institute, 2020).

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Implementing Industry 4.0 Concepts to a Media Content Supply Chain and a Food Processing Business: Case Studies from Finland

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Abstract

Industry 4.0 is an ongoing revolution and is affecting profoundly in the media industry and is changing the manufacturing sector. The research elucidates a clear understanding of the Fourth Technology Revolution, Industry 4.0. The study focusses critically on the benefits and possibilities that Industry 4.0 technologies bring to operational supply chain and customer outcomes. Two case studies from Finland viz, Sanoma Media Finland's (Sanoma) content supply chain and a Southern Finland located meat product manufacturer (hereafter referred as Company X is a food processing business) have been studied. Sanoma Media Finland is the leading multi-channel media house in Finland and Company X is a Helsinki-based food processing SME specialising in producing and delivering raw doner kebab. The authors have tried to research the concept of the Fourth Industrial Revolution by conducting a literature review, and to create a scenario where those concepts are implemented to the supply chain in the two case companies. Findings from the Sanoma Media Finland case illustrates that using Industry 4.0 technologies, media companies can take advantage of knowing the consuming habits of the audience. Using available data for building automated content supply chain would decrease the costs and increase the accuracy of content popularity. Findings from the case of Company X, illustrates that the Industry 4.0 aspects substantially helps to push the company in the right direction. Automated manufacturing processes, data gathering from machines for remote monitoring via the IoT, and more automatic inventory and order management helps to cut costs and reduce spoilage, while simultaneously improving the quality and increasing the output. The research study concludes that implementation of Industry 4.0 ultimately leads to improved financial performance and enable companies to remain competitive. Transformation requires that every stakeholder in the supply chain commits to the new standards.

Keywords: Industry 4.0, Content Supply Chain, Finland, Food Processing, Scenario analysis

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Introduction

The purpose of this research is to state a clear understanding of the so-called Fourth Technology Revolution, Industry 4.0. This research is focusing critically on the benefits and possibilities that Industry 4.0 technologies bring to operational supply chain and customer outcomes.

The authors attempt to research the concept of the Fourth Industrial Revolution by conducting a literature review, and to create a scenario where those concepts are implemented to the supply chain a chosen company. First, the company is introduced. Second, the literature review regarding the Fourth Industrial Revolution is presented. Third, a scenario is created where the concepts of the said revolution are applied to the supply chain of the company.

This research illustrates the real effect of the technological revolution in the supply chain management using Sanoma Media Finland's (Sanoma) content supply chain as a point of reference. Sanoma is the largest commercial media house in Finland and reaches almost every Finn weekly (Sanoma, 2020). Consumption of digital videos is increasing, and the competition between online video services will intensify (Wayne, 2018). Taking advantage of modern technology is necessary for media companies like Sanoma to compete the most significant online video platforms such as Netflix, Amazon and Hulu.

The authors use two cases studies to elucidate the Industry 4.0 concepts implementation viz, Sanoma Media Finland's (Sanoma) content supply chain and Company X, a food processing business in Finland.

The Industry 4.0: Review of Literature

The first industrial revolution began in the late 1800s and was initiated by the introduction of mechanical looms, an early form of automation. This was followed by the second industrial revolution roughly at the end of the 19th century, which created the conveyor belt-based division of labour and mass production. The third industrial revolution started in the late 1960s as new digital innovations began to offer robotised solutions to manufacturers and it has lasted up to the present day (Drath & Horch, 2014; Kovács & Kot, 2016). The Fourth Industrial Revolution, or Industry 4.0, is a concept that was first coined in Germany in 2011 (Xu, Xu & Li, 2018), although similar developments were also taking place in other European countries at that time (Tjahjono *et al.*, 2017). The concept, even though being currently discussed in many contexts, still in many cases, lacks a clear definition (Hermann, Pentek and Otto, 2016; Piccarozzi, Aquilani & Gatti, 2018). Indeed, as Szozda (2017) states, Industry 4.0 is still developing in many directions and continues to remain unexplored in many respects, thanks to its still unfolding nature. Industry 4.0 is a vast domain that touches on a wide variety of fields including, but not limited to, manufacturing, data management and competitiveness (Piccarozzi, Aquilani & Gatti, 2018). Despite the difficulty of defining the boundaries and concept of Industry 4.0, its very essence can be seen in the ability of the machines, components and systems to communicate with each other, which makes self-regulated production, real-time production planning and self-optimisation possible (Pan *et al.*, 2015; Kovács & Kot, 2016; Sanders, Elangeswaran & Wulfsberg, 2016). Opportunities of Industry 4.0 are considered extensive. For example, lower transportation costs, easier mass customisation, environmental

sustainability and increased flexibility in production are some of the benefits that the next industrial revolution is supposed to realise (UNIDO, 2018).

Even though the concept still lacks clear and universally shared definition which makes a theoretical study of it difficult (Hermann, Pentek & Otto, 2016; Piccarozzi, Aquilani & Gatti, 2018), the core of Industry 4.0 can be identified as the use of novel and emerging information technologies that tie together the business operations, manufacturing and services which leads to a growing efficiency and cost reductions (Wang *et al.*, 2016; Szozda, 2017; Drath & Horch, 2014). According to Prause and Atari (2017), technologies especially related to the Industry 4.0 are Internet of Things (IoT), Big Data, 3D printing and Artificial intelligence which facilitate the emergence of smart manufacturing and logistics operations and processes. These enable inter-machine communication and greater automation of production, as well as deeper insights into production issues with minimal need for human involvement (Tjahjono *et al.*, 2017). Although these technologies are not necessarily new, their price reductions have made them widely available, thus ushering in the advent of the next industrial phase. However, they point out that the wide-scale introduction of these technologies may take another 15-20 years (Strange and Zucchella, 2017).

Especially in the manufacturing industry, additive manufacturing, or 3D printing, has garnered significant attention. 3D printing helps in producing complex but still lightweight and durable parts in a relatively short time. Furthermore, it can reduce waste and create cost savings by reducing the need for machine tools (Joshi & Sheikh, 2015). 3D printing is already in use, for example, in the aerospace industry (Joshi and Sheikh, 2015) and the automotive industry (Wee *et al.*, 2016). However, it does have some limitations. As Joshi and Sheikh argue (2015), the mechanical properties of 3D printed parts can still be qualitatively weaker than those produced in the traditional manner.

The Internet of Things, also a vital component of Industry 4.0 is making smart manufacturing a reality. The internet of Things (IoT) refers to the information network of physical objects; the machines collect and deliver data regarding their processes. The IoT eases monitoring and data analytics, providing insights into the production processes, and also makes it possible for the machines to communicate with each other. There are many fields where IoT is already being utilised; for example, in power generator manufacturing, where on-going data collection has helped in improving the reliability of the machinery (Rymaszewska, Helo & Gunasekaran, 2017).

Linked to the IoT is also the concept of Big Data, which refers to the data obtained from the various, e.g., manufacturing processes through the monitoring capabilities of the machines themselves. By analysing the data, patterns that are not readily visible may be detected to gain information regarding possible pain points of the production process. One example of Big Data usage is in semiconductor manufacturing, where leveraging it has helped in fault detection and predictive maintenance (Moyne and Iskandar, 2017).

Although much talked about, Industry 4.0 is still unfolding. Indeed, some of the interest garnered by the Fourth Industrial Revolution can be explained by the fact that as the previous revolutions could only have been observed ex post facto, the arrival of Industry 4.0 was announced beforehand and it, as an industrial revolution, can be argued to take place presently (Drath and Horch, 2014). Perhaps Industry 4.0 should rather

be seen as a vision (Hermann, Pentek & Otto, 2016), or as a strategy (Johansson *et al.*, 2017) that is a child of the digital revolution (Hahn, 2019), than a singular concept. It seems certain, however, that its full implications still remain to be seen.

The modern world is familiar with digital elements when consuming products and services, for example, in mobility, housing, dining, entertainment and retail. Product manufacturers and service providers can take advantage of new technologies that Industry 4.0 brings to provide better and smarter services and products to the customers. Technologies considered to be part of the Industry 4.0 have similar feature outcomes like automation and connectivity. The connectivity between users, machines and applications is called as Internet of Things (IoT) (Davies, 2015; Szozda, 2015; Louis & Dunston, 2018).

Connectivity and automation enable companies to produce services and products in a more efficient way using digital platforms, robotics, artificial intelligence and big data which are all digitally connected, providing a highly integrated supply chain (Davies, 2015). Disruptive innovations are creating the trends and companies are looking for new solutions all the time. Full automation of the flow of materials and products in production lines creates valuable data for managing purposes (Szozda, 2015).

Increasing productivity in the supply chain

Industry 4.0 creates improvements and significant enhancements in productivity and revenue growth (Piccarozzi, Aquilani & Gatti, 2018). The speed of product manufacturing will improve. For example, models are created digitally, and the data can be transferred automatically to the production robots. According to Davies' (2015) data-driven supply chains can impact the manufacturing process by accelerating the time needed to deliver orders up to 120%.

Different products can be produced in the same factories, and even small lots can be taken into production fast and effective way. This flexibility leads to innovation because prototypes can be produced quickly. Automation of the production process, monitoring of the product throughout the production chain and use of configurable robots enable continuous optimisation (Davies, 2015).

To reach productivity benefits of IoT, organisations need to invest in modern equipment, ICT and computing skills and integrations. In some cases this can even outweigh the benefits of improved performance (Louis and Dunston, 2018).

Full visibility into the supply chain

The connected environment in the production supply chain enables companies to analyse information in real-time (Szozda, 2015). This information is valuable for streamlining the production processes and the whole supply chain. Transparency will increase the effectiveness by enhancing the collaboration between suppliers, manufactures and customers (Tjahjono et al., 2017). Customers will be able to track their orders, check availability, and even be part of the design process (Davies, 2015). This kind of flexibility may give the company a competitive advantage in its market; for example, Nike has an e-commerce service where customers can design their running shoes and order them straight to the home door.

At the same time, the customer's quality awareness level increases as well, and the demands for better service, products and customer experience is rising. Transparency in supply chains also gives increasing power to clients, providing them with additional ways to compare products and services (Willems, 2018).

Better understanding and decision making based on shared data

More than ever, end users have a willingness to share data and interact. Data and metrics provide valuable insights into customer needs and behaviours (Willems, 2018). Data analyses bring great value to companies to provide enhanced customer experience, products and services. Increased value of services and products allow companies to invest more resources to research and development and improve supply chain productivity and efficiency (Willems, 2018). Knowledge and understanding helps organisations to make a better decision regarding business strategy development (Piccarozzi, Aquilani & Gatti, 2018).

Big data and shared information also create a responsibility to handle critical data safe and secured. There is a growing need for costly expert resources in legal issues related to data processing and liability, and intellectual property management (Davies, 2015). Data protection and management, especially the processing of personal data, is strictly regulated in Europe (Wachter, Mittelstadt and Russell, 2017). Companies need also invest in cybersecurity, data capacity and secured connections (Szozda, 2015). There is also a more significant risk for reputation issues if some critical data leaks outside of the company. Companies need to be clear of the ownership of the data and the storage method. Data can include critical and confidential personal or industrial data, which cannot be leaked to the competitors (Davies, 2015).

Transformation in organisations

Robotics, automation and artificial intelligence used with other IoT technologies enhance production processes, efficiency and data management (Piccarozzi, Aquilani and Gatti, 2018). Automation reduces the need for manual labour for certain parts of the supply chain. The benefits are cost-saving in human resources in performing positions (Karandeep, 2019). Therefore, Industry 4.0 is creating fears of an irreversible technological impact on jobs (Willems, 2018).

Simultaneously companies need to hire more experts to build and maintain the sophisticated technology and to run the new business models (Davies, 2015). When the organisation is living in the digital transformation period, also the leadership is under pressure to enhance and develop to keep organisational performance competitive in accelerating changing markets (Niemi and Pekkola, 2019). Innovative thinking and excellent problem-solving skills are mandatory to achieve competitive advantages (Para-González, Jiménez-Jiménez & Martínez-Lorente, 2018).

Media Content Supply Chain: The Case of Sanoma Media Finland

Sanoma Media Finland is the leading multi-channel media house in Finland. Almost 100% of Finnish people spend time with Sanoma's print and digital media weekly (Sanoma, 2020). Sanoma provides content in their newspapers, magazines, tv and radio channels, online and mobile services. Sanoma’s broadcasting

department, Nelonen Media, operates four national television (TV) channels and Video-on-demand service Ruutu. Majority of commercial broadcasters' profit comes from tv, radio and online advertisement. Even if we tend to think that media companies produce content for audience, the gained attention is actually the product which is sold to the customer. Advertiser is the customer, not the audience.

The knowledge about Sanoma and its processes is based on meetings and interviews with Sanoma's technology and commercial leadership within the last three years.

Industry 4.0 in the media industry

Industry 4.0 is affecting profoundly in the media industry because today almost every company can be a media company. Free online video platforms, such as Youtube, Facebook, TikTok and Instagram, gives companies and individuals the possibility to create their channels and start building an audience. Media companies and broadcasters are competing for the same audience.

Television advertising revenue has been decreasing, and Internet advertising will overtake broadcast television advertising (Wayne, 2018). This is why media companies need to have a clear strategy of how to stand out from this increasing flood of video content. Most TV-companies have started to focus on online services instead of traditional TV-distribution. Media companies also need to decrease their costs in the content supply chain.

Video-on-demand (VOD)

Video-on-demand is an online video streaming service where the audience can choose what content they want to watch, when and where. Video-on-demand has enabled vertical integration for TV-companies to charge the audience for watching (Wayne, 2018). Subscription-based video on demand (SVOD) is based on monthly fees that the audience is paying for holding access to the content. When the customers can choose their content, their expectations are rising, and patience capabilities are falling. If the content they are watching is not pleasing, they will change the program or even the video service provider.

Competition between media companies has been changed, and there are new competitors in the markets. Digitalisation and online video services have enabled large service providers like Netflix, Hulu and Amazon to take market share from traditional TV-companies and broadcasters (Wayne, 2018). In Finnish local markets, the competition is between Ruutu, mtv.fi and Areena.

The content supply chain for Video-on-Demand

Video services need to provide as accurate content as possible to audience to keep the customers committed. For example, Netflix has invested heavily in the company's movie recommendation system (Hallinan & Striphas, 2016). In this point of view, the content sourcing department is the most valuable asset in the content supply chain. Licenses for content is usually sourced trough broadcast license selling companies also called as the distributors. TV-company's content sourcing department negotiates with the distributors for the

licenses to show the content in the companies' online channels. After the deal is done, the studio and the Media Management starts to discuss the media and data delivering methods. This is a time-consuming period because no industry standards for data deliveries exist.

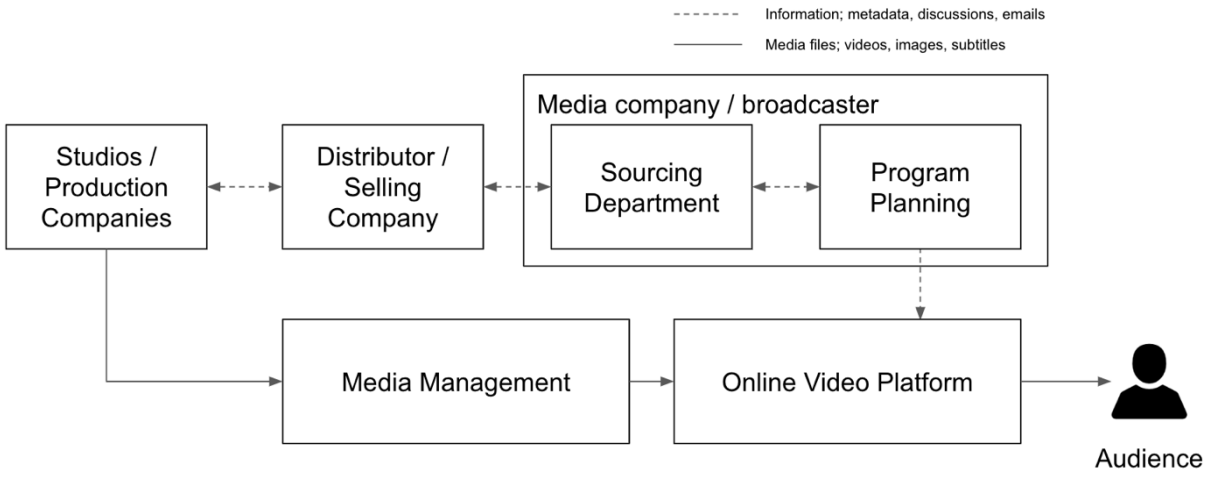

Figure 1 Media Content Supply Chain

Sourcing department needs to have extraordinary know-how on what kind of content and when the customers prefer to consume. Sourcing Department needs to have enormous databases of all available content in the world and also excellent negotiating skills and analysing tools to get good enough content at an affordable price.

Usually, content sourcing is collecting data from online video platform about customer behaviour. They have various data sources to keep up with main content trends all over the world. Data is analysed manually, and many sourcing decisions rely on the expertise of individual content professionals.

After sourcing the content, the data about the licences and publishing rights agreement will go to the Program Planning department. They need to design a schedule for publishing to maximise the views in the licensing period. In addition to estimation about upcoming program, it's target audience and it's behavioural hypothesis, the program planning department uses historical data and competitor information to schedule the publishing.

Content sourcing platform (IoT)

Content sourcing and planning can be optimised using a centralised platform to collect all the data that affects customers behaviours and watching habits. Machine learning environment combined with historical and new data would create a hypothesis about the most valuable video content and when is the best time to do the publication. Predictions about view rates can be created even before the actual sourcing.

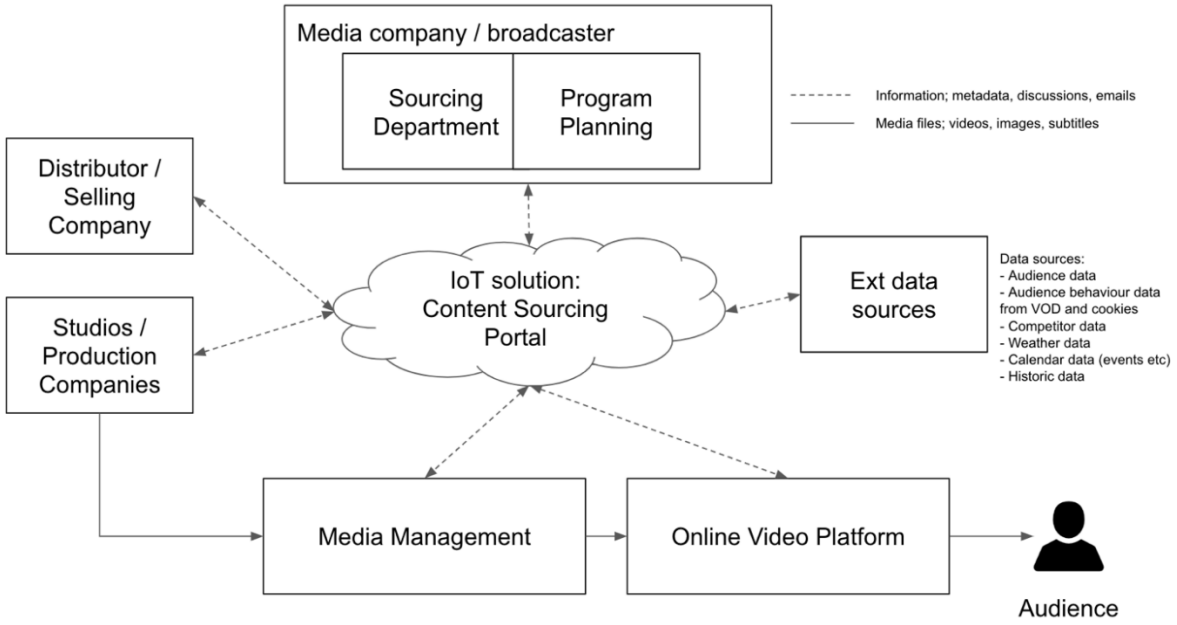

Figure 2 Media Content Supply Chain using IoT platform

Orders from the TV-company for new content could be provided automatically into the distributor's customer relation management (CRM) system and delivered to the enterprise resource planner (ERP); also, the automation of managing the actual media files would enhance more efficiency. Incoming media assets from the studios and production companies could be automatically linked to the program metadata and processing and publishing would be fully automated.

Benefits

Operational efficiency is increased when all the metadata for program assets are handled automatically in the databases and platforms. Automation reduces manual labor and risk for human errors (Davies, 2015). Also, the sourcing and planning department could be leaned down to a few because the IoT generates accurate hypothesis and predictions. Customer experience would also increase when the content sourcing is not based only on human knowledge but then overall data targeted for each audience segment.

Food Processing Business: The Case of Company X

The case company is a Helsinki-based food processing SME Company X. The company is specialised in producing and delivering raw doner kebab. Having a turnover of little under 8 million euros and employing seven people, Company X controls roughly 20% of the Finnish doner kebab market. The product portfolio of the company currently only contains doner kebab, and it does not produce or deliver any other products. Company X is organised as a limited liability company.

The main customers of Company X are the various doner kebab restaurants around Finland. The densest concentration of customers is located in southern Finland, but also central, and north Finland have several restaurants that order from Company X. The company both manufactures the products and delivers them to the premises of the customers. The company has grown its customer base over the last five years but faces heavy competition both from local manufacturers as well as those importing doner kebab from abroad. The main competitive advantages of Company X have been its excellent quality, reasonable price, and good delivery system.

An author of this text has worked for the company. The knowledge here is based both on direct experience as well as on studying the entire supply chain of the company as part of the previously held job.

Introducing Industry 4.0 concepts to the supply chain of Company X: A Scenario

In here, first the current state of Company X's supply chain will be presented. After this, a scenario will be developed its in which the concepts and technologies of Industry 4.0 are applied to Company X's supply chain to propose improvements to operations. Company X is currently suffering from both slowness in manufacturing, relatively high labour costs, as well as high spoilage rates. The slowness in manufacturing is associated with old machinery, i.e., lack of automation and slow rate of information exchange. This also leads to spoilage, as the meat processing systems are entirely operated by hand, which causes problems with precision regarding the amounts of ingredients, possibly leading to a suboptimal product. Furthermore, as the rate of automation is negligible, the labour costs are relatively high. The need for human hands in the production process is significant, as all of the machines need to be filled and emptied by hand and monitored by humans. Furthermore, the current supply chain suffers from slowness of information exchange. The raw materials are always ordered when the stocks are running low; there is no automatic data transfer system that would alert the raw material suppliers that replenishment is needed. This has led to situations where the raw materials stocks have run dangerously low. Similarly, the orders from customers are recorded by hand, since there is no automated system which they could use to place orders.

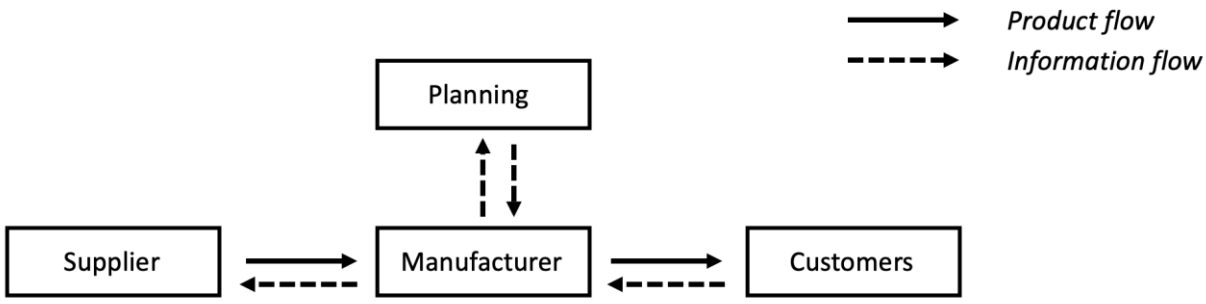

Figure 3 Company X supply chain, modified from Szozda (2017)

To address all of these problems, several smart digital solutions, including investments in new machinery, could be made. The first thing is to automatise the production of the doner kebab meat. This is

done by procuring machinery which can operate with a high degree of autonomy; the only thing that is needed to be done by a human should be to pour in the raw materials with a pallet truck and start the process through a digital interface. The machines should be compatible with the IoT. This would enable automated production monitoring, as well as monitoring the quantities of raw materials used; there would no longer be any need for humans to observe whether the meat mass has reached the desired consistency as the machines are to be programmed to complete the production cycle automatically. The investment in these new machines would lead to a higher manufacturing capacity thanks to more efficient production cycles due to the reduction in need of human interaction. Furthermore, there would be less spoilage thanks to the greater precision of the automatic machine monitoring. Due to these improvements, the labour costs and spoilage rates would go down while the production efficiency could be significantly improved along with the overall quality of the product. Higher quality would also reduce the number of complaints and increase customer satisfaction; there would be a decrease in the need to give discounts due to faulty products which would further increase the profits.

A further positive development would be that thanks to the digital data streams collected from the machines, the production could be optimised by analysing the individual task times (such as filling up the machine, storing away and freezing the ready product, moving the products to trucks) and by creating a new workflow based on the most opportune times to complete each task. As the machines would be running the whole day, it would be a significant improvement that the entire working time could be utilised to manufacture new batches. Currently, there are delays due to suboptimal workflow planning and outdated machines, as well as because of the heavy reliance on human labour.

Also, the introduction of more centralised data collection could help in managing the inventory; by looking at previous data, the changes in demand could be anticipated better. This way, the stock could be kept at an optimal level, reducing possible losses due to spoiling. Also, more automated inventory management would eliminate the need to keep the inventory information up to date by hand, which is currently the case; this would both saved work and make sure that the oldest batches would always be sold first. Also, by automatizing the raw material stock monitoring, the supplier could be automatically informed through a shared cloud service that there would soon be need for replenishment. The customers as well could be let into the cloud service to place their orders. This data could be instantaneously fed into production planning systems which would calculate the production need; something which currently is completed entirely by humans.

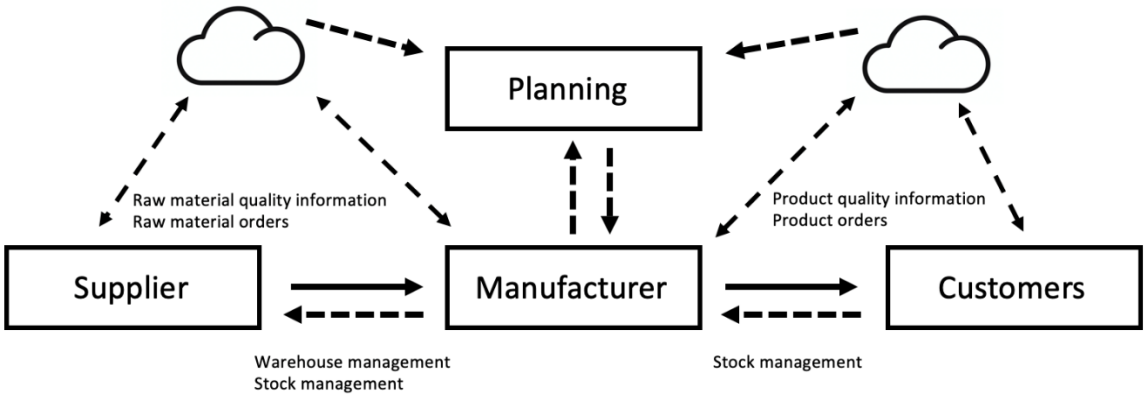

Figure 4 Company X supply chain with Industry 4.0 implementation, modified from Szozda (2017)

The introduction of above-mentioned technologies would increase both the profit margin as well as customer satisfaction. Higher quality, reduced spoilage and waste, and reduced labour costs thanks to automation and better work planning would all contribute positively to the future financial performance of Company X.

Limitations

Connected supply chain requires that all parts in the supply chain have a contemporary architecture software to control their operations. In the media industry, there are a large variety of companies of different sizes and with unique processes. IoT solution requires the enforcement of all the stakeholders to upgrade their systems to provide interfaces and data sharing functions according to predefined standards.

Megatrends in the world drive customers behaviour in the ocean of digital video content. Watching habits can change so fast that automation might not be able to collect and analyse enough relevant data to make long term hypotheses.

Conclusion

Industry 4.0 is an ongoing revolution and is affecting profoundly also in the media industry. TV-companies are facing continuous transformation and challenges with keeping their positions in competition with the world's leading online video services, and also the individual content creators. Media companies need to publish accurate content for their audience in a cost-effective way. Using Industry 4.0 technologies, media companies can take advantage of knowing the consuming habits of the audience. Using available data for building automated content supply chain would decrease the costs and increase the accuracy of content popularity (Hallinan and Striphas, 2016).

Industry 4.0 technologies enable companies to remain competitive, but at the same time, they require a complete transformation in the organisations. New kind of know-how needs to be increased, and business models and organisational units need to modify to face the new requirements. New technologies need to be

tested and evaluate with new experts or technology partners. Transformation also requires that every stakeholder in the content supply chain commits to the new standards.

The Fourth Industrial Revolution is changing the manufacturing sector. However, its entire impact will only unfold in the coming years, as it in many ways remains largely unexplored as pointed out by Szozda (2017). Yet, many of the technologies vital to Industry 4.0 can already be implemented in various contexts.

In the case of Company X, the Industry 4.0 aspects would substantially help to push the company in the right direction. Automated manufacturing processes, data gathering from machines for remote monitoring via the IoT, and more automatic inventory and order management could help to cut costs and reduce spoilage, while simultaneously improving the quality and increasing the output. All this would ultimately lead to improved financial performance.

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A New Supply Chain and Sustainable Development Mechanism of Guangdong under the Framework of RECP

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Abstract

This article takes the theory of regional economic development as the research perspective and uses relevant economic indicators to analyze the differential performance of the coordinated development of the regional economy in Guangdong Province under the RCEP framework from two aspects, including static and dynamic aspects. Subsequently, the regional economic development in Guangdong Province is analysed, in terms of its industrial layout of the coordinated economic development, logistics and transportation network. Secondly, based on the regional economic theory, this paper further analyses the crux of the uncoordinated regional development of Guangdong Province, and finally put forward the countermeasures and suggestions to promote the coordinated development of Guangdong Province. This paper is to strengthen and consolidate the interconnection of regional supply chains, promote institutional opening, improve the level of trade and investment facilitation, form a regional economic layout with complementary advantages and high-quality development, which is the core hub of RCEP, together with accelerating the high-quality development of East Asian economies, and promoting China's domestic and international with construction of a new dual-cycle development pattern.

Keywords: Sustainable Development, Institutional Mechanism, Industrial Supply Chain, Regional Economic Theory

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Introduction

This paper mainly studies the coordinated development of Guangdong, China, which is located at the core of the geographic scope of the RCEP Free Trade Zone. Firstly, the growth pole theory, sustainable development theory, gradient transfer theory and other related theories of regional economic development were combed, laying a theoretical foundation for the full context of the current study. Secondly, based on the Guangdong Provincial Statistical Yearbook data, the comprehensive development process of the regional economy was analysed, by virtue of statistical description and analysis of the main economic indicators of Guangdong Province's GDP, GDP per capita, disposable income of urban residents per capita, as well as disposable income of rural residents per capita, so as to explore the dynamic evolution trend of development differences. Thirdly, this paper summarized the industrial layout and characteristics of the logistics and transportation network of the regional economic development in Guangdong Province, in terms of analysing the location resources, economic policies, technological innovation, industrial structure and other factors that affect the coordinated development of Guangdong Province, aiming to break through the development bottleneck, and thus make up for the shortcomings of the industry with an effective path. Finally, a path was proposed for the coordinated development of the regional economy in Guangdong Province from the aspects of taking advantage of Guangdong Province's "dual-node" location, digital economy & speed economy, as well as strategic industrial clusters.

Thanks to the past 4 decades of reform and opening up policy, Guangdong's economy has rapidly developed, in that its comprehensive economic strength has ranked first in the country, and its economic aggregate has ranked first in the country for 32 consecutive years. However, at the same time, the development of various regions in Guangdong Province has shown great imbalance and uncoordinated development, which is manifested in the continuous expansion of the development gap between regions at the spatial level, as well as the unsustainable regional economic development mode at the time level. The issue of regional economic incoordination has gradually become an important factor restricting both of the economic and social development of Guangdong Province. Guangdong Province, the vanguard, bridgehead, pioneer area, and demonstration area of China's reform and opening up zone, is located at the "dual node" of the "Belt & Road" initiative and the new development pattern of the Guangdong-Hong Kong-Macao Greater Bay Area, so some vital issues are followed to be addressed, namely, how to seize the RCEP opportunities to promote coordinated regional economic development, enhance high-quality economic development, give full play to advantages, make up for shortcomings to seize opportunities, and how to deeply participate in the "Belt and Road". All those items are really worthy of our thinking and exploration.

There are many domestic and foreign studies on the mechanism and system of the coordinated development of regional economy. From the perspective of the research objects, there are studies mainly exploring the coordinated economic development mechanism between different regions of the whole country and between different regions within a certain region. For example, Xu (2018) studied the coordinated development mechanism of China's regional economy and concluded that we shall start with the economic operation mechanism for overall planning to promote the coordinated development of regional economy.

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Burenmende (2015) discussed the coordinated development of China's regional economy, coming up with the basic path and the long-term construction mechanism. Li (2018) discussed the influencing factors of the coordinated development of regional economy, and proposed the construction of regional economic coordination from the three aspects of optimizing the market competition mechanism and establishing the regional economic coordinated development mechanism. The second kind of research is to study the mechanism and path of the coordinated development of a certain industry and the regional economy. For example, Guo and Xu (2016) analyzed the influencing factors of the coordinated development of regional economy and technology finance, putting forward the idea of constructing a coordinated development model of regional economy and technology finance. She (2015) studied the region of Shandong Province concerning the relations between the policy of coordinated economic development and industrial proliferation. It is believed that the policy of coordinated development of regional economy should focus on “people” rather than “things”. Ng et al. (2016) analyzed innovation to promote inclusion in Southeast Asia, of which results showed that the regional coordination mechanism casts a huge potential role on development. From the perspective of research methods, some research studied the mechanism of coordinated development of regional economy via constructing an evaluation index system. For example, Wei (2018) systematically discussed the mechanism of coordinated development of China's regional economy from the aspects of the connotation, dynamic mechanism and evaluation indicators, standards and quantitative methods of the coordinated development of regional economy. Zhang et al. (2018) constructed an index system to study the coordinated development of the regional economy in Jiangsu Province from the three aspects of economic relations Intensity, overall economic efficiency, and economic development gap, so as to explore its dynamic mechanism. Zhang (2013) used a non-parametric DEA analysis method to study the Yangtze River Delta region, exploring the mechanism of economic convergence in terms of material capital accumulation, efficiency improvement, technological progress and human capital investment.

In recent years, with the development of economic globalization and economic integration, scholars have done more research on the coordinated development of regional economy. Yet, most of the existing relevant research literatures are focusing on the framework of RECP, with limited studies concerning the comprehensive, multi-level, and systematic analysis of the coordinated development of regional economy under the framework of regional economic theory. Besides, there are many documents that study the coordinated development of inter-regional economies while not many ones that study the coordinated development of the internal economy and relevant studies on the regional coordinated development of Guangdong Province in particular are very few, especially those taken into account Guangdong’s comprehensive strength of the research economy ranks in the forefront of China, and its important position in the cooperation framework. Third, there are relatively many documents to study the coordinated development of regional economy from the establishment of an evaluation system to measure the degree of regional development coordination, while the research on the unsustainable regional economic development mode from the static index analysis of the spatial level and the dynamic evolution analysis of the time level is so limited.

This paper mainly discussed the following three issues: First, based on the growth pole theory of regional economic development, sustainable development theory, gradient transfer theory and other related theories, it explored the connotation of the coordinated development of regional economy in the new era. Second, based on the statistical yearbook data of Guangdong Province, it conducted the static index analysis and explored the dynamic evolution trend of the coordinated development of the regional economy in Guangdong Province, followed by analysis of the factors that affect the coordinated development of the regional economy in Guangdong Province. Third, by combining the status quo of economic development in Guangdong Province, it studied the institutional mechanisms and effective paths to break through the development bottleneck and make up for the shortcomings of the industry.

The high-quality economic development of Guangdong Province is not only hinged on the total economic volume and its growth, but also includes the multi-dimensional measurement of economic efficiency, structure, stability, and sustainability. It is an evolutionary development under the coordination of both of the quantity and quality. The coordinated development of the regional economy is conducive to stimulating the new vitality of the open economy in Guangdong Province, promoting the rational flow and efficient agglomeration of elements, enhancing the motivation for innovation and development, promoting institutional opening, forming a regional economic layout with complementary advantages and high-quality development, and forming an economic globalization ultimately. Therefore, Guangdong Province shall seize the new opportunities brought by RECP, by innovating systems and mechanisms, to promote the coordinated development of the regional economy, accelerate the transition from rapid scale expansion to improved development quality and efficiency, so as to become the core hub of RCEP to promote China's construction of a new development pattern in terms of domestic and international "dual cycle".

Literature Review

Growth Pole Theory

The growth pole theory was first proposed by French economist Francois Perroux in 1950. The theory holds that economic development relies on regions with better conditions and strong innovation capabilities, large-scale, and dominant propelling & leading industrial sectors. Therefore, regions with better conditions and advantageous industries shall be turned into economic growth poles. The formation of growth poles tend to become and serve as the centre of regional economic growth. Although the economically underdeveloped places have abundant natural resources, their economic development is mostly in the primary stage of primary industry and manufacturing due to poor technical foundation, underdeveloped transportation, scattered population, and low degree of urbanization. Through the continuous development of the growth pole, the acceleration of the flow of commodities and resource elements will not only enable the economic development of the region, but also spread out via various channels, thereby driving the economic development of the surrounding regions. Hence, with the guidance of the growth pole theory, the essential process of regional development functions as the key of regional polarization and diffusion, and the method of regional planning is to promote the intensification and diffusion of regions with advantages in location and resource endowments.

Many scholars, recently, have used the growth pole theory to study regional economic policies. For example, Azizova et al. (2019) held that, in the process of inter-regional cooperation, the formation and effective operation of "growth points" were key tools for regional development policies. When resources and opportunities were limited, the possibility of applying the theory of "growth poles" was getting bigger. Rauhut and Humer (2020) studied EU cohesion policy and spatial economic growth, and their results suggested that there was a great overlap with Perroux's "growth pole theory". Xiang and Song (2017), studied the optimization of China's counterpart support policy based on the growth pole theory. In addition, many scholars used the growth pole theory to conduct research on industry-related issues. For example, Li and Sun (2017) studied the cultural industry development strategy of the Jingchu cultural circle based on the growth pole theory. Lee (2016) used the growth pole theory to analyze the social and cultural influence factors of tourism development.

Literatures above uses the Growth Pole Theory to propose relevant policies, development models, together with implementation paths, with a view to promoting economic growth in poverty-stricken areas from different angles and levels, which is conducive to the formation of inter-regional logistics integration & industrial agglomeration linkage, the promotion of the development of regional industrial chain clusters, as well as building a regional industrial linkage development pattern of "dislocated competition, point-to-face linkage, and complementary advantages".

Sustainable Development Theory

Sustainable Development Theory, taking fairness, sustainability, and commonality as its three basic principles, refers to development that not only meets the needs of contemporary people, but does no harm to the ability of future generations to meet their needs. In his book "Economy, Natural Resources: Deficiency and Development", Edivard B. Barbier defines sustainable development as "on the premise of maintaining the quality of natural resources and the services they provide, maximizing the net benefits of economic development." D-Pearce holds: "Sustainable development means that today's use should not reduce future real income", and "when development can maintain the welfare of the present generation, it will not reduce the welfare of future generations."

The theory of sustainable development is widely used in economics-related research, mainly including: those that studied the sustainable development planning and principles of the area, such as: Brais et al. (2019) put forward the operational principle of combining the sustainable development theoretical goals within the sustainable development framework with the actual implementation strategy. Zhang and Xiao (2019) took the Zhoushan Islands in eastern China as an example to study the island's sustainable development planning. Others built a sustainable development model to study the coordinated development of regional economies. For example: Li et al. (2019) constructed a regional agricultural sustainable development evaluation system based on the five elements of economy, society and environment. Empirical analysis was conducted and found that the level of sustainable agricultural development in Chengdu has been increasing year by year. Gong et al. (2019) established a measurement model of urban sustainable development, and studied the urban evolution trend of Chengdu of China, followed by measuring its coordinated development, and concluded that the

development level of the city has been continuously improved, and the coordination has continued to improve. Deng et al. (2017) have constructed an evaluation index system for economy, society, technology, resources and environment, and conducted an empirical analysis on the data of Sichuan Province from 2005 to 2015, of which results showed that the sustainable agricultural development system of Sichuan Province was moving towards a more orderly system.

It can be clearly seen that the sustainable development theory lays a theoretical basis for the study on the coordinated development of the regional economy. By virtue of applying the sustainable development theory, we can conclude that we shall focus on the sustainable, stable and healthy development of the "nature-economy-society" complex system in the aspect of economy. Quantitative growth is quite limited in that only on the premise of maintaining the quality of natural resources and their lasting supply capacity, relying on scientific and technological progress to improve the efficiency and quality of economic activities, can the Pareto optimality of resource allocation be truly achieved.

Gradient Transfer Theory

The gradient transition theory, originated from the Product Life-Cycle Theory, was proposed by Vernon L. Smith. The theory believes that each country or region is in a certain stage of economic development, and there are differences in innovation activities in different stages of economic development, which determines that regional development at a different level of gradient. High-gradient regions are highly innovative, which makes industries, labor, capital and other factors diffuse and transfer from high-gradient areas to low-gradient areas over time, and this gradient transfer process is mainly expanded through a multi-level urban system.

Gradient transfer theory, emphasizing the priority of efficiency and taking into account the fairness, actually provides corresponding guiding policies for the optimization of industrial structure, transfer and upgrading, and development mode in the region. The theory has achieved good results in practice. In the research of relevant literatures, the great majority of scholars, based on the law of unbalanced development, through the study of the differences in economic development conditions and levels of economic growth, from the perspective of industrial structure adjustment, transfer and upgrading, etc., have analysed industries and factors from high gradient to low gradient transfer, thereby driving the economic development of underdeveloped areas. Under the guidance of this theory, China's reform and opening up took the lead in opening up the coastal areas, and adhered to the development strategy of bringing the rich first, and China’s economy has maintained a sustained high-speed growth for more than 3 decades, forming a miracle in the history of world economic development. Yet, gradient transfer theory also has its very own limitations, mainly due to the fact that it cannot divide the gradient scientifically, and it is easy to widen the development gap between regions in practice. Besides, it ignores the fact that there exist underdeveloped areas in those with high gradients, and relatively developed areas in backward ones. Simply fixing the development positioning of areas with different gradients is likely to lead to further widening of the gap, making developed areas more advanced and backward areas less developed.

Research Methods

Methods

Literature research method

It sorts out and integrates the existing literatures, and qualitatively analyzes the objectively existing regional differences and the situation of regional coordinated development in Guangdong Province on this basis, laying a theoretical foundation for the thesis.

Comparative analysis method

By comparative analysis method, this paper conducted a comprehensive comparative analysis on the unbalanced economic development of 21 cities in Guangdong Province, based on the statistics of Guangdong Province Statistical Yearbook, and from the perspectives of GDP, GDP per capita, disposable income of urban residents per capita, disposable income of rural residents per capita, etc.

Dynamic and static analysis method

First, analyzing the gaps in GDP, industrial structure development and urbanization levels between cities in Guangdong Province from the perspective of static analysis. Second, introducing time variables and using the weighted coefficient of variation, GDP growth rate, GDP per capita growth rate and other indicators to analyze Guangdong Province in terms of spatial difference of the level of coordinated development of regional economy and the evolution trend in the time dynamics.

Data sources

The original data comes from the China Statistical Yearbook (2001-2021), Guangdong Provincial Statistical Yearbook (2001-2021), and Guangdong Provincial Statistical Yearbook (2001-2021) for 21 prefectures and cities. Part of the index values were obtained through secondary calculations. For the missing data of very few years, the interpolation method is adopted.

Results and Discussion

Guangdong Province's total GDP has grown rapidly, leading for 32 consecutive years in China, surpassing more than 90% of countries such as Russia, South Korea, Australia, and Spain. Yet, the gap among eastern, western and northern wings of Guangdong and the Pearl River Delta region has always been huge and hard to cover. Especially compared with the three other major economic provinces of Zhejiang, Jiangsu, and Shandong in China, the gap between the rich and the poor in Guangdong Province is particularly large.

According to the differences in economic development level, location conditions, and three industrial structures among regions within the province, Guangdong can be divided into 4 regions, namely, the Pearl River Delta, Eastern Region, Western Region and Northern Region (Also known as Mountainous Region), which can be shown in Table 1:

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Table 1 Regional division of Guangdong Province

Region	Municipal city	Number of administrative districts
Pearl River Delta	Guangzhou, Shenzhen, Zhuhai, Zhongshan, Dongguan, Foshan, Jiangmen, Huizhou, Zhaoqing	9
Eastern	Shanwei, Jieyang, Shantou, Chaozhou	4
Western	Zhanjiang, Maoming, Yangjiang	3
Northern	Shaoguan, Meizhou, Qingyuan, Heyuan, Yunfu	5

Static analysis of coordinated development of regional economy in Guangdong Province

Analysis of inter-regional GDP differences and relevant changing trends

The two-level differentiation of economic aggregates between municipal cities in Guangdong Province has further intensified. Guangdong's GDP in 2020 year was 11,076.094 billion Yuan, being the only province in the country which exceeded 11 trillion yuan, and its nominal growth rate was as high as 924.6%. In 2020 year, the GDP of the Pearl River Delta, Eastern Guangdong, Western Guangdong and Northern Guangdong was 8,952.392, 705.351, 773.997, and 644.354 billion Yuan, respectively. GDP of the Pearl River Delta accounted for 80.8% of the province's GDP, and the area of Eastern, Western and northern Guangdong accounted for 70% of the province, GDP only accounted for 19.2% of the province's GDP. Among the 21 cities in Guangdong Province, Qingyuan, Yangjiang, Shaoguan, Meizhou, Shanwei, Heyuan, Chaozhou and Yunfu had a GDP of less than 200 billion yuan, all of which fell on the eastern, western and northern regions of Guangdong. After the long-term GDP of Yunfu City exceeded 100 billion, this was about 28 times different from that of Shenzhen City with the highest economic aggregate. In contrast, Jiangsu Province, of which GDP closely following Guangdong Province, had 4 cities of trillion-dollar value in 2020 year (compared to 3 cities in Guangdong). Suzhou, which has the highest economic aggregate in 2020 year (2,017.05 billion Yuan), was with an only about 6 times gap with the city of Suqian, 326 billion Yuan, of which GDP ranked the lowest in the province. As shown in Figure 1, compared with 2000 year, the gap between the GDP of most cities in eastern Guangdong, western Guangdong, and northern Guangdong in 2020 year and the largest Shenzhen city in 2020 year has been widening, not only in the absolute value of the total economic gap between municipal cities, but the relative gap is also getting bigger and bigger. In 2000 year, the GDP of 8 cities was less than 10% of the first ranking, and as many as 10 cities in 2020 year. In short, the agglomeration capacity of the Pearl River Delta is very strong, the siphon effect is too strong, excellent talents, funds and other elements are concentrated in the Pearl River Delta, and the uneven development of the province's regions is very huge.

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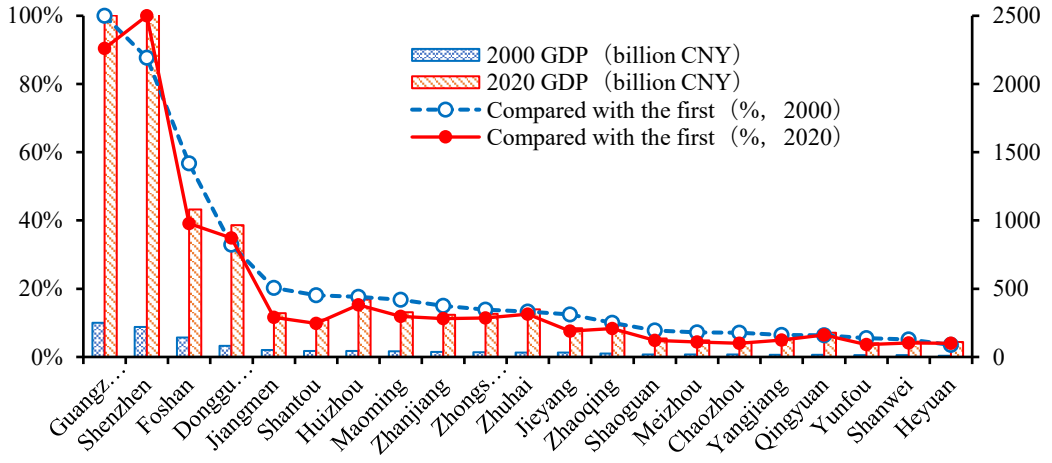

Figure 1 Differences and changes in the total GDP of 21 cities in Guangdong

Analysis of regional differences in per capita GDP and relevant changing trends

The gap of GDP per capita in Guangdong Province is shrinking, yet signs of "polarization" still exist. In 2020 year, Guangdong's per capita GDP is 96,138 Yuan, and the national GDP per capita was 72,371 Yuan, with Guangdong Province ranking the 6th. GDP per capita of the six cities of Chaozhou, Yunfu, Shanwei, Heyuan, Jieyang, and Meizhou was 50% lower than the provincial average, while the five cities of Shenzhen, Zhuhai, Guangzhou, Foshan and Dongguan are higher than the provincial average. Figure 2 shows that, compared with 2000 year, the gap between the GDP per capita of most cities and the province's first place has been shrinking, whereas the gap is still very large, and the problem of uneven regional economic development still exists. In 2020 year, Shenzhen ranks first in GDP per capita, with a GDP per capita of 157,575 Yuan. Zhuhai, Guangzhou, Foshan and Dongguan are those only cities with GDP per capita reaching the first half of Shenzhen, and there are even 9 prefecture-level cities whose GDP per capita is less than 30% of Shenzhen. It can be seen that there are still signs of "polarization" in the distribution of urban economic levels, and the trend is not optimistic.

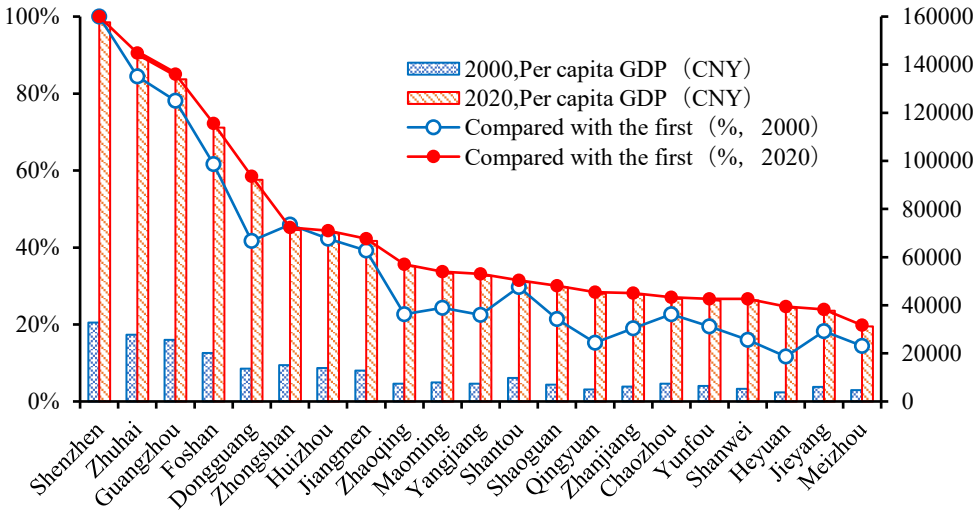

Figure.2 Differences and changes of GDP per capita in 21 cities in Guangdong

Analysis of the difference in residents' income among regions and relevant changing trends

In 2010 year, the disposable income of urban residents per capita in Guangdong Province and the disposable income of rural residents per capita were 412.13 and 193.25 Yuan, respectively, and in 2020 year they were 50,257.0, 20143.4 Yuan. In 2020 year, the disposable income of urban residents per capita in the Pearl River Delta, Eastern Guangdong, Western Guangdong, and Northern Guangdong were 59,225.1, 29,622.2, 31,971.0, 31,095.7 Yuan, and the disposable income of rural residents per capita were 26,856.5, 17,357.1, 19,267.8, and 17,698.0 Yuan, respectively. As shown in Figures 3 and 4, from the perspective of each prefecture-level city, the absolute value of urban residents' per capita disposable income has increased significantly, but the relative value has not declined significantly. Rural residents' per capita disposable income, which has shown large growth rate of absolute value, and the relative value gap has narrowed significantly.

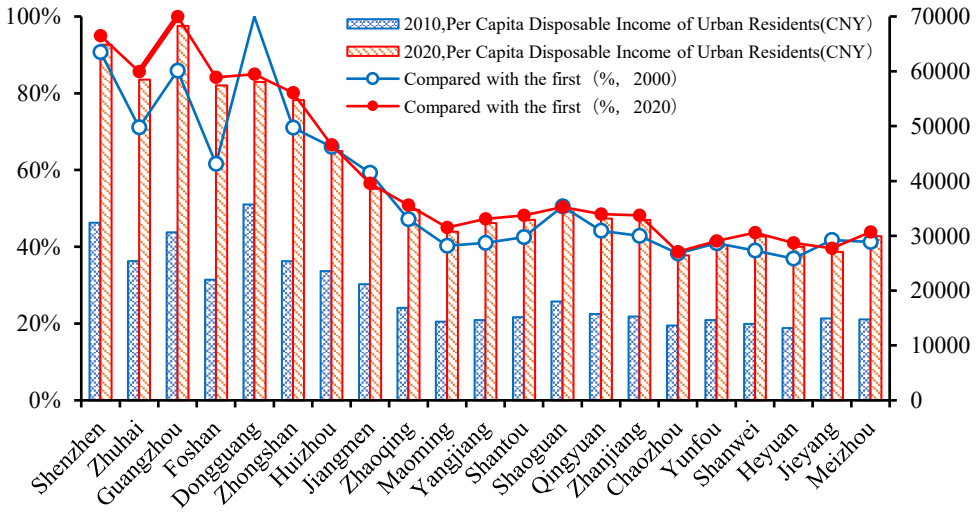

Figure 3 Changes in the differences in the per capita disposable income of urban residents in 21 cities in Guangdong

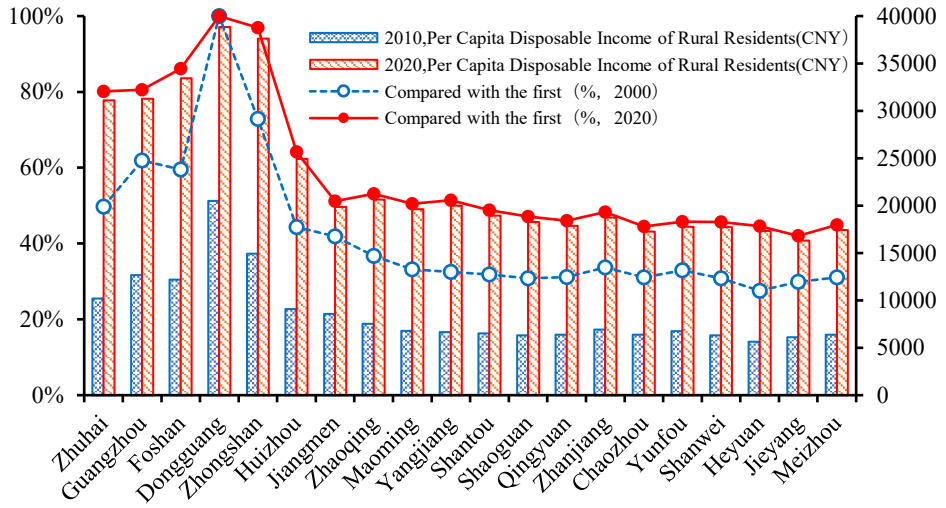

Figure 4 Changes in the differences in the per capita disposable income of rural residents in 20 cities in Guangdong

Dynamic analysis of coordinated development of regional economy in Guangdong Province

Static analysis is mainly a comparative analysis performed at a certain time node and cannot be analysed from a long time span. Therefore, there are certain limitations in measuring development trends. Hence, we introduced time variables to conduct a dynamic analysis of the status quo of the coordinated development of regional economy in Guangdong Province over a long time span.

Analysis of Coefficient of Variation

Analyse the dynamic evolution by calculating the coefficient of variation (CV).

$$\mathrm{CV} = \frac{\sigma_i}{\mu_i} \times 100\% \qquad (1)$$

Among them, σ_i represents the standard deviation of indicators in different regions in the i-th year, and μ_i represents the average value of indicators in different regions in the i-th year.

It can be seen from Figure 5 that the coefficient of variation of GDP among the 21 cities in Guangdong Province fluctuates roughly in the range of 70%-82%. On the whole, the coefficient of variation of GDP has shown a downward trend in fluctuations, indicating that the gap in economic development between cities in the province is gradually narrowing.

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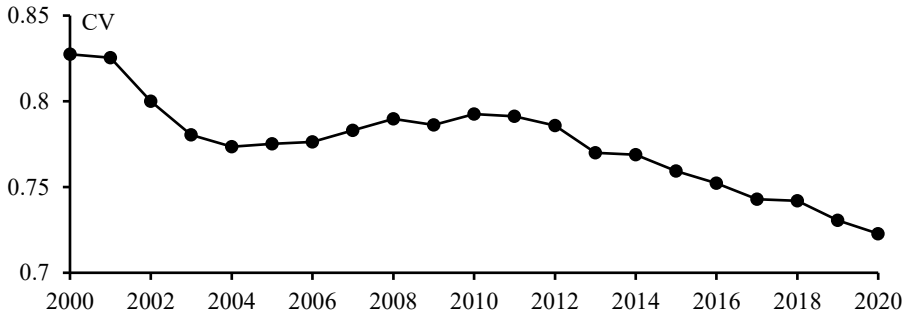

Figure 5 Coefficient of variation trend of GDP from 2000-2020 year

Location analysis

Using 2000 year as the base period and 2020 year as the reporting period, the GDP growth rate and per capita GDP growth rate are used to calculate the economic development center of Guangdong Province. The data collection results are shown in the table 2.

Table 2 The regional orientation of 21 cities in Guangdong province GDP growth

(billion CNY)

Region	2000 Year	2020 Year	GDP Growth Value	Growth multiple
Guangdong	1074.13	11076.09	10001.97	9.31
Guangzhou	249.27	2501.91	2252.64	9.04
Shenzhen	218.75	2767.02	2548.28	11.65
Foshan	141.51	1081.65	940.14	6.64
Dongguang	82.03	965.02	882.99	10.76
Jiangmen	50.47	320.10	269.63	5.34
Shantou	45.02	273.06	228.04	5.07
Huizhou	43.92	422.18	378.26	8.61
Maoming	41.74	327.93	286.20	6.86
Zhanjiang	37.38	310.02	272.64	7.29
Zhongshan	34.54	315.16	280.62	8.12
Zhuhai	33.24	348.19	314.96	9.48
Jieyang	31.11	210.21	179.11	5.76
Zhaoqing	24.98	231.17	206.19	8.25
Shaoguan	19.27	135.35	116.08	6.02
Meizhou	18.05	120.80	102.75	5.69
Chaozhou	17.79	109.70	91.91	5.17
Yangjiang	16.02	136.04	120.02	7.49
Qingyuan	15.79	177.72	161.92	10.25
Yunfou	13.77	100.22	86.45	6.28
Shanwei	12.85	112.38	99.53	7.75
Heyuan	8.77	110.27	101.50	11.57

It can be seen from Table 2 that from 2000 year to 2020 year, all cities in Guangdong Province that are close to or higher than the province's average GDP growth rate are Shenzhen, Dongguan, Zhuhai, Qingyuan, Heyuan, and Guangzhou. The province's average GDP growth Value is 476.284 billion yuan. The cities that are higher than the provincial average are Guangzhou, Shenzhen, Foshan and Dongguan. Therefore, when GDP is used as a measurement indicator, only Shenzhen, Guangzhou, and Dongguan meet the province's economic development centers. Shenzhen's economic foundation and location conditions determine its central position and have an advantage in development speed.

Table 3 The regional orientation of 21 cities in Guangdong province per capita GDP growth

(CNY)

Region	2000 Year	2020 Year	Growth Value	Growth multiple
Guangdong	12735.66	96138	83402	6.55
Guangzhou	25626	134000	108374	4.23
Shenzhen	32800	157600	124800	3.80
Foshan	20231	113900	93669	4.63
Dongguang	13679	92200	78521	5.74
Jiangmen	12851	66700	53849	4.19
Shantou	9741	49600	39859	4.09
Huizhou	13877	69900	56023	4.04
Maoming	7981	53100	45119	5.65
Zhanjiang	6231	44400	38169	6.13
Zhongshan	15077	71300	56223	3.73
Zhuhai	27693	142700	115007	4.15
Jieyang	6001	37700	31699	5.28
Zhaoqing	7422	56200	48778	6.57
Shaoguan	7028	47400	40372	5.74
Meizhou	4728	31200	26472	5.60
Chaozhou	7444	42700	35256	4.74
Yangjiang	7377	52300	44923	6.09
Qingyuan	5003	44800	39797	7.95
Yunfou	6399	42000	35601	5.56
Shanwei	5262	42000	36738	6.98
Heyuan	3826	38900	35074	9.17

Analysis of the regional industrial layout of Guangdong Province

According to Table 3, Zhaoqing, Qingyuan, Shanwei, and Heyuan have higher per capita GDP growth rates than the provincial average, but Shenzhen, Zhuhai, Guangzhou, and Foshan where per capita GDP growth is higher than the provincial average. Although the per capita GDP of Zhaoqing, Qingyuan, Shanwei, and Heyuan has grown rapidly, the economic foundation is relatively weak, and the per capita GDP growth is only 1/2 of the provincial average, which still cannot have a significant impact on the province's economic growth. Therefore, according to the analysis of location orientation, Shenzhen, Zhuhai, Guangzhou, and Foshan

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are still in line with the province's economic development centers.

On the whole, from 2000 year to 2020 year, the cities that constitute the regional economic development center of Guangdong Province are represented by Shenzhen, Guangzhou, Dongguan, Zhuhai, and Foshan in the Pearl River Delta, which is ahead of Eastern Guangdong, Western Guangdong and Northern Guangdong.

Analysis of the regional industrial layout of Guangdong Province

With the rapid economic development of Guangdong Province, the differences between regions are also expanding. The industrial structure of the Pearl River Delta, Eastern Guangdong, Western Guangdong and Northern Guangdong has different priorities in the industrial structure. From the perspective of the industrial structure of various regions in Guangdong Province in 2020 year, the ratio of the first, second, and tertiary industries in the Pearl River Delta, Eastern Guangdong, Western Guangdong, and Northern Guangdong is: 1.6:41:57.4, 8:43:49, 18: 34:48, 15:33:52. It can be seen that in the primary industry, eastern Guangdong, western Guangdong, and northern Guangdong are much higher than the Pearl River Delta. In the secondary industry, the Pearl River Delta and eastern Guangdong are not much different, while western Guangdong and northern Guangdong are basically the same. Among the tertiary industries, the Pearl River Delta is farther away, being higher than that of Eastern Guangdong, Western Guangdong and Northern Guangdong. The above data shows that the Pearl River Delta, relying on its location factors, economic foundation, national policies and other factors, has a large proportion of the tertiary industry, and the modern service industry is relatively complete.

Affected by differences in resource endowments, distinctive economy, comparative advantages, etc., the cooperation benefits of the Pearl River Delta, Eastern Guangdong and Northern Guangdong are not yet obvious, and the industrial chain needs to be restructured, built and integrated. From the perspective of the context of the industrial chain, the mountainous areas of northern Guangdong and the east and west wings provide part of the basic agricultural and sideline industries, raw materials, and primary products. While the Pearl River Delta region provides most of the final consumer products of light and heavy industries. In other words, there is only a fairly loose supply chain of the preceding and following industries in the Pearl River Delta and other regions. We can confirm this from the regional industrial layout of Guangdong Province.

Guang-Fo-Zhao (Guangzhou-Foshan-Zhaoqing) metropolitan area has significant industrial development levels, clear division of labor, and high-end services gathering and sharing. Guangzhou has formed a structure of "service center + large-scale park". The productive service industry is concentrated in the central city, and advanced manufacturing is concentrated in the park. Foshan has formed a structure of "professional town + park", traditional manufacturing has formed many specialized town clusters, and advanced manufacturing Industry is also concentrated in the park. Zhaoqing is dominated by a "park + villages and towns" structure, the manufacturing industry is mainly concentrated in advantageous locations such as high-tech zones, and the peripheral villages and towns are dominated by traditional industries. The industrial development pattern of Shen-Guan-Hui (Shenzhen-Dongguan-Huizhou) metropolitan area shows a significant

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radiating effect of Shenzhen, and the evolution of the internal industrial structure and industrial division of labor has been significantly adjusted. The industrial spatial layout of the metropolitan area has changed from a typical "road economy" to “Shen-Guan-Hui on the track”. Cross-border regional key platforms and leading enterprises have become important nodes supporting the integrated development of regional industrial networks. Zhu-Zhong-Jiang (Zhuhai-Zhongshan-Jiangmen) metropolitan area has shown a trend of evolving from homogeneous competition and decentralization to a characteristic division of labor and service sharing integration. Manufacturing is still the main type of industrial agglomeration, and the industrial spatial layout is relatively obvious characteristics of cluster agglomeration, the trend of industrial spatial agglomeration in cross-border areas is beginning to appear, and the interaction between cities is still insufficient.

Eastern Guangdong has a better economic foundation, with more developed light manufacturing and service industries, and a relatively high degree of export. More industries are concentrated in industries related to residents' daily necessities, such as textiles, clothing, footwear, toys, and furniture. These industries do not have high requirements on the scale, technology, and labor quality of the enterprise, the industry has low barriers to entry, most of the products are of medium grade, the scale of the enterprise is small, and the management is extensive. It will take a certain amount of time to form the advantage of scale.

Featured pillar enterprises in the western Guangdong petrochemical industry have an outstanding role, with large-scale enterprises, well-developed agriculture, abundant agricultural products, and great potential in the marine industry. Although western Guangdong has advantages in scale, it lacks technological advantages. The industrial chain is not long enough. Production is mainly concentrated in certain links of the industrial chain, especially the production of low-end products. The low output of high-value-added downstream products and the few product varieties have affected the petrochemical industry, with a further overall development of industry and agriculture.

The mountainous area of northern Guangdong has abundant labor resources and low prices, which can fill in blank industries and provide favorable conditions for undertaking the transfer of industries in the Pearl River Delta and developing labor-intensive industries. At present, the Pearl River Delta Economic Belt and the Mountain Economic Belt are gradually forming complementary advantages, but there is no major breakthrough in scale and structure.

Analysis of regional logistics transportation network layout in Guangdong Province

As the starting point of the Maritime Silk Road, Guangdong Province is adjacent to Hong Kong, Macau, Hunan, Jiangxi, Guangxi, Fujian and Hainan. It is geographically close to most RCEP members and has a superior geographical location. It is the gateway to the world from the southern coast of China. Therefore, the development of the logistics industry in Guangdong Province plays a particularly prominent role in the development of the regional economy.

The proportion of logistics output value in GDP reflects to a certain extent the level of regional economic development and the degree of regional economic coordination. It can be seen from Figure 6 that from 2008 year to 2020 year, the logistics output value of Guangdong Province will remain above 3% of GDP.

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Even if it is affected by the new coronavirus epidemic, it will still account for 3.03% in 2020 year. The Pearl River Delta and Western Guangdong logistics output will account for the overall proportion of GDP trend declined, but still remained between 4.0% and 5.0%. The northern Guangdong showed an overall upward trend, but due to the impact of the new coronavirus epidemic, it dropped rapidly from 5.5% to 2.5%. In the eastern Guangdong, it was with a fluctuation around 2.0%.

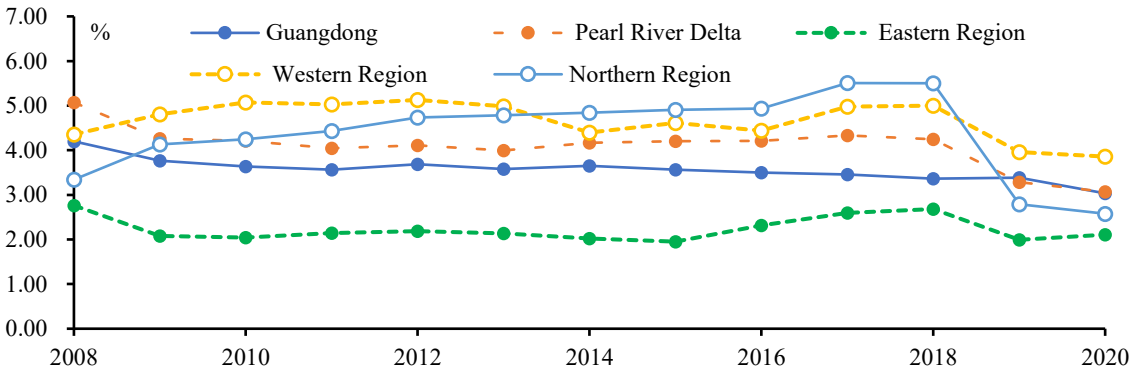

Figure 6 The proportion of logistics output value in each region of Guangdong Province to GDP

The development of the logistics industry in Guangdong Province has benefited from its well-developed logistics transportation network. Guangdong Province has initially formed the main framework of "twelve vertical, eight horizontal, two rings and sixteen shots", supplemented by 70 dense lines and connecting lines, with the Pearl River Delta as the core, and coastal cities, ports, airports and railway hubs as the main support. The Guangdong-Hong Kong-Macao Greater Bay Area develops in-depth cooperation, leads the development of the east and west wings and the coastal economic belt, and quickly connects to the expressway network of surrounding provinces. The main manifestations are as follows: First, the expressway network covering the whole province radiating to the Pan-Pearl River has been initially formed. By the end of 2020 year, the total mileage of expressways opened to traffic will be the first in the country to exceed 10,000 kilometers. The second is the construction of many railway lines including Beijing-Guangzhou railway, Beijing-Kowloon Railway, Ganzhou-Shaoguan Railway, Nanning-Guangzhou Railway, Guiyang-Guangzhou Railway, etc., initially forming a radial road network with the Guangzhou hub as the center, connecting the Pearl River Delta and the east, west, and north of Guangdong, and radiating east, south, central and southwestern China pattern. In 2020 year, the railway operating mileage reached 4,869 kilometers, of which high-speed railways reached 2,065 kilometers, and high-speed railways covered 20 prefecture-level cities in the province. Third, the Guangdong coastal port cluster with the Pearl River Delta as the core has become the logistics center of the Asia-Pacific region. There are five large coastal ports, namely Guangzhou Port, Shenzhen Port, Zhuhai Port, Shantou Port and Zhanjiang Port, and two major inland ports, Foshan Port and Zhaoqing Port. There are 338 berths of 10,000 tons and above. 3000-ton ships can reach Guangxi directly from Guangzhou Port, Shenzhen Port, Zhuhai Gaolan Port, etc., and 1,000-ton ships can reach downtown Shaoguan directly from Sanshui, Foshan. The fourth is to form a "5+4" backbone airport aviation route. Five hub airports in the Pearl River Delta region,

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including Guangzhou Baiyun Airport, Shenzhen Bao'an Airport, Pearl River Delta Shinkansen Airport, Zhuhai Jinwan Airport, and Huizhou Pingtan Airport, will be built in the Pearl River Delta region, and Jieyang Chaoshan Airport, Zhanjiang Airport, Meixian Airport and Shaoguan Airport will be built in eastern Guangdong, western Guangdong and northern Guangdong branch airports.

Although Guangdong Province has initially achieved full coverage of major integrated transportation hubs and key scenic spots, the transportation infrastructure in Eastern, Western and Northern Guangdong is still far from the Pearl River Delta. For example, the coastal areas of eastern and western Guangdong are rich in marine resources, the terrain is flat, and there are many ports. There is a lot of room for development. However, the area density of expressways is generally low, only 58% of the provincial average, less than 1/3 of the Pearl River Delta. Seriously restrict the development of the logistics industry. To achieve a new round of development in eastern Guangdong, western Guangdong and northern Guangdong, it is necessary to make up for the shortcomings of transportation facilities, add more railways and highways, promote a smoother and reasonable flow of production factors, and expand relations with RCEP member countries. The bilateral trade volume further serves the development of Guangdong's regional economy.

Theoretical analysis and discussion

Growth Pole" theory: No impact power in core cities

The growth pole theory emphasizes the importance of building a growth center point, that is, the importance of the growth pole for accelerating regional development. However, from the perspective of regional development in Guangdong Province, the core city growth pole has not been formed.

From the perspective of the province, the influence of core cities has declined. From the above analysis, it can be seen that Guangzhou and Shenzhen are undoubtedly the growth poles of the provinces. Guangzhou and Shenzhen will account for 22.6% and 25.0% of the province's GDP in 2020 year, but the current agglomeration and radiation effects of the two cities are Weaken. The average economic growth rates of Guangzhou and Shenzhen from 2001 to 2005, 2006 to 2010, 2011 to 2015, and 2016 to 2020 were respectively higher than the provincial average of 2.15%, 1.64%, 1.33%, and 0.49%. In the last four "five years", the contribution rate of the two cities of Guangzhou and Shenzhen to the province is gradually weakening.

From a regional perspective, Eastern Guangdong, Western Guangdong, and Northern Guangdong all lack their own economic core. Shantou, Maoming and Shaoguan are traditional economic strong cities in eastern Guangdong, western Guangdong and northern Guangdong respectively. In 2000 year, Shantou City, Maoming City, and Shaoguan City accounted for 42.2%, 43.9%, and 25.5% of the total economic output of each region, respectively, occupying a dominant position in each region. At the same time, the economic structures of these three cities also have structural advantages in the region. The secondary and tertiary industries have a relatively high proportion. The three cities can be described as the core cities in their respective regions, and they should play the role of regional economic growth poles. However, after years of development, Shantou, Maoming, and Shaoguan have not formed growth poles in the region, but have shown

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a multi-polar development trend in the region. As shown in Table 4, in 2020 year, the GDP of the three cities of Shantou, Maoming, and Shaoguan accounted for 38.7%, 42.4%, and 21.1% of each region, respectively, showing a downward trend compared with 2000 year, and their influence on the region will not increase but decrease. Zhanjiang in western Guangdong has a share of 40.1%, which is close to Maoming. While Qingyuan in northern Guangdong overtakes Shaoguan with 27.6%.

Table 4 Regional share of GDP of each city

Eastern Region	Proportion	Western Region	Proportion	Northern Region	Proportion
Chaozhou	15.6%	Zhanjiang	40.1%	Shaoguan	21.0%
Shantou	38.7%	Maoming	42.4%	Meizhou	18.7%
Jieyang	29.8%	Yangjiang	17.6%	Qingyuan	27.6%
Shanwei	15.9%			Heyuan	17.1%
				Yunfou	15.6%

To this end, Guangdong Province shall effectively play the core driving role of the growth pole. On the one hand, from the perspective of the province as a whole, it is highly necessary to make full use of the "Dual-Area-Driven" development policy of the Guangdong-Hong Kong-Macao Greater Bay Area and the pilot demonstration area to further strengthen the growth pole of the Pearl River Delta, so as to give full play to the role of the main position of the Greater Bay Area and the first phalanx of the construction of the first demonstration area, improve the energy level of the central city, and exert the agglomeration and spill-over effects of the central city, thereby activating the economic growth vitality of eastern, western and northern Guangdong. It can contribute to the main function of the regional economic layout with obvious, complementary advantages and high-quality development, realizing the scale economy effect of the urban agglomeration. On the other hand, it is proposed to combine the economic development status of eastern, western and northern Guangdong, build a new development pattern of the "twin cities" economic circle, and optimize the functional layout of which, so as to comprehensively improve the development level and core competitiveness, thereby leading the drive to promote the "twin cities" effect of the city's economic circle. By consolidating the foundation for the development of the twin cities of "Shantou-Chaozhou", "Zhanjiang-Maoming" and "Shaoguan-Qingyuan", strengthening the coordination of planning, policies and projects, and exploring the establishment of high-quality development in the fields of industrial development, public services, ecological and environmental protection, to name but a few, the required benefit-sharing mechanism is likely to radiate and drive the overall development of the region. For example, in the western region of Guangdong, Zhanjiang and Maoming shall be positioned as two central cities in that Zhanjiang gives full play to the advantages of its green steel industry cluster and green paper industry cluster, while Maoming gives full play to the advantages of green petrochemical industry cluster and modern agricultural industry cluster. On this basis, by giving full play to the advantageous industries of both Zhanjiang and Maoming, an industrial linkage development pattern is formed featuring "dislocated competition, point-to-face linkage, and complementary advantages" with a lead of regional economic growth.

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Sustainable development" theory: a long way to go

The theory of sustainable development emphasizes development that can meet the needs of contemporary people without jeopardizing the ability of future generations to meet their needs. In the process of rapid economic development in Guangdong Province, a series of problems have almost inevitably appeared. It is not only manifested in the continuous expansion of the development gap between regions at the spatial level, but also in the unsustainable mode of regional economic development at the time level. First, from the above analysis, it can be seen that the uneven development of the regional economy in Guangdong Province is showing an increasingly serious trend. Second, the continuous improvement of environmental quality in eastern, western and northern Guangdong has become more difficult. The water quality of Lianjiang is still heavily polluted. The task of remediation of heavy metal pollution in areas such as Guiyu in Shantou and Dabaoshan in Shaoguan is still quite heavy. The third is that Eastern Guangdong, Western Guangdong, and Northern Guangdong lack science and technology engines, and technological investment is far behind the Pearl River Delta. In 2020 year, the R&D expenditures of enterprises in the East Wing, West Wing and the mountainous areas of northern Guangdong will account for only 0.9%, 0.4% and 0.7% of GDP respectively, which is far lower than the province's 2.8% level. The total R&D expenditure in eastern Guangdong, western Guangdong and northern Guangdong is only 4.4% of the province's R&D expenditure.

With the iteration of sustainable development theory, development has changed from simple economic growth at first to sustainable development including ecological civilization. Taking advantage of the ecology can not only fully release the ecological effect, but also convert it into economic potential energy. Guangdong Province is building a new regional development pattern of "one core, one belt and one area" (namely, the Pearl River Delta core area, the coastal economic belt, and the northern ecological development area) with a new path of ecological priority and green development. Pearl River Delta core area shall pay more attention to industrial ecologicalization and ecological industrialization. By releasing the structural power of green development, enhancing the supply of high-quality ecological production, and building an institutional system that internalizes environmental costs, it is bound to activate the advantages of green development and increase the upgrading of production, technological transformation, and comprehensive environmental improvement, so as to achieve a win-win situation between environmental friendliness and economic development while the economy maintains its rapid growth and the industry moves to a high-end level. Coastal economic belt needs to continuously upgrade and strengthen its advantageous industries such as green petrochemicals and new energy, and gradually form coastal heavy chemical industrial belts such as petrochemicals and steel, as well as clean energy industrial clusters such as nuclear power and offshore wind power. When undertaking the transfer of industries in the Pearl River Delta, the "Northern Ecological Development Zone" is required to conform to the positioning of regional ecological functions, strengthen ecological construction, pay attention to environmental protection, strengthen pollution prevention & control, thereby strictly prohibiting the transfer of polluting industries and backward production capacity. It is also required to develop a circular economy, promote energy conservation & emission reduction, and promote the economical & intensive utilization of resources, together with improving the carrying capacity of the industry.

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Gradient transfer" theory: latecomer with no advantage

Gradient transfer theory advocates that developed regions should accelerate their development first, and then transfer industries and factors to more developed and underdeveloped regions to drive the development of the entire economy.

According to the theory of gradient transfer, eastern Guangdong, western Guangdong, and northern Guangdong are adjacent to the Pearl River Delta and have obvious "gap". They have the advantage of being a latecomer in the industrial upgrading and structural adjustment of the Pearl River Delta. However, from the perspective of regional economic development in the last 20 years, Eastern Guangdong, Western Guangdong, and Northern Guangdong have not only widened the gap with the Pearl River Delta in terms of economic aggregates, but also the gap with the Pearl River Delta in terms of economic development speed. In 2020 year, there will be a total of 12 cities in eastern Guangdong, western Guangdong, and northern Guangdong. The GDP growth rate of Shanwei, Yangjiang, Yunfu, Qingyuan, and Shaoguan is higher than the provincial average, and the GDP growth rate of the remaining 7 cities is low. In the province's average level, especially Jieyang City's GDP growth rate is only 0.2%, while Heyuan and Chaozhou both have 1.3%, which is far lower than the province's average level of 2.3%. With the integration of regional economy, the economic radiation of the Guangdong-Hong Kong-Macao Greater Bay Area continues to expand. The urban agglomerations of Fujian, Hunan, and Guangxi adjacent to Guangdong have certain advantages in terms of labor, land and other production factors. New competition is formed in the western and northern Guangdong regions. In recent years, the eastern, western and northern Guangdong regions are more like "slope" rather than depressions, and it is difficult to form late-comer advantages.

After a periodical development, Pearl River Delta region is faced with the bottleneck of crowded population, limited land area, and high labor costs. Industrial upgrading and industrial transfer are imperative. The resource endowments of eastern, western and northern Guangdong will make up for the shortage of the Pearl River Delta. In this regard, it is expected to adhere to the principle of "overall planning as a whole ", thereby strengthening the overall top-level guidance of Guangdong provincial government on regional coordinated development, strengthening strategic planning, factor allocation, policy support, etc., with a view to expanding the space for economic development, together with promoting the optimization of the province's economic structure and regional coordinated development. On the basis of fully considering the resource endowments of eastern, western, and northern Guangdong, according to the gradient transfer theory, it is expected to continue to increase resource planning and policy supply, optimize, adjust, transfer and upgrade the industrial structure of the Pearl River Delta. The linkage and synergy of the development of regional sectors will accelerate the eastern, western and northern Guangdong to undertake industrial spillovers from the Pearl River Delta, and enhance the balance and coordination of regional economic development. For example, Guangdong can explore and practice "headquarters + bases", "front-end + back-end", "R&D + manufacturing", "final assembly + supporting" and other co-construction models, so as to strengthen supporting industries in the Pearl River Delta in the fields of, say, autos, steel, and energy.

Conclusion

The regional economic development of Guangdong Province has continued to achieve results, the development level of the Pearl River Delta has accelerated, and the eastern, western and northern Guangdong have shown good signs, however, the economic gap with the Pearl River Delta has been increasing. The unbalanced regional economic development in Guangdong Province has narrowed the economic development space of backward areas and the market is shrinking day off, which has led to the distortion of regional economic relations, affecting the efficiency of economic operation, and in turn dragging down the economic development of the Pearl River Delta.

Weak endogenous development momentum in the east, west and north of Guangdong

Eastern Guangdong, Western Guangdong, and Northern Guangdong all suffer from poor innovation momentum and lack a good platform to attract industries and talents. First, from the perspective of economic growth, in recent years, the education level of the labour force in the Pearl River Delta has been continuously improved, the accumulation of human capital has continued to accelerate, and the improvement of the quality of human capital, technological innovation and technological progress has gradually become the main driving force of economic growth. Yet, eastern Guangdong, western Guangdong, and northern Guangdong are still in the stage of factor scale expansion, the innovation factors of economic development are relatively weak, the development mode is relatively extensive, and the technological innovation ability is not strong. Meanwhile, the quality of employed persons is low and the proportion of employed population with junior high school and below education in the eastern and western wings and the mountainous areas of northern Guangdong is much higher than that in the Pearl River Delta, other than that, the education level of junior high school or higher is much lower than that of the Pearl River Delta. Second, the proportion of R&D investment by industrial enterprises above designated size in eastern Guangdong, western Guangdong, and northern Guangdong in terms of regional GDP is much lower than the average level of the Pearl River Delta. The proportion of R&D institutions set up by industrial enterprises above designated size is relatively low, and most enterprises have not established research institutions. Industrial transformation and upgrading are under great pressure. A considerable number of industries are located in the industrial value chain, and some industries have overcapacity. The proportion of high-tech manufacturing and advanced manufacturing in the added value of industries above designated size is more than 20% lower than that in the Pearl River Delta region.

The actual effect of the industrial transfer policy is not obvious

The industrial transfer in the Pearl River Delta is not strong enough, and the industrial radiation to eastern, western and northern Guangdong is not strong enough. Based on the analysis of the regional industrial layout of Guangdong Province, it can be seen that Guangdong Province has strongly recommended industrial transfer in recent years, but the effect is not good, and the economic backwardness of eastern, western and northern Guangdong has not been fundamentally changed. First, the transfer of competitive high-tech innovation industries in the Pearl River Delta is relatively small, and they cannot bring economic vitality to

eastern, western and northern Guangdong. The purpose of formulating the industrial transfer policy is to eliminate backward production capacity that is insufficient to promote the Pearl River Delta and cause environmental pollution, and ignores whether the backward areas have all-factor support capabilities. Second, the number of leading industries in Eastern Guangdong, Western Guangdong, and Northern Guangdong is relatively small, especially those industries with high technological content that cannot play a leading role. There are 343 large industrial enterprises in Guangdong, most of which are in the Pearl River Delta, and there are only 24 in eastern, western and northern Guangdong. It is difficult to provide a good environment for the coordinated development of the regional economy.

The role of central cities in the east, west and north of Guangdong being not prominent

There are a total of 12 cities in Eastern Guangdong, Western Guangdong, and Northern Guangdong, with small internal differences. The central cities in their respective regions are not prominent, and their contribution to regional growth is limited. Shantou in eastern Guangdong is gradually declining and is chased by Jieyang. Shantou's role as the economic leader of the central city in eastern Guangdong is not obvious. The economic aggregates of Zhanjiang and Maoming in western Guangdong are close to each other. In addition, there is no significant difference between the two cities in major indicators such as industrial added value, fixed asset investment, consumption, fiscal revenue and expenditure, and per capita disposable income of residents. The same problems exist in the five cities in the mountainous area of northern Guangdong. The economic aggregates of Shaoguan and Qingyuan are close, and the gap is small. Shaoguan cannot become the economic leader and assume the status of the central city of northern Guangdong.

Recommendations

The new connotation of regional coordinated development must reflect "innovation, coordination, green, openness, and sharing", and build a new mechanism for regional coordinated development of "effective overall planning, orderly competition, green coordination, sharing and win-win". Imbalance is common, and relative balance should be promoted in development, and "equalization of basic public services, relatively balanced access to infrastructure, and roughly equivalent people's living standards" are the three major goals of regional coordination. Therefore, the development strategy of the Pearl River Delta urban agglomeration needs to pay more attention to the cultivation and formation of development momentum, and the mountainous area of northern Guangdong places more emphasis on ecological protection to form a new source of driving force for the high-quality development of Guangdong Province.

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Improve the construction of systems and mechanisms, and implement the regional development strategy of "One Nuclear, One Belt, and One District"

It is suggested to give full play to the diffusion effect of the regional economic growth pole and weaken the polarization effect of the growth pole, accelerate the exploration and establishment of a new mechanism for the integration of regional markets with unified planning systems, co-promotion of development models, consistent governance, and regional market linkages, and build a multi-form. The wide-ranging and in-depth cooperation mechanism system of “one core, one belt and one area” is to work hard to break down administrative division barriers, promote the free flow of urban and rural elements, and maximize the release of peace Strengthen the development momentum of urban centres in eastern Guangdong, western Guangdong and northern Guangdong, and enhance the overall competitiveness of the region. It is suggested to focus on the following ten aspects to carry out system and mechanism innovation: establish a regional strategic coordination mechanism, innovate industrial development mechanisms, improve major infrastructure construction promotion mechanisms, build regional coordination mechanisms, deepen regional interest compensation mechanisms, optimize regional mutual assistance mechanisms, and improve market integration. When the development mechanism is improved, the basic public service equalization mechanism is improved, the regional policy regulation mechanism is innovated, and the regional development guarantee mechanism is strengthened.

Relying on the digital economy and speed economy, take the "acceleration" of the coordinated development of the regional economy

New factors such as the digital economy and speed economy have broken the inherent pattern. In the context of the speed economy and digital economy represented by new infrastructure such as high-speed rail, the Internet, and artificial intelligence, factors such as new technologies, new industries, and new models have begun to surpass the impact of traditional factors such as spatial distance and resource endowment on the coordinated development of regional economies. Driven by the construction of high-speed, highly comfortable transportation facilities such as high-speed rail, high-speed, aviation, and the construction of the Pearl River Golden Waterway, the province's comprehensive three-dimensional transportation network will be continuously improved, and coastal cities and ports will radiate northward, and the coordinated development of coastal economic belts will be promoted. Regions such as the East and West Wings in the catch-up stage, through industrial coordination, shall make full use of domestic and international markets, accelerate the transfer of Pearl River Delta industries to eastern, western and northern Guangdong, expand the scale of transfer, develop characteristic industries, and expand economic development space. The process of industrial transfer is accompanied by industrial upgrading, and the process and quality of industrialization in the underdeveloped areas of Guangdong Province will surely improve significantly.

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Deep integration of "1+20" strategic industrial clusters, opening up and innovation to promote the coordinated development of regional economies

At present, the matter is not whether to open to the outside world, but how to improve the quality of opening up and the internal and external linkages of development. Innovation is the first driving force for development. And it is to focus on innovation and is to focus on development, to seek innovation is to seek the future. Openness and innovation are two important ways for Guangdong Province to achieve coordinated regional development. As a gathering area of domestic strategic emerging industries, Guangdong Province has gathered a large number of enterprises with advanced manufacturing and strategic emerging industries as the core. Guangdong Pilot Free Trade Zone, consisting of the three major areas of Guangzhou Nansha, Shenzhen Qianhai, and Zhuhai Hengqin, "benchmarks Europe and the United States", shall deeply integrate 10 key pillar industry clusters, such as the new generation of electronic information and 10 strategic areas, serving as semiconductors and integrated circuits. New type of industrial clusters, breaking regional administrative divisions, shall make every effort to build world advanced industrial clusters with international competitiveness. It is expected to build an innovative service system with resource sharing, service coordination, and complete functions, and build a high-level and open economic system to provide new impetus for the development of RCEP regional economic integration.

Using urban agglomerations and metropolitan areas as platforms to create a new engine for high-quality regional economic development

With the advancement of new urbanization, the population and economic factors in the development of Guangdong Province are increasingly concentrated in urban agglomerations. Metropolitan areas with a population of more than 20 million, such as Guangzhou-Foshan-Zhaoqing, Shenzhen-Dongguan-Huizhou have promoted the rapid economic development of the surrounding regions. Central cities drive metropolitan areas, metropolitan areas drive urban agglomerations, and urban agglomerations drive regional development. It is bound to be the mainstream trend of urban development in the future. Through the platform of urban agglomerations and metropolitan areas, we shall strengthen the coupling and interaction between the Pearl River Delta and Eastern Guangdong, Western Guangdong, and Northern Guangdong, promote “quality improvement” with “expansion”, create a large platform for population agglomeration and industrial upgrading, and cultivate new growth poles. The first is to avoid collapse between metropolitan areas, break the administrative boundaries between metropolitan areas, promote the integrated development of cross-city and cross-county junction areas, further enhance comprehensive carrying capacity, accelerate industry and population agglomeration, and improve factor concentration, technological innovation, and culture Leading and comprehensive service functions, promoting industrial transformation and upgrading, and supporting the overall development of the region. Second, it is expected to give play to the functions of small towns in eastern, western and northern Guangdong and the location advantages of connecting large and medium-sized cities to create a batch of distinctive industrial towns and commerce towns and tourist towns, encourage industrial and

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commercial enterprises in large and medium cities to develop in small towns. The third is to strengthen the connection of transportation channels and promote the integration of basic public services, focusing on opening up "broken roads".

Building, supplementing, strengthening, and extending chains, the chain length system empowers high-end industrial clusters

Based on "enlarging", "improving quality" and "increasing efficiency", we shall realize the high-end industrial clustering, promote the integration of industrial chain, supply chain and value chain in the RCEP region, promote the free flow of economic factors in the region, and strengthen cooperation in the division of production among members. It is suggested to promote the expansion and upgrading of the consumer market in the region, and promote the further development of the industrial chain and supply chain in the region. In response to the scattered industrial distribution, short industrial chain, and imperfect industrial chain links in Guangdong Province, various measures have been taken to integrate and utilize external superior resources, and actively build a "chain length + chain owner" work promotion system for the chain length system. Among them, the government level serves as the "chain leader", coordinating the overall work of the construction of key industrial chains. The enterprise level serves as the "chain master", coordinating the implementation of major plans and projects, comprehensively improving the level of industrial development and modernization, and promoting the high-quality leapfrogging of the regional economy in Guangdong Province develop. "Building a chain", researching and combing the development status of the industrial chain by chain lengths, studying and formulating industrial chain diagrams, technical route application field diagrams, and regional distribution diagrams, and grasping the external dependence status of key enterprises in the industrial chain and various links of the industrial chain. "Replenishing the chain", and to accurately assist the coordinated development of the industrial chain, coordinate and solve major difficulties in development, coordinate and promote the development of industrial chain enterprises, investment promotion, project construction, talent introduction and other major issues. "Strong chain", guide enterprises to increase R&D investment, independent or independent jointly establish technical centres, design centres and other institutions. We shall promote the construction of major innovation platforms, build innovation complexes and other public service platforms, and make breakthroughs in a number of key core technologies in the industrial chain. "Extend the chain", carry out industrial chain investment, and lead industrial extension with technological innovation. Establish supporting industries with chain owners as the core, leading enterprises to drive the overall development of the industry, extend the industrial chain up and down, increase the added value of products, and extend the value chain of the enterprise.

Improve the quality and efficiency of the logistics system and accelerate regional economic integration

Under the opportunity of economic globalization and the adjustment of the international industrial

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structure, it will deeply integrate into the global supply chain, improve the quality and efficiency of the regional logistics system, and promote the coordinated development of the regional economy. It is suggested to strengthen the construction of infrastructure such as rural road networks in eastern, western and northern Guangdong, cold chain infrastructure, logistics information sharing platform, cold storage, and smart warehouse. Promote the integrated development of the logistics industry and the regional primary, secondary, and tertiary industries, improve the level of integration, intelligence, and informatization, and build a smart logistics service network. We shall accelerate business linkage, make full use of local population and production scale, stimulate market demand, promote resource, information, and data sharing between logistics enterprises and other industrial enterprises, radiate and gather surrounding market demand, and give play to the core driving role of regional logistics.

Research Prospects

A data model is established, in this paper, to conduct an empirical analysis on the new mechanism of supply chain and sustainable development in Guangdong Province, which mainly uses the statistical yearbook data for analysis of the change trajectory and trend of economic indicators in terms of the quality of economic operation, and the coordinated development of regional economy related to Guangdong regional economy. The index quantification not only examines the changes of the total index and the overall level of the total scale, but also analyzes the changes in the industrial structure of the regional economy and the layout of the logistics and transportation network, based on which the growth pole theory is used, together with sustainable development theory and gradient transfer theory of regional economic development to further analyze the differential performance of the coordinated development of regional economy in Guangdong Province under the framework of RCEP. Finally, six countermeasures and suggestions have been put forward to promote the coordinated development of regional economy in Guangdong Province, with a view to strengthening the interconnection of regional industrial chains and building a new development pattern of domestic and international "dual circulation" mutual promotion.

The coordinated development of regional economy is a complex social and economic system, which involves multiple fields, multiple levels and multiple indicators, including social economy, resource elements, technological innovation, industrial layout, ecological environment, opening to the outside world, and regional planning. Therefore, this paper still needs to conduct in-depth research from the following three aspects: First, it is necessary to further use big data technology, making full use of the statistical yearbook data to extract the most common regional factor indicators to optimize the data model, as well as making the established regional coordinated development model more complete and scientific. Second, it is necessary to combine both of the Guangdong-Hong Kong-Macao Greater Bay Area and the Belt & Road Initiative to further explore the internal and external factors in the coordinated development of the region, aiming to strengthen the cross-regional governance of Guangdong Province, in terms of planning mechanism, market mechanism, cooperation mechanism, support mechanism, and mutual assistance mechanism, with urban-urban linkage, urban-rural integration, international regional competition and cooperation and other research efforts. Third, it is necessary

to further expand the breadth and depth of research, efficient and coordinated development with countries along the Belt & Road initiative, to form coastal and inland interconnection, and to promote the formation of Xiongan New Area in the north helping the coordinated development of Beijing, Tianjin and Hebei; the Yangtze River Delta in the middle leading the Yangtze River Economic Belt; the Guangdong-Hong Kong-Macao Greater Bay Area in the south driving the new pattern of regional economic growth in the Pan-Pearl River Delta.

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A Study of India's Role and Importance in Future Global Supply Chains

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Abstract

This study discusses the role and importance India will play in the future global supply chain. Since the Sino-US trade war, the global political and economic situation has changed a lot. As the most populous country in the world, India plays a pivotal role in both production and consumption. The subsequent COVID-19 outbreak has brought about a big change in global economic thinking. What part India will play in the future role of the global economy deserves our attention. Therefore, this paper mainly studies the following questions. 1) Current status of India's role in the global supply chain 2) After the Sino-US trade war, the division of work that India may play in the global supply chain 3) As a new supply chain role, what is missing in India's political and economic situation at this stage? 4) The role India can play in future global supply chains. Use hermeneutics to conduct research, and make in-depth interpretations of the significance of recent major events from public information. The conclusions of this study show that India will become an important player in the global supply chain. While there are many issues to overcome, the external environment will provide it with a role as a major global supply chain player. Although it is currently mainly focused on the software industry, India is bound to enter the field of manufacturing in the future.

Keywords: Made in India, post-pandemic industrial chain, global industrial division of labor, political economy, industrial division of labor

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Introduction

India will play a major role in the global supply chain

India is the world's largest population country and the most important supplier of software technology talents. With the Sino-US trade war that started in 2018 and the global epidemic in 2020, some advantages of India that went unnoticed in the past have gradually emerged. It made everyone start to notice this rising star who is slowly showing his head.

India is home to 60% of the world's population in the Pacific region, and the total U.S. investment in the region in 2020 exceeded $969 billion, In the past ten years, it has doubled, and India has also been pursuing the status of a world power. With lower labor prices and superior geographical location, Indian supply chains are challenging China.

Why do we say this? First of all, in terms of human resources, India has the largest population in the world. According to the latest statistics, India's population has surpassed China to become the world's largest population country. In manufacturing, human resources are an indispensable condition, and India just happens to be far ahead of other countries in the supply of human resources. India's growth in the past few decades has been very good. Now India's per capita GDP is only about 1/6 of China's, and its total population is very close to China's. India's growth in the past few decades has been very good. Now India's per capita GDP is only about 1/6 of China's, and its total population is very close to China's. However, India's population structure is very young and labor costs are relatively low, so its growth potential is still very large.

Secondly, in terms of the quantity and quality of human resources, the quality of human resources in India is also one of its major advantages. Since English is the official language of India, people all over India can communicate in fluent English, which brings great advantages to India in an open world. In other words, all industries will have no communication problems when investing in India. Secondly, the advantages of India's human resources in mathematics and computers are also beneficial for its future global industrial chain. As a result, Indian employees are ahead of other countries in software design.

In addition, India also has a certain foundation in basic industries, so it can easily obtain the entry of manufacturers from other regions. This also means that India may seek out industries from other regions that have to exit due to high labor costs, or companies that want to diversify their investments to avoid concentration of risks in one region due to political factors. This huge development potential makes India an impressive competitor.

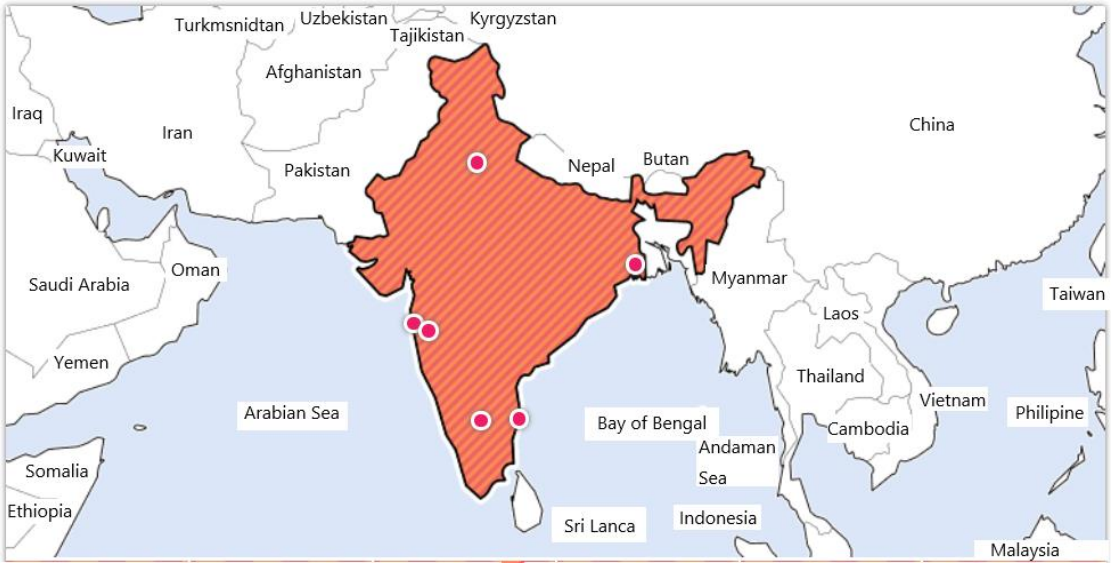

Figure 1 The importance of India in location of global supply chain

Investment Strategy Considerations in India

For professional investors, India occupies an extremely advantageous position at both ends of the supply chain, one is the production end and the other is the consumer end. India has become a good production base due to its low labor cost, good human quality, and strong basic industries. For high-tech products, India provides a good production base.

And because of India's large population, it has become an important consumer in the supply chain. The consumption of 1.3 billion people is not trivial. If we focus on the consumption side of the supply chain, India is undoubtedly a good investment destination. With a population of 1.3 billion, there are still 700 million people don't use smartphones. This is India, a huge market where all mobile phone manufacturers such as Apple, Samsung, Xiaomi, etc. want a piece of the pie. Especially as China's growth momentum slows down, it seems that everyone's pace of layout will be more urgent this year.

Post-pandemic impact

The thinking that India has become an important supply chain, first from the Sino-US trade war since 2018, the business community began to think about whether there is another production base that can be used as an alternative? When they found that India has such superior conditions, they turned to put a lot of money into India, and even see India as an important investment target in the next stage.

However, between 2020 and 2021, India's inability to control the epidemic has caused doubts among entrepreneurs. They began to think whether it is appropriate to invest a large amount of capital in India? The rising number of confirmed cases has caused the factory to operate ineffectively smooth. Although it has now reached the post-epidemic stage, and most countries have also announced that the new crown pneumonia has entered the regional infectious disease level, so the impact of the epidemic will be reduced accordingly. But this shadow still exists in the minds of entrepreneurs.

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The innovation of this research and its contribution to the industry

Although there has been a lot of discussion in newspapers and magazines due to the rise of India, investing in India is still a very novel topic, and this topic still lacks a complete discussion from the perspective of industrial economy. Therefore, when making professional judgments as entrepreneurs and investors, it is inevitable that there will be a fly in the ointment.

In India, Supply Chain Management (SCM) is becoming more and more important due to the opening of the domestic economy into globalization. However, the literature review shows that there are not many papers trying to document and understand the importance of SCM in the Indian business environment. Therefore, the research objective of Gurumurthy et al. (2013) is to analyze the contributions of academicians and practitioners to solving various supply chain problems.

Secondly, the development of the supply chain is inseparably related to the basic elements of the industrial economy. In the industrial economy, manpower, technology, and capital are all issues that the development of the supply chain must face. If India is to become an important player in the global supply chain, it is bound to solve these three bottlenecks. Therefore, it is particularly meaningful to discuss this issue from the perspective of industrial economy.

The main research questions of this study

This study mainly explores the following research questions

1. What is the current status of India's role in the global supply chain?
2. What is the division of labor in the global supply chain that India may play after the Sino-US trade war?
3. As a new supply chain role, what is missing in India's political and economic situation at this stage?
4. What role can India play in future global supply chains?

Literature Review

In the research of Thaller et al. (2012), the supply chain resources in India were sorted out in detail, including the relevant logistics research and educational institutions in India, and what research topics are currently discussed in the field of logistics. The study also discusses the integration of Indian logistics centers, risk assessment of logistics chains, and how to improve India's commercial transportation infrastructure.

Marwah et al. (2013) conducted a study on the supply chain of the Indian manufacturing industry to provide an understanding of the determinants of successful SCM operations for Indian manufacturing organizations.

When discussing supply chains, we must look at the reasons for the formation of supply chains from the perspective of industrial economics. The supply chain is the combination formed by the enterprise in order to reduce the cost. When they are combined into a supply chain, they have a competitive advantage, so if we want to explore the role of India in the global supply chain in the future, we must discuss each factor that affects costs.

Advantages of labor cost

The labor cost refers to the cost equivalent to the human in the production process. Salary comes directly to mind, but labor costs are more than that. Labor cost refers to the sum of all direct and indirect expenses paid by an enterprise for the use of laborers in the production, operation and provision of labor services within a certain period of time. If the company pays 1,000 yuan of wages to employees, then the labor cost will never be the direct 1,000 yuan, and there are other indirect costs.

In addition to the monthly salary, labor costs also include the costs invested by the company in the hiring process, including: recruitment costs, selection costs, hiring costs, and placement costs. In addition, the cost of human learning includes: the cost of pre-job education and the cost of on-the-job training. If the employee leaves, there are also the cost of leaving, including: separation compensation cost, separation management fee, vacancy cost, etc.

Because the manufacturing industry is highly dependent on labor costs, when labor costs increase, they will respond immediately, and the most obvious way is to relocate factories. In the past, manufacturing from Japan to Taiwan, from Taiwan to mainland China, and now from mainland China to Southeast Asia, are all obvious examples.

Advantages of technology cost

Technology is an important factor in industrial competition. Only by mastering good technology can we take a place in the fiercely competitive market. For India to become an important element in the world's supply chain, it must be irreplaceable in technology. In addition, the cost of acquiring the technology must also be sufficiently competitive.

However, technology is not pleasing in financial statements. When we discuss technology from a financial perspective, it will be difficult for technology to set KPIs (key performance indicators of enterprises), and it is difficult for work data to be clearly quantified. Moreover, technology is an expenditure, and it cannot actually help the company to achieve value up (the value up is usually the performance of the business side). "Good technical managers can help technical workers to play a greater role in their work. For finance, that is to reduce costs. But for product operators (or CEOs), technology is something that must be done, so the contradiction that often occurs within the company is, should we spend money to make the product function more complete?

If India wants to attract foreign investment, it must technically meet the requirements of the above two ends, that is, for the financial department, the technical cost of setting up a factory here is the least, and for the operating department, setting up a factory here. Get the most technical support.

Advantages of the policy

In economics, in order to promote industrial development, policy tools, such as financial subsidies or tax incentives, are often used. To measure its benefits, policy tools have certain benefits, and often very obvious. If India wants to occupy a place in the future world supply chain, it is necessary to make good use of the power of policy tools. Taiwan's tax incentives have been implemented since 1960 when the Regulation on Incentive Investment was promulgated, and since 1991, it has been continued by the Regulation on Promoting Industrial Upgrade.

Although tax incentives can help stabilize the economy, stimulate investment, and promote industrial upgrading, the long-term or wide-ranging tax incentives have negative effects. Therefore, in order to implement this policy, there must be appropriate support. Tax incentives are a part of the government's industrial policy and are often part of various industrial development plans. They are of considerable importance. However, since the use of tax incentives has significant costs, it is still necessary to consider the cost-effectiveness of its use. In order to promote the benefits of tax incentives and achieve the expected industrial development goals, it is still necessary to be cautious.

Supply chain in the post-pandemic era

In the post-pandemic period, the industry has begun to think whether it is a good idea to concentrate all the technology and production in one area. Therefore, there is thinking about decentralizing production points.

However, changing production agglomeration is easier said than done. It involves the joint actions of a large number of manufacturers, households, and upstream and downstream players. The previous industrial settlement has been in operation for many years, and it is not easy to change it all at once.

The sustainable management of the supply chain is also a matter of concern to the experts. The Sachin and Rajesh (2022) study builds empirical models using data from twenty-five Indian companies. The main implication of this study is to observe whether companies and their supply chains implement environmental, social and governance (ESG) practices, and whether can help them achieve financial benefits, as well as other competitive advantages.

Research Methods

The scope of this study is wider, so we must interpret it from a broader perspective, so we use the hermeneutic method to carry out this study. According to the explanation of "Concise Oxford Dictionary", the so-called interpretation is "To evaluate or bring out the meaning", or "explain or understand behavior". Therefore, we can collect relevant information from public information, to explain these phenomena.

The role that India can play in the future global supply chain can be discussed in terms of politics, economy, culture, as well as labor costs, technology costs, and policy preferences. to provide a rationale for our research question.

Results and Discussion

Results

Status of India's Role in Global Supply Chains

India is the most important supplier to the software industry today, because the unique way of thinking of Indians makes them take a lot of advantage in software design. And the advantage of language also makes India occupy a very important position in the country of computer network, Indians can communicate with the academia and industry all over the world without any obstacles. Many software design companies in Silicon Valley in the United States have been acquired by Indian capital. So up to now, India has already achieved a leading position in the field of software design.

Reduce dependence on China and develop manufacturing independently. India, a pharmaceutical powerhouse, has embarked on an ambitious plan to reduce its reliance on China for key raw materials in order to become self-sufficient and become the "pharmacy of the world". India is already the world's third-largest pharmaceutical manufacturer by volume and one of the lowest manufacturing costs in the world.

About a third of pills in the US and a quarter in the UK are made in India. However, India's $42 billion pharmaceutical industry relies heavily on China for key active pharmaceutical ingredients, or APIs, the chemicals responsible for the therapeutic effects of drugs. According to a government report, India imports about 68 percent of its APIs from China because it is cheaper than producing them domestically.

For the pharmaceutical industry, the Indian government has set aside more than $2 billion worth of incentives to encourage private Indian companies and foreign companies to start producing 53 APIs for which India relies heavily on Chinese production. 32 factories across India started producing 35 APIs in March this year. This is expected to reduce India's reliance on China by as much as 35%, according to estimates by Moody's Indian subsidiary rating firm ICRA Limited.

The pandemic has forced India to build a logistics powerhouse. On May 26, 2022, global logistics leader UPS and Indian group Inter Globe Enterprises announced a joint venture to launch new logistics brand MOVIN to meet the demands of the fast-paced Indian market

After the Sino-US trade war, India may play a role in the division of labor in the global supply chain

Although many industries left China to Southeast Asia after the Sino-US trade war, due to the rapid economic growth in China in recent years and the high labor costs, many companies have already left China to set up factories or invest all over the world. Although they leave China, they do not necessarily see India as the first choice for investment transfer. In fact, many of these companies leaving China are in Southeast Asia, such as Vietnam, Thailand, or the African continent.

However, in the high-tech industry, India has a place, which can be attributed to India's own foundation in the information software industry and basic manufacturing. As India's economy is expected to accelerate, and with the active promotion of the "Made in India" policy, India has become the hottest investment hotspot for domestic mobile phone brands and foundries recently. Therefore, the leaders of the technology industry, Apple and Samsung, have already deployed in India. India and Vietnam are the main positions to undertake

Apple's production capacity, but India has mostly Taiwanese assembly plants, while Vietnam is a mainland fruit chain supplier to invest in and set up factories.

Currently in India, Taiwan's Hon Hai, Pegatron and Wistron have three fruit chain foundries to set up factories; mainland Apple supply chain companies have invested and set up factories in Vietnam include Luxshare Precision, Goertek, Yutong Technology, Lens Technology, Lingyizhi, Meiyingsen, Bourne Optical.

From an objective point of view, on the one hand, labor costs in mainland China have risen, and Southeast Asia still has a large number of cheap labor. Apple can obtain higher profits by setting up production lines in Southeast Asia. On the other hand, India and Vietnam are emerging markets with huge potential. In addition to these factors, Apple also wants to diversify its supply chain to reduce potential supply chain risks caused by various factors.

Table 1 Overview of Apple's supply chain vendors in India

No.	Name	Major product	Note
1	Quanta	Macbook	
2	Pengding Holdings	printed circuit board	
3	BYD Electronics	ipad	
4	Hong Hai	Iphone 13	Set up a factory in Chennai, India, with 17,000 employees.
5	Wistron	One of Apple's top three Taiwanese suppliers	
6	Pegatron	Production Iphone	Set up factory in Chennai, India, with an estimated 17,000 employees
7	Zheng Wei	Cables and Connectors	

The three companies of Apple's three major Taiwanese suppliers have a total investment of 65 billion rupees (NT$24.866 billion). India is the 11th largest economy in the world today, with an average GDP growth rate of around 8% over the past decade. Studying Indian supply chain management (SCM) practices has become more urgent, as Japanese SCM practices have in the past received a lot of scrutiny from researchers and practitioners. Few theories can explain the cross-cultural differences between Japanese and Indian SCM practices. Japanese companies are increasingly looking for ways to leverage India's IT and manufacturing prowess and manage global cooperation strategies (strategic alliances and supply networks) with Indian partners. Park et al. (2012) researched Japanese supply chain management practices as a standard and attempted to better understand the differences between Indian and Japanese supply chain management practices and their implications for practitioners.

Discussion

As a new supply chain role, what is missing in India's political and economic situation at this stage?

Negative events

The Wastron violence event is an indicator. Wistron has invested in India for more than ten years. It is Apple's main supplier, but its southern India plant was destroyed a few years ago, which made Apple start to consider whether to replace the manufacturer, because the maintenance is good. The order of production has always been the main consideration for the investment of large international manufacturers.

The coronavirus (COVID-19) pandemic has had a noticeable impact on the supply chain of nearly every manufacturer. Whether it's frozen food and groceries or emergency items, even supply chain services face multiple hurdles. Determining strategies for dealing with such crises is indeed critical for manufacturing with complex supply chains. Biswas and Das (2022) study identified five fundamental barriers to supply chains, such as lack of manpower in Indian manufacturing during lockdown, local enforcement, lack of transportation, scarcity of raw materials and insufficient cash flow.

Transportation facilities must be competitive!

Infrastructure is the base for a country's development. Quality transportation and logistics system are indispensable for a country to advance their economy. International, interstate trades all reply on efficient transportation system, which includes subsystems such aviation, railway, road and seaport. To become an international logistics hub to support country's development, India knows the importance of backbone of its economy, in particular, if it wants to become the production base or consumer side of the international supply chain.

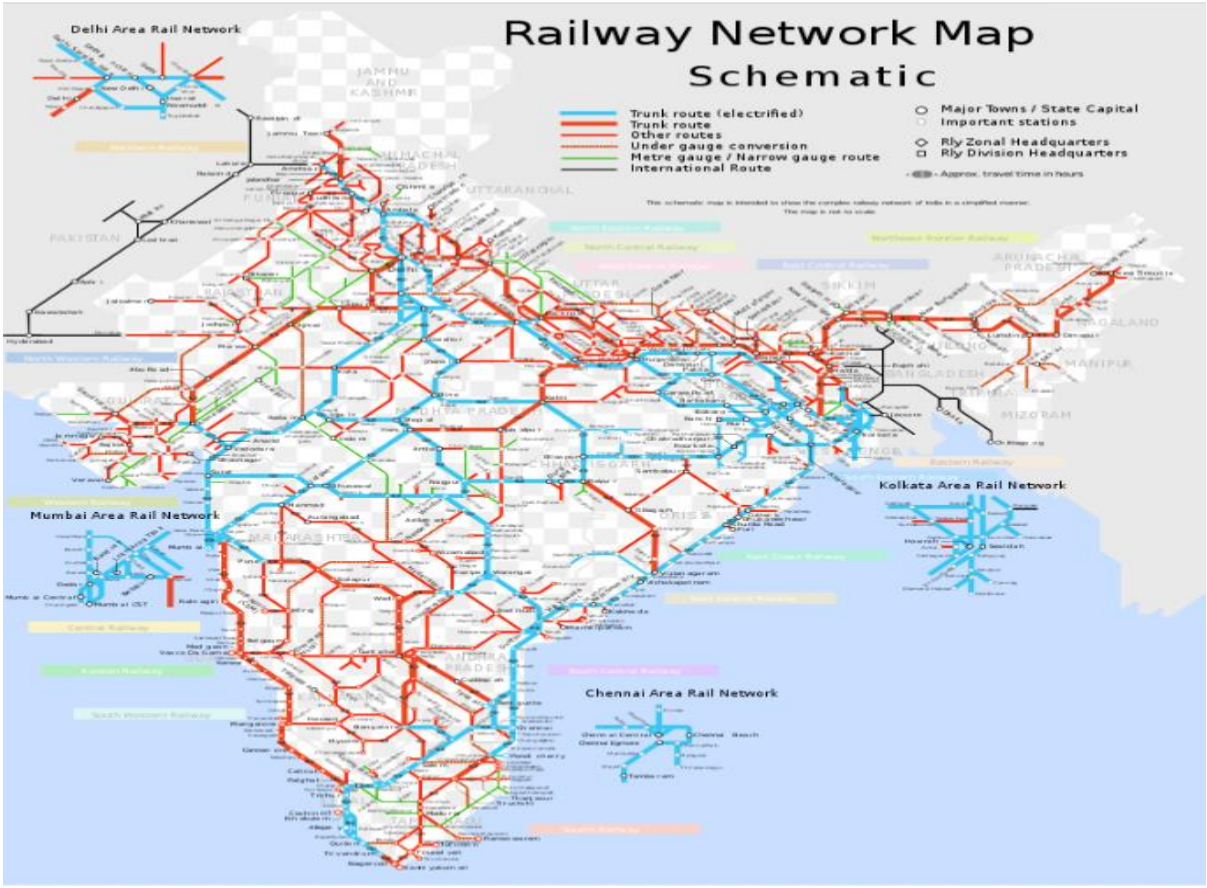

Figure 2 Transportation system in India

Source: CC-by-sa Plane Mad/Wikimedia retrieved 6 September, 2022

from https://en.wikipedia.org/wiki/Rail_transport_in_India#/media/File:Railway_network_map_of_India_-_Schematic.svg

A schematic map of the Indian Railway network. Includes all major cities and all important junction stations.

The role that India can play in the future global supply chain

1. The difference between production in India and production in China

India claims to be the largest democracy in the world, so it has a lot to do with how it's managed in China and Vietnam difference.

The risk of a supply chain shock has never been more apparent than it is today in the wake of the heightened crises of the U.S.-China trade war, the COVID-19 pandemic and the war in Ukraine. Once seen as a panacea for economic development, global value chains (GVCs) are coming under increasing scrutiny in different parts of the world. The increasingly complex cross-border production processes expose companies and citizens to numerous risks. At the same time, it is becoming increasingly clear that greater integration into global value chains will not necessarily lead to improved economic outcomes or shared prosperity, especially for developing countries.

Chapman et al (2022) therefore took this as the theme and conducted research on India. This report explores how India can better integrate into global value chains while building resilience. The report also draws

on a survey of executives of 200 Indian and foreign companies in six sectors: aerospace and defense; automotive and auto parts; capital goods; electronic systems design and manufacturing (ESDM); new energy and renewable energy. renewable energy; and pharmaceuticals and medical devices. The report presents the main conclusions for India's entry into the future global supply chain, as follows.

1) India is a good opportunity to replace another supply chain in China.

2) Geopolitical developments provide good opportunities and information for investment decisions in India.

3) India's attractiveness depends on investment in human capital development and infrastructure

4) The industry is highly dependent on imports and exports. Therefore, due attention should be paid to imports.

5) Companies agree that India must reassess its trade policies. Trade policy is critical for successful integration into global value chains.

6) The most difficult barriers to expanding production in India include complex tax policies and procedures, the quality of infrastructure, and trade policy uncertainty.

7) The biggest limitation of companies participating in global value chains is that they must meet quality standards. Governments have a clear role to play in supporting businesses in these areas.

8) In the medium term, India should focus on strengthening its digital and physical infrastructure, strengthening financial and investment regulation, and ensuring clarity and certainty on trade policies and tariff rules.

2. How India can be part of global supply chain.

Adhikary et al. (2016) conducted an empirical study on supply chains in India. The study states that LSCM spending in India is around 13% of GDP and is therefore considered a growing sector in the country. And a vibrant, active and intelligent LSCM makes a meaningful contribution to improving business vision in the economy. The need of low-cost labors has pushed the industrial chain closer to India. Affected by the pandemic, low-cost manufacturing countries such as Vietnam and India have emerged around the world. According to statistics, the labor cost of general skilled workers in Vietnam is only 1/3 of China's, and India is even lower, maybe 1/5.

Digitization and smart supply chains are transforming food chains to help eliminate waste, improve food safety, and reduce the likelihood of a global food catastrophe. Abideen et al. (2021)'s research was designed to conduct in the systematic literature (2010-2021), and presented in a systematic review with the help of a bibliometric analysis of the aforementioned research agenda. The findings suggest that technological Industry 4.0 (IR 4.0) tools face specific barriers to application due to their scope and goals, while it has received more attention than any other tools.

Before the COVID-19 pandemic, Indian companies had been focusing on connected and lean supply chains, bridging the gap by improving supply chain efficiency. However, the pandemic has left most Indian companies facing severe supply chain disruption (SCD) due to undiscovered supply chain vulnerabilities. Sudan and Taggar (2021) study revealed that many Indian companies experienced significant disruptions in

transportation and logistics services, including impact on transportation and logistics data, time delays, cancellations of shipments due to cramped capacity, restricted circulation, closures. There are many ports and customs clearance is slow. This also adversely affects production and transport consignments, including logistics services, and causes delays and re-routing to end consumers.

The COVID-19 pandemic has affected global supply chains with unprecedented speed and scale, as research by Raj et al. (2022) points out, between various supply chain challenges. Labour scarcity (PSL) emerged as the most significant challenge, closely followed by material scarcity (SSM). The results also showed that supply inconsistency (PIS) was the challenge most related to other factors.

3. Will India show its strength in global supply chain through innovation and knowledge?

In early May, Japan selected six projects in the data, IT, medical and cold chain markets to work with India as part of an arrangement to counter China's dominance of supply chains in the Indo-Pacific region. "The projects will initially launch a demonstration program to help Japanese companies visualize their supply chains, upgrade logistics, facilitate trade procedures and diversify their production bases," the Japanese embassy said in a statement.

How capable is India's supply chain in terms of delivery time management? Jana (2010) investigates the activities of the Indian garment industry to supply Western markets, in particular to identify areas where supply chain management can be improved. Using focus group discussions, case studies and questionnaires, his analysis shows that long lead times in the pre-production area are a very worrying issue. However, Indian apparel manufacturers were found to be more cost-conscious rather than less aware of the time value of pre-production areas.

Gupta and Ramesh (2015) conducted research on the healthcare supply chain, which has been a subject of interest for many years. The healthcare supply chain is a dynamic process, and there are many factors that affect the stability of this supply chain, one of which is the operational management performance.

Singh's (2017) exploratory study of healthcare and hospital supply chains in India shows how, from a physician's perspective, is it possible to share medical decisions, using source applications such as Google Sheets and WhatsApp, considered a good approach.

4. India supply chain revolution

India has a long way to go to wean itself off its dependence on China. Amitendu Palit, a senior research fellow at the National University of Singapore's South Asia Institute, said it would be "a long time" before India's local production scale would be sufficient to meet the needs of Indian drugmakers. “By then, India will need to import bulk APIs from China. Reducing reliance on imports is very important to reduce disruptions in India’s pharmaceutical supply chain,” Palit said.

And in 2020, India banned more than 200 mostly Chinese apps, including the wildly popular video platform TikTok. Xiaomi India has been under investigation by Indian law enforcement agencies since February this year. The Central Law Enforcement Bureau, India’s agency for combating financial crimes, temporarily detained the company’s assets of about 4.8 billion yuan on the grounds that Xiaomi India violated India’s Foreign Exchange Control Act and illegally sent money overseas.

Automation is a recipe for solving today's problems in supply chains. Research by Ranjith and Massand (2021) argues that the major supply chain challenges facing industries today include significant reductions in imports, delays, impacted logistics and negative returns on investment. Recommended solutions to supply chain challenges are the use of automation and technology, meeting the changing needs of customers, and using optimization

How can a sustainable supply chain system be promoted? The paper by Lis et al. (2020) offers some perspectives, and scientific inquiry in this field revolves around questions including: (1) the human aspect, (2) sustainable supply Business Choice, (3) Manufacturing, (4) Circular Economy, (5) Efficiency, (6) Sustainable Practices, (7) Commerce, (8) Costs, (9) Environmental Impact, and (10) Textiles.

Research by Saxena and Gupta (2014) pointed out that information technology provides important information in supply chain management. Supply chain management and logistics involves optimizing the delivery of goods, services and information from suppliers to customers. An efficient supply chain makes a company competitive and profitable. Research by Mitra and Datta (2014) narrates that in recent years, research on Green Supply Chain Management (GSCM) or Sustainable Supply Chain Management (SSCM) has received increasing attention. Although GSCM/SSCM has been studied for both developed and developing countries, there is little information on GSCM/SSCM practices in India and the state of adoption of GSCM practices by Indian companies is still in its infancy, consumer awareness of environmental sustainability is rather low, and there is a lack of regulatory frameworks to promote environmental sustainability. Data analysis results show that supplier collaboration on environmental sustainability has a positive impact on environmentally sustainable product design and logistics, which in turn positively correlates with a company's competitiveness and economic performance.

5. Land infrastructure, other incentives

The use of preferential policies is an important factor in promoting industrial development. In addition, how to make it easier for manufacturers to obtain land is also an important consideration. Table 2 is the tariff schedule for Indian electronic products.

Table 2 the tariff schedule for Indian electronic products. (Reference A) Source: MAIT, MIC, (2008)

Item of product	Basic duty%	Aditional duty%	Escise duty%	Educational duty%	Total duty%
Computer (desktops, NB)	0	4	12	3	19.97
ADP machine	0	4	14	3	22.12
HDDs/FDDs/CD-ROM Dries/DVDs/Flash Drives/ Combo Drives	0	4	0	3	7.12
Other storage device	0	4	14	3	22.12
Microprocessor	0	4	0	3	7.12
ICs	0	4	14	3	22.12
Motherboard & Populated PCBs	0	4	14	3	22.12
Monitor (CRT&LCD) Printers and Plotters/Keyboards etc.	0	4	14	3	22.12

Parts & Accessories of Monitors and Projectors/Printers Multifunctional devices and plotters	0	4	14	3	22.12
Routers and Modems	0	4	14	3	22.12
Set-top boxes	0	4	14	3	22.12
Color data graphic display tube	0	4	14	3	22.12
MP3/Mpeg 4 players	5	4	8	3	22.47
Digital Camera (including still image video)	0	4	14	3	22.12
Cellular (Mobil) phones	0	4	0	3	7.12
Parts and Accessories of mobile phones	0	0	0	3	3
Packaged softwires	0	0	12	3	15.36

Safeguards with regard to supply chain workers are also important. : SAARC Business Association of Home-Based Workers (SABAH) Nepal, CLASS Nepal, Self Employed Women's Association (SEWA) BHARAT (in Delhi), Social Awareness and Voluntary Association (SAVE), three agencies working together on women in India and Nepal A survey was conducted They concluded that the details of work for domestic workers, the working environment, the nature and remuneration of agreements, access to social security and basic services, and supply chain transparency are important issues in supply chain management today.

Nimawat and Namdev (2012) conducted research specifically on green supply chain management in India. Green Supply Chain Management (GSCM) is an effective way to differentiate a company from its competitors, and it can greatly influence the success of a program. and Green Supply Chain Management includes four major activities; namely Green Procurement, Green Manufacturing, Green Marketing and Reverse Logistics With the increasing awareness of corporate responsibility and meeting the requirements of environmental policy provisions, Green Supply Chain Management (GSCM) is very important for Indian manufacturers. become more and more important. Because India's Environmental Performance Index ranking is not good and now wants to enter the global supply chain, it is bound to increase its strength in this regard.

Conclusion

This paper discusses the various difficulties faced by the viability of India as a global supply chain and how to overcome them. To achieve this goal, a national vision statement is necessary, which can unite the entire country to work towards this goal. And this goal - to make India part of the world's major supply chain is very possible.

Every country needs a vision statement that sparks the imagination and inspires greater efforts at all levels of society. This is an important step towards reaching a political consensus on a national development strategy that includes, inter alia, the roles and responsibilities of different actors in the economy, including central, state and local governments, and the private sector.

For India to become a part of the global supply chain, small and micro industries and mass organizations must also become part of all participating members. Identify potential risks and bottlenecks, identify possible solutions, and focus on achieving your goals.

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Performance Evaluation on the Promotion of Rural Health Teaching Strategy based on DEA Analysis in China

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Abstract

The urbanization development has resulted in young farmers' emigration to big cities, and the left middle aged and elderly farmers generally show declining physical and mental functions and are suffering from chronic diseases. Physical health is the major demands of the middle aged and the elderly. To protect the physical and mental health and enhance the quality of life, the government has positively promotion of rural health teaching strategy to reinforce preventive health care, make screening, and manage and prevent chronic diseases.

In this study, Delphi Method is utilized for drafting the performance evaluation indicators for rural health teaching strategy and Data Envelopment Analysis is applied to evaluate efficiency. Taking Zhejiang Province as the research object, cities in Zhejiang Province are selected total 13 DMUs in this study. The research results show that 1. 1 DMU presents strong rural health teaching strategy efficiency, 5 DMUs reveal the rural health teaching strategy practice efficiency in 0.9 and 1, and 7 DMUs appear the rural health teaching strategy practice efficiency lower than 0.9 and 2. the key factors in rural health teaching strategy are found out through sensitivity analysis to understand the sensitivity to efficiency. Finally, suggestions are proposed according to the results, expecting to help farmers present the knowledge and skill about disease prevention and health enhancement so as to promote self-preventive health care and further enhance health quality.

Keywords: farmer, health teaching strategy, performance evaluation

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Introduction

The urbanization development results in young farmers' emigration to big cities and the rest middle aged and elderly farmers generally present declining physical and mental functions and are suffering from chronic diseases. Physical health is considered as the major demands of the middle aged and the elderly. The government therefore positively conducts illness prevention and health promotion measures, reinforce preventive health care, make screening, and manage and prevent chronic diseases to protect the physical and mental health and promote the quality of life. In addition to the governmental coping measures, the middle aged and the elderly have to start from self-health management to positively protect and enhance the health. The goal of rural health teaching strategy lies in the practice of health behavior. It is critical in teaching strategy to form individual value from the awareness; especially, the value formed by farmer-centered value could really affect the attitudes and behaviors. Rural health teaching strategy should be the process to assist farmers in establishing correct health knowledge and value. Instructors should engage in the teaching with the attitude to improve farmers. As a result, the knowledge and skills of "farmers' health promotion" are urgently demanded. It therefore should draft strategies for learning courses related to rural health teaching strategy, provide learning opportunities for protecting farmers' health, design suitable teaching activity and contents, integrate community life and resources, and adopt coping strategies to have the middle aged and elderly farmers age healthily, successfully, and actively as well as to establish the harmonious society being close to, respecting, and pleasing the elderly. The rural health teaching strategy is evaluated the effectiveness in this study, expecting to help the middle aged and elderly farmers present the knowledge and skills of disease prevention and health enhancement in order to promote self-preventive health care ability and further enhance the health quality.

Literature Review

Rural health teaching strategy

Bo et al. (2015) indicated that a person engaging inrural health teaching strategy should present professional training, knowledge, and skills, asrural health teaching strategy was professional. Velasco et al. (2015) pointed outrural health teaching strategy transferring health knowledge, through teaching strategy strategies, into behavior models required for farmers and villages. Wang (2016) regardedrural health teaching strategy as the strategy beneficial to farmers' health; with planned and integrated methods, the participants voluntarily prevented, started, or maintained existing behaviors, rather than simply changing the behaviors. Kendrick et al. (2015) defined rural health teaching strategy as the subject covering definitely constructed learning opportunities, which contained to promote health training beneficial to individual and community health, enhance knowledge, and develop life skills. Von et al. (2015) pointed out rural health teaching strategy as the science and art strategies to enhance people's health competence, cultivate the health attitudes, and develop

the health behavior to further enhance the quality of life. Wang and Wang (2016) proposed the points of rural health teaching strategy as farmers and the behaviors, aiming to encourage farmers practicing healthy lifestyles, smartly applying existing health service, being able to individually or collectively make decisions, and improving personal health state and living environment. Kramlich and Dende (2016) indicated that rural health teaching strategy could design activity and evaluaterural health teaching strategy plans and activities to enhance farmers' health. Wu et al. (2016) regarded rural health teaching strategy as the combination of any planned learning experiences according to actual experiences or sound theories to provide opportunities and keep the knowledge, attitudes, and skills of health behaviors. Clark et al. (2016) mentioned that rural health teaching strategy concerned about farmers' health, enhanced farmers' knowledge, attitudes, and behavior changes through the support of teaching strategy, organization, economy, and environment, and facilitated the voluntary care of personal health. It concerned about the comprehensive physical, mental, spiritual, and social health, stressed on farmers' self-care, self-responsibility, community orientation, and interdisciplinary with holistic, humanistic, and lifelong teaching strategy.

Performance evaluation

Social resources are limited. The optimal utilization of limited resources has been the concern of managers. Efficiency and effectiveness are often used for measuring organizational ability in applying resources and achieving goals as the point in performance evaluation. Fatemeh and Pourmahmoud (2016) regarded efficiency as doing the thing right and emphasizing the use of correct means. It mainly measured the degree of the internal resources of an organization being effectively applied in short period. With the discussion of the relationship between inputs and outputs, it aimed to acquire the most outputs with the least inputs, or find out the method to reduce production costs in order to enhance the use benefit of resources, as well as regard the results as the reference for improving organizational productivity (Cairney & Stewart, 2015). Ohsatoa and Takahashi (2015) defined effectiveness as doing the right thing, indicating that an organization, under the premise of the customers acquiring the maximal value, utilized the ability to generate income with external business; it stressed on the measurement of ends, mainly discussing whether an organization effectively achieved the set goal within a period of time (Bedardb et al., 2015).

Efficiency could be the performance on transferring inputs into outputs, focusing on effectively utilizing preset production resources. In economics, the idea of Pareto Optimality (Zhou & Zhu, 2017) could be used for the further explanation. From the aspect of input orientation, an organization was considered efficient when, with the same outputs, increasing input resources or reducing the yield of several other outputs to increase the yield of the output. From the aspect of output orientation, an organization, with the same inputs, reducing production or increase several other input resources to reduce inputs, was efficient.

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Research indicator and objective

Establish of research indicator

By summing up above effectiveness evaluation indicators of rural health teaching strategy, Delphi Method is utilized for drafting the indicators. Delphi Method, also named expert judgment, is the group decision-making method with qualitative and quantitative characteristics and is interdisciplinary and future oriented. In the research process with inadequate data or unknown situations of certain issues, the anonymous expert survey with several runs of votes and feedback could reduce the different opinions down to the lowest for a commonly acceptable answer.

The so-called “experts”, according to literature suggestions, should present 1) interests in participating in Delphi Method survey, 2) rich information for sharing, 3) publically approved knowledge and technology in specific field, 4) expertise in the surveyed subject, including practical experience and theoretical research, and 5) agreement with the research results containing the personal special information. Kang et al. (2015) also indicated that an expert should present knowledge standard, reliability, and accuracy as well as show deeper knowledge of the industry than amateurs so that experts’ judgment was closer to the real conditions than it of ordinary people. The value of Delphi Method is established based on such answers.

Establishment of evaluation indicator

According to Delphi Method to establish evaluation indicators, the variables are defined as following.

(1) Input variable:

1. Financial dimension: including capitals of rural health teaching strategy personnel costs, pension, food expenses, overtime pay, and welfare and benefits.

2. Teaching strategy scale: containing the number of people for farmers’ health teaching strategy.

(2) Output variable:

1. Medical outcome: covering the number of medical utilization and seeking for medical aid.

2. Prevention outcome: activity to prevent from diseases, e.g., total number of people for vaccination and quitting smoking and drinking.

Research method and object

Aiming at Zhejiang Province as the research object, the cities are selected as the research samples. With “Delphi Method” and “Data Envelopment Analysis”, public statistical yearbooks of the cities are regarded as the performance indicator data of inputs and outputs for analyses. Total 13 DMUs are selected as the research objects in this study.

Efficiency evaluation method

Data Envelopment Analysis (DEA) is applied in this study to evaluate the efficiency. Unlike traditional regression analysis which seeks for the mean path from a series of data, DEA envelopes the data of various samples and attempts to find out the relationship that it presents the advantage for a good efficiency evaluation model. With linear planning technique, factors in the measurement of performance among various evaluated units could be taken into account, and units with similar characteristics could be compared the performance.

Empirical analysis of rural health teaching strategy outcome

Evaluation of rural health teaching strategy outcome

By substituting inputs/outputs in this study into CCR and BCC models, the overall production efficiency and pure technical efficiency of the cities could be calculated. By dividing the two, the returns to scale of the cities are acquired. The overall production efficiency, pure technical efficiency, and scale efficiency are organized in Table 1.

Table 1 Relative efficiency of cities

City in Zhejiang Province	overall efficiency	technical efficiency	scale efficiency
Hangzhou	0.99	0.98	0.99
Ningbo	1.00	1.00	1.00
Wenzhou	0.96	0.95	0.97
Shaoxing	0.88	0.86	0.90
Taizhou	0.80	0.81	0.80
Huzhou	0.85	0.86	0.85
Jiaxing	0.81	0.81	0.81
Jinhua	0.78	0.77	0.79
Quzhou	0.72	0.71	0.72
Lishui	0.94	0.93	0.94
Zhoushan	0.92	0.91	0.93

From Table 1, Hangzhou shows the overall production efficiency=1, as relatively the most efficient city; the rest cities reveal low overall production efficiency. Especially, Suqian appears the lowest overall efficiency, as relatively the most inefficient city. In other words, in addition to 1 DMU with the relative overall production efficiency=1, the rest 12 DMUs are relatively inefficient, possibly because they could not effectively apply inputs

or do not achieve the optimal production scale. It requires further analyses.

Sensitivity analysis

The risk evaluation in this study aims to analyze and find out key factors in rural health teaching strategy through sensitivity analysis. The inputs and outputs are removed step by step for DEA to understand the sensitivity to efficiency.

Table 2 Sensitivity analysis by removing single inputs and outputs step by step

DMU	Original relative efficiency	Removing financial dimension	Removing teaching strategy scale	Removing medical outcome	Removing prevention outcome
Hangzhou	0.99	0.93	0.92	0.90	0.90
Ningbo	1.00	0.96	0.95	0.94	0.93
Wenzhou	0.96	0.92	0.91	0.88	0.89
Shaoxing	0.88	0.83	0.84	0.80	0.81
Taizhou	0.80	0.75	0.76	0.73	0.74
Huzhou	0.85	0.80	0.81	0.78	0.77
Jiaxing	0.81	0.77	0.75	0.73	0.74
Jinhua	0.78	0.73	0.72	0.70	0.71
Quzhou	0.72	0.67	0.65	0.63	0.64
Lishui	0.94	0.90	0.89	0.88	0.89
Zhoushan	0.92	0.91	0.88	0.85	0.84
No. of efficient DMU	1	0	0	0	0

Data source: Self-organized in this study.

The research results are based on the sensitivity change; the sensitivity factors contain financial dimension, teaching strategy scale, medical outcome, and prevention outcome. From Table 2,

(1) The efficiency of all DMUs reduces after removing “financial dimension”. That is, financial dimension presents higher importance to all DMUs.

(2) The efficiency of all DMUs reduces after removing “teaching strategy scale”. That is, teaching strategy scale shows higher importance to all DMUs.

(3) The efficiency of all DMUs reduces after removing “medical outcome”. That is, medical outcome reveals higher importance to all DMUs.

(4) The efficiency of all DMUs reduces after removing “prevention outcome”. That is, prevention outcome appears higher importance to all DMUs.

Conclusion

From the efficiency acquired with DEA and the information of variables, 1 DMU, about 8% of all DMUs, shows strong rural health teaching strategy efficiency=1, revealing good practice efficiency of rural health teaching strategy; 5 DMUs, about 38% of all DMUs, show the rural health teaching strategy practice efficiency in 0.9 and 1, as marginal inefficiency, revealing that such rural health teaching strategy practice efficiency could be more easily enhanced; and, 7 DMUs, about 54% of all DMUs, appear the rural health teaching strategy practice efficiency lower than 0.9, as obvious inefficiency, where Suqian presents the lowest rural health teaching strategy practice efficiency. Along with domestic economic development and social advance, people concern more about physical and mental health, social adaptation, and quality of life. The society enhances the demands for rural health teaching strategy and health promotion, which therefore are encountering unprecedented challenges. In order to enhance national health quality, new health teaching strategy patterns are positively explored in Hangzhou. The first fixed place for rural health teaching strategy, Hangzhou rural health teaching strategy garden, was constructed in 2002. Along with the completion of Chinese Center for Disease Control and Prevention, a brand-new Hangzhou rural health teaching strategy garden was built in the city disease control center building. With the government's high emphasis on rural health teaching strategy, the new rural health teaching strategy model was highly concerned. Later on, Hangzhou, world-famous of gardens, seemed to appear lots of gardens with various forms and scales of rural health teaching strategy sites in the city and districts, and even towns, villages, and communities. Integrating interactive games, multimedia shows, entities, and specimens, the rural health teaching strategy gardens become the highlight in Hangzhou. Such health sites become the health knowledge acquisition stations for farmers. Health teaching strategy sites are a new-style exploration of rural health teaching strategy in Hangzhou. With the vivid intuitive image and interactive expression, the abstract concepts are visualized, the profound reasons are generalized, and the dull principles are brightened to attract the public, affect the public, and educate the public. After the practice in past years, the charm of rural health teaching strategy is manifested, the social effectiveness is witnessed, and the construction and operation create health beneficial environment as well as enhance the health awareness and self-health care capability of the crowd. It presents significant meanings on the reduction and elimination of health risk factors, prevents and controls major diseases and sudden public health events, protects and enhances people's health, and promotes population health quality.

Accordingly, the following suggestions aiming at rural health teaching strategy are proposed in this study.

1. The urgent demands for the knowledge and skills of rural health teaching strategy, local government draft health teaching strategy related learning courses aiming at livening up aging. Besides, middle aged and elderly farmers generally present rich life experiences that written materials and TV programs about chronic diseases suitable for middle aged and elderly learners could be developed. Teaching activity and contents suitable for middle aged and elderly learners could be designed to assist middle aged and elderly farmers in

knowing and preventing chronic diseases. Moreover, the integration of farmers' community life and resources allow middle aged and elderly farmers present the competence of disease prevention and health enhancement to promote self-preventive health care capability and further enhance the health quality for independent life.

2 The reinforcement of teaching strategy promotion, farmers' health promotion of high-risk groups, early awareness, and early control are the primary tasks for chronic disease prevention and control. The government therefore should change "the view of welfare" into "the view of teaching strategy" to provide the learning opportunity for rural health teaching strategy. Subject-based professional rural health teaching strategy courses therefore should be established for providing correct and complete knowledge and skills of rural health teaching strategy so that an individual could present health self-effectiveness for independent self-care, maintain healthy lifestyles, and practice prevention and care of chronic diseases for farmers' health.

3 Under the idea of global village, internationalization is an inevitable trend. Humans' future happiness and health could be co-created by connecting with the world. For this reason, the core capability development trend of rural health teaching strategy professions should be continuously grasped to reinforce the international connection. Besides, the consensus of rural health teaching strategy professionals should be integrated, attempting to promote it as rural health teaching strategy or the reference indicators approved by academic units. The earlier promotion could better establish professional value.

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One Solution for Good? Systematic Analysis of Industrial Human Resource Supply Chain: Study on the Educational Dilemma and Countermeasures of Declining Birth Rate in Taiwan

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Abstract

This study uses the concept of system analysis to explore the problem of industrial human supply chain, and conducts policy research on Taiwan's educational industry. Since the industrial human supply chain is an overall social issue, it is related not only to social welfare and employment policies, but also the consequences of educational policies. Therefore, this research can make concrete contributions to both industrial development and educational plans. This research mainly explores the following questions: 1) What is the relationship between the human resource supply chain and the education industry? 2) What measures can the government take in the face of insufficient human resource supply? 3) Is there a good policy that can take into account the industry development and education industry supply chain? In response to the above problems, this study adopts the research method of systematic analysis, and puts the current situation of the educational industry and the industrial domain into the same system for analysis, and therefore systematically compares the policies proposed by the government and other feasible solutions. This research conducts research on the policies adopted by Taiwan in the past three years regarding human resource shortages, and present comparative results. The results of this study point out that (1) the educational industry and enterprises should be inseparable, so the content of education should meet the needs of the industry. (2) The government is the most important role that affects the development of the industry, and the government has the responsibility to make good policies. (3) The work-study program that takes into account the needs of the educational industry and enterprises, and the introduction of international mobile students and employment populations is a good solution help to meet the needs of industries and employment in various countries.

Keywords: Human resource, Supply Chain, Educational Policy, Low Birth Rate, Tertiary Education

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Introduction

Research background - low birthrate and university exit

According to reports, Taiwan's birth rate has continued to decline since the 1980s. In 2010, Taiwan became the country with the lowest birth rate in the world. This situation remains unchanged by 2021. The average freshman registration rate was 83.4% in 2011. Since then, the number of births in Taiwan has continued to decline. As of 2021, the registration rate of colleges and universities across the country has never reached 90%, and the registration rate of private technical and vocational colleges has maintained 80%. The impacts of low fertility and declining birthrate on education are that schools are facing a shortage of students. They are financially not able to support their sustainable development, and some of them had to face the crisis of closure.

The Ministry of Education in Taiwan has targeted tertiary education institutes with fewer enrollment numbers, encouraging them to take the initiative to propose transformation plans in advance, effectively use the resources that has already invested, and actively develop college characteristics and suitability through restructuring or adjusting the current scale and operation direction.

The Ministry of Education also expects to establish the "Tertiary College Transformation and withdrawal mechanism fund" from the year of 2016. During the transformation withdrawal period, colleges can borrow from the fund to carry out transformation planning, or to pay for the pensions of faculty and staff. Expenses such as severance payments and concessionary grants can be obtained through financing to protect the rights and interests of relevant personnel.

Importance of Research - Human Resource Supply Chain

The problem of declining birthrate is an important educational issue in Taiwan in recent years that requests for urgent solutions (Gao & Chen, 2015; Chen, 2016; Zeng, Zhang, & Guo, 2009; Yang, 2013; Shiokawa, 2006). According to statistics from the Department of Household Affairs of the Ministry of the Interior, Taiwan's total fertility rate in 2010 reached a record low, and the fertility rate dropped to 0.895, making it the country with the lowest fertility rate in the world (Chen, 2016; Wang, 2012). According to another statistic record, from 1990 to 2010, the number of newborns in Taiwan dropped from 321,932 to 196,627 in 2021, a decrease of 125,305 or 38.92%. Taiwan will lose 180,000 workers every year since 2015 on ward. After 10 years of accumulation, there will be a gap of 1.8 million workers of human resources supply (Cheng, 2015), which created a significant impact on Taiwan's future development and international competitiveness.

Previous research results

The essence of the problem is the collapse of the academic industry and the hollowing out of industrial manpower. People tend to interpret it as a natural phenomenon of industrial competition. Colleges with poor performance naturally should be abandoned by the market. The government should no longer spend money to subsidize it and should allow it to collapse and fend for itself. Under this severe situation, many inappropriate

policies followed, such as forcing the withdrawal of private schools, making a field that can create scientific and technological human capital go to waste. Therefore, in order to avoid this regret from self-repetition, it is necessary to do in-depth research on this issue.

Issues not addressed by predecessors

From a system analysis point of view, the ideal state of the supply chain is a balance between supply and demand. With a decrease in the number of births, Taiwan must face the problem of an imbalanced problem between supply and demand of industrial human resources. The chairman of MediaTek, a leader in Taiwan's high-tech industry, pointed out with great concern that due to the continuous decline of Taiwan's population, Taiwan must face three industrial crises. The first crisis is the lack of technology professionals cultivated by Taiwan itself, the second is the inability of university education to connect with high-tech education, and the third crisis is that these problems will lead to the backwardness of Taiwan's technology development (Chen, 2021).

The research question of this study

The problem with Taiwan's education supply chain is the lack of students. The problem of Taiwan's industry is the shortage of labor. The lack of students in the education supply chain has caused the collapse of the education industry. The shortage of industrial labor force has resulted in the hollowing out of the industry. Therefore, we will discuss the following research questions:

1. Can we find an effective way to solve this problem?
2. What is Taiwan's solutions to this problem? Does it work?
3. What can the cases of Taiwan's education industry policy and labor force policy tell us?
4. From the perspective of supply and demand, what kind of business strategy should be maintained in the education industry chain?

Innovation and contribution of this research

The educational industry is also a research topic in supply chain research. Technical colleges will face the impact of the low birthrate problem earlier than the industry. This problem has become an existential crisis that technical colleges must face. Colleges and universities are responsible for educating national talents and carry an important responsibility of the last mile education. After graduation from tertiary institutes, students will enter the industry service and supply the labor force required by the industry. There are as many as 160 colleges and universities in Taiwan. The number of college students admission exceeds the total number of high school graduates, and the admission vacancy has reached 20%. Insufficient admissions creates difficulties for the operation of these institutes. In the face of such an education crisis, this paper attempts to discuss the impacts of Taiwan’s various educational policies on the tertiary educational institutes and its consequences.

Literature review

System Analysis Theory

System analysis, which aims to study the interaction of each part (each subsystem) in a specific system structure, the external interface and interface of the system, as well as the overall behavior, function and limitation of the system, so as to provide reference for the future changes of the system and related decisions and basis. One of the frequent goals of system analysis is to improve the decision-making process and system performance in order to achieve the overall optimization of the system.

Therefore, the development of the education industry and the human resources supply chain of the industry can be regarded as a system. The education sector needs to cultivate good-quality manpower for the industry, and for its own development, the industry must send personnel to the school for further study, and after completion, they will become high-quality manpower in the industry. The whole process is a continuous cycle system, as shown in Figure 1.

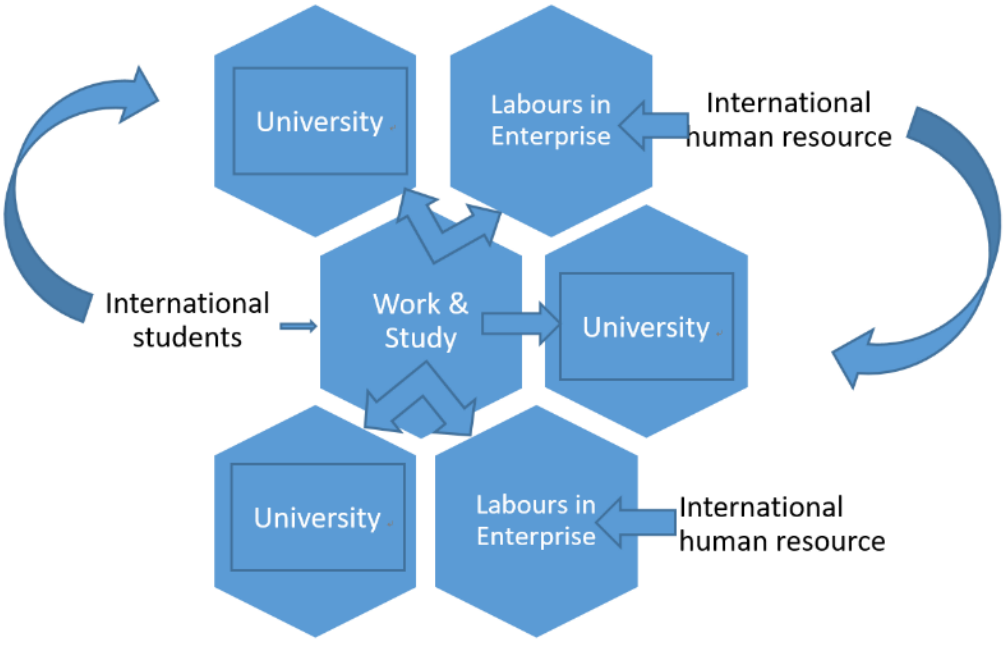

Figure 1 Viewing the education industry supply chain through systematic analysis

Education Industry Chain

We can link the supply and demand management of human resources in the education industry chain with the industry, and the dynamics of this system can be easily analyzed. The customer end of the education industry chain is students, so the education industry must be easy to operate in a place with a high birth rate. The product of the education industry is graduates, so graduates must meet the needs of the industry before customers (students) are willing to come in. Otherwise, if they can't find a job after graduation, customers (students) are reluctant to buy this kind of product.

Human Resource Supply Chain

Human resources supply chain is about supply chain manpower planning, which means that given production (or service) plans, labor costs, work procedures (such as maximum working hours) and other information, the manpower planning system can make some feasible employee plans to ensure providing the required labor at the lowest cost at any time. In order to achieve its development goals, an organization forecasts the supply and demand of human resources are required, and formulates systematic human resources policies and measures to meet its own human resource are in need.

Only when the supply chain manpower plan fully considers the changes in the internal and external environment can it adapt to the needs and truly serve the development goals of the enterprise. Internal changes mainly refer to changes in sales, development, or corporate development strategies, as well as changes in the flow of company employees; external changes refer to changes in the social consumer market, changes in government policies on human resources, and changes in the talent market. In order to better adapt to these changes, the human resource plan should make predictions and risk changes in the possible situations, and it is best to have coping strategies to face risks.

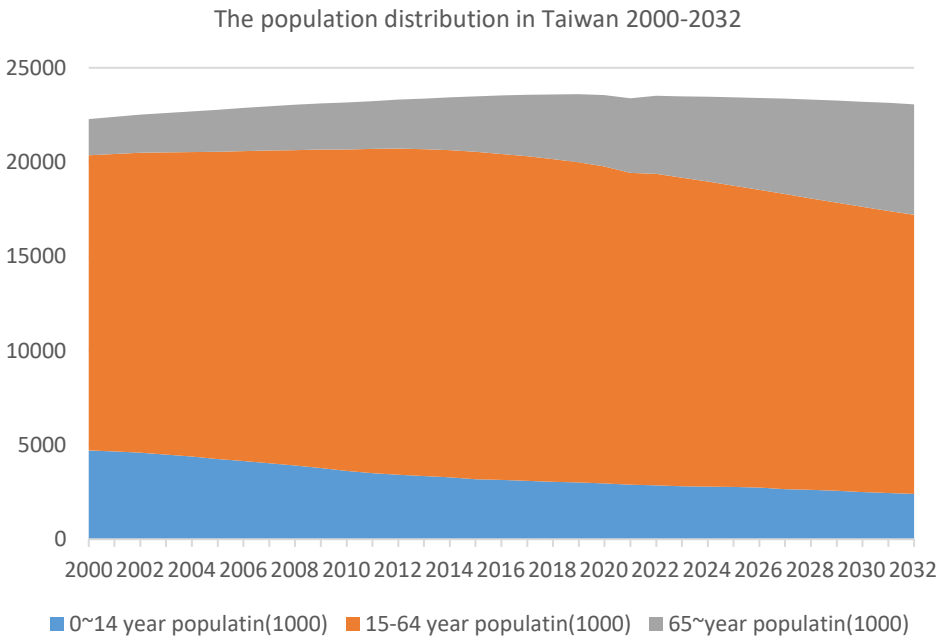

Figure 2 Distribution of population growth rate and population structure in Taiwan Source: National Development Commission Population Estimation Inquiry System
https://pop-proj.ndc.gov.tw/chart.aspx?c=13&uid=4113&pid=60

As can be seen from Figure 2, Taiwan has a big problem with its population structure. The workable labor force between 15 and 64 will continue to decrease in the next 10 years, which is very unfavorable for Taiwan's industrial development.

Research methods

Case Study Method - Education Industry Policy in Taiwan

This paper adopts a case study method to analyze the policies adopted by the Taiwan government when it faced the two major crises of educational industry exit and industry hollowing caused by the declining birthrate.

Case Study Method - Industrial Human Supply Chain Policy in Taiwan

Secondly, it analyzes Taiwan's industrial human supply chain policy, to explore whether education industry policy and industrial human supply chain policy can complement each other from the perspective of systematic analysis.

Results and Discussion

Taiwan's past commendable vocational industry policies

Taiwan's economic growth is closely related to the development of technical and vocational education, which is an important driving force for Taiwan's social progress and economic prosperity. After World War II in 1945, Taiwan's Ministry of Education actively subordinated technical and vocational education, which was listed as an important infrastructure project for national development. In the 1960s, the Ministry of Education encouraged Taiwan's private sector resources to invest in technical and vocational education to provide sufficient intermediate industrial manpower for Taiwan's economic transformation. Later on in 1974, Taiwan's first degree-granting technical college was established. At this time, a complete technical and vocational education system was then established.

The development of technical and vocational education has provided a large number of high-quality labor power for Taiwan's economic development. This educational system cultivated middle-level technical personnel with academic background and technical skills, and created a technology-oriented economic miracle for Taiwan in the 1970s and 1980s (Taiwan Labor Front, 2021). In order to build a high quality technical and vocational education equipment, the Ministry of Education continued to promote the 'Technical and Vocational Education Reconstruction Program' in 2009 and 2012, investing a good amount of resources to improve the teaching and learning quality of technical and vocational education. Technical and vocational education has undergone several transformations and reforms, in line with the focus of Taiwan's industrial development, and continuing to cultivate professionals for Taiwan's industrial development.

The development of Taiwan's vocational and technical education industry is facing a crisis due to the low birth rate

However, even though technical and vocational education has helped created a miracle for Taiwan's economic development, Taiwan's educational policy was inevitably caught in the myth of world university rankings. In order to upgrade Taiwan universities' ranks among world educational ranking, many national

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universities have received extremely abundant education funds (Ministry of Education, 2014a) to improve their teaching and research facilities, which has encouraged high school graduates move towards research oriented comprehensive universities. As a consequence, technology and vocational education has become students' second choice.

For a long time in Taiwan, the allocation of educational resources to colleges and universities over technical occupations (Xu, 2012) has directly affects students' choices for further education. Under the influences of Confucianism, Taiwanese society generally attaches great importance to diplomas, and the concept of "everything is inferior, only high education is respected " is deeply rooted; coupled with Taiwan's economic development, general families' income has increased, parents do not need or want their children to work too early (graduated from 2-year colleges). Going to university has become a social ethos in Taiwan (Lai, 2013).

According to the statistics of the Ministry of Education, since 2010, the number of students enrolled in high schools has decreased from 350,000 to 320,000 each year, but the number of students in vocational colleges has dropped from 390,000 to 390,000. Reduced to 300,000 (Wu, 2020), the source of students in technical colleges is mostly coming from vocational high schools, and the number of students lost by vocational schools is three times that amount of high school students. During 2008, the proportion of vocational students in the same age group was 52.07%; by 107, the proportion of vocational students had dropped to 48.02%. The reduction of vocational students will directly affect the number of students that can be recruited by technical colleges.

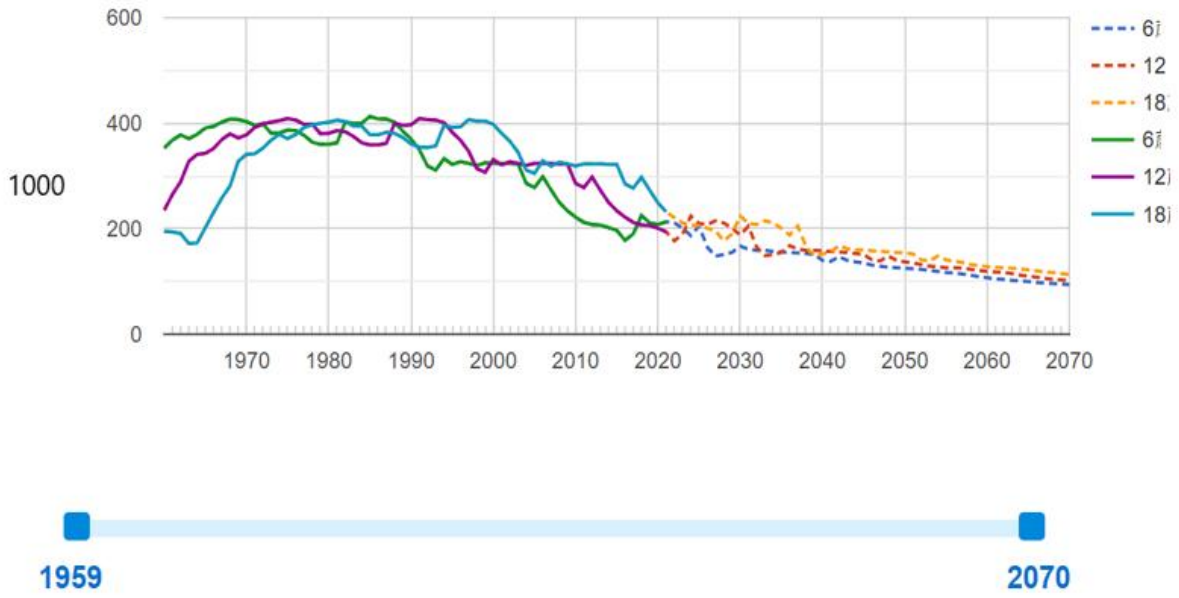

Figure 3 Demographics of Taiwan's school-age groups Source: National Development Commission Population Estimation Inquiry System https://pop-proj.ndc.gov.tw/chart.aspx?c=13&uid=4113&pid=60

The task of technical and vocational educational institutes is to cultivate all kinds of practical professional and technical talents. Each tertiary institute needs to construct a full range of teaching facilities and hire teachers with professional experiences. Generally, universities mainly teach theories. In contrast, technical and vocational education requires more investment. The source of students is a key indicator of the colleges' survival. The task of teachers is no longer simply to do a good job in teaching, but they also need to take the responsibility of recruiting students, as this is an immediate and obvious survival pressure.

Inappropriate policies that make the development of Taiwan's vocational and technical education industry face a crisis

Faced with the problem of insufficient amount of students, the direction of the bill formulated by the Ministry of Education is obviously difficult to respond to the industry's demands. In 2017, the Ministry of Education launched the draft of "The Regulations of withdrawing Private Senior Secondary Schools and Tertiary Institutes" (Ministry of Education, 2017). The rationale presented the legislative logic of the Ministry of Education. The Ministry of Education believes that insufficient students will lead to financial deterioration of colleges. In order to save teaching expenditures, colleges will inevitably reduce the quality of teaching (for example, combining classes and therefore affecting students' rights to education). Schools with poor teaching quality must accept the elimination mechanism from this free competition market. The task of the Ministry of Education is then to develop an exit mechanism that expels colleges that are not strong enough to survive, rather than to make these colleges continue to play their educational role.

The Ministry of Education argued that as 'tuition and miscellaneous fees are important sources of income for colleges and universities, and the reduction of student will seriously affect the college financial structure', the Ministry of Education further argues that it will result in unforeseen consequences on the issue of teaching quality. The Ministry of Education made another daring presumption: low enrollment rate will lead to low income of the colleges. For the purpose (merely) of saving the cost of teaching faculties' hourly teaching fees, the college will inevitably put students from different departments of low enrolment in one classroom for saving the expenses of teaching, and that will seriously damage those students' educational rights. This assumption, exhibits a general distrust of the college with low registration rate. The draft was submitted to the Legislative Yuan in 2016 and was approved in May 2022. In 2021, some legislators directly predicted that by 2029, at least 40 colleges and universities will be closed as there will be no students admitted to them. They called on the Legislative Yuan to review and pass the bill to release the land and property of those private colleges (Pan, 2021a). Apparently, the legislative spirit of this bill is not to continue those colleges' educational duty. The bill fails to solve the problem of insufficient human resource supply chain.

As early as in 2014, the Ministry of Education has formulated a notice on 'Precautions on protecting students' rights and interests of education in colleges and above' (Ministry of Education, 2014b). In this notice, the Ministry of Education directly defines colleges with low enrollments are colleges with poor educational quality. The Ministry of Education claims that the purpose of this notice is to 'maintain the teaching quality of college, and ensure the rights of students to be properly taught'. The content of this bill, again, consistently

shows a distrust of the teaching quality of colleges with insufficient enrolment rate. The Article 4 of the Regulations defines that if the number of students in each grade of the college lower than 30 students or the enrollment rate is lower than 80%, they will have to accept the inspections from the Ministry of Education

The title of this notice is called 'Precautions' (Ministry of Education, 2017). it was granted with the power as an executive order from the Ministry of Education. The practice of the inspection includes requiring colleges to submit written reports every semester. The representatives from the Ministry of Education can carry out the inspection and visit colleges without prior warning (Pan, 2021b). On-campus inspections include that the inspectors can go into the classrooms in the middle of teaching for counting how many students attended the classes, for checking whether the professors are on time for class. Scholars warned that these behaviors have violated the constitutional guarantee of universities' Academic freedom (Pan, 2021b). College with poor inspection results will lead to restricted admissions of students and reduced financial subsidies from the Ministry of Education.

Facing the phenomenon of low birthrate, Taiwan can adopt the best education industry chain policy

The first step is to use fiscal and tax subsidies to assist the industry. The Taiwanese government can use fiscal and taxation methods to assist the industry, as well as subsidize a large amount of funds to colleges that are eligible to recruit overseas students.

Secondly, it is also a feasible way to introduce students because of the manpower required by the industry. Taiwan has a very good manufacturing industry, but due to the lack of labor, a large number of them have moved to China and Southeast Asia, resulting in the hollowing out of the industry. Therefore, it is a win-win strategy to recruit students to help meet the needs of industries with insufficient labor, and to help students earning their educational fees.

Further discussion

Both regulations exhibit a general distrust of the teaching quality of those tertiary technological institutes with lower student registration rate. Considering the industry's worries of the insufficient supply of industrial human resources, which directly impact the national industrial and economic development, the above-mentioned two decrees of the Ministry of Education obviously cannot fully respond to the supply shortage of human resources in the industry.

Taiwan government has invested in educational resources for a long time, and that has established a full range teaching facilities for cultivating technical professionals. Faced with the issue of insufficient supply of human resources in the local industry, the Ministry of Education should not just let technical colleges dropped out from this free market due to the lack of students. On the contrary, Taiwan should expand the opportunities for international students to study in Taiwan, formulating a friendly immigration policy, and encourage international students to stay in Taiwan to serve after completing their studies. The Ministry of Education should consider lifting the restrictions on the admissions of foreign students, providing incentives such as scholarships

and grants. The formulation of friendly immigration policies will mitigate the impact of declining birthrate and labor force to Taiwan's economy, society, and national prosperities.

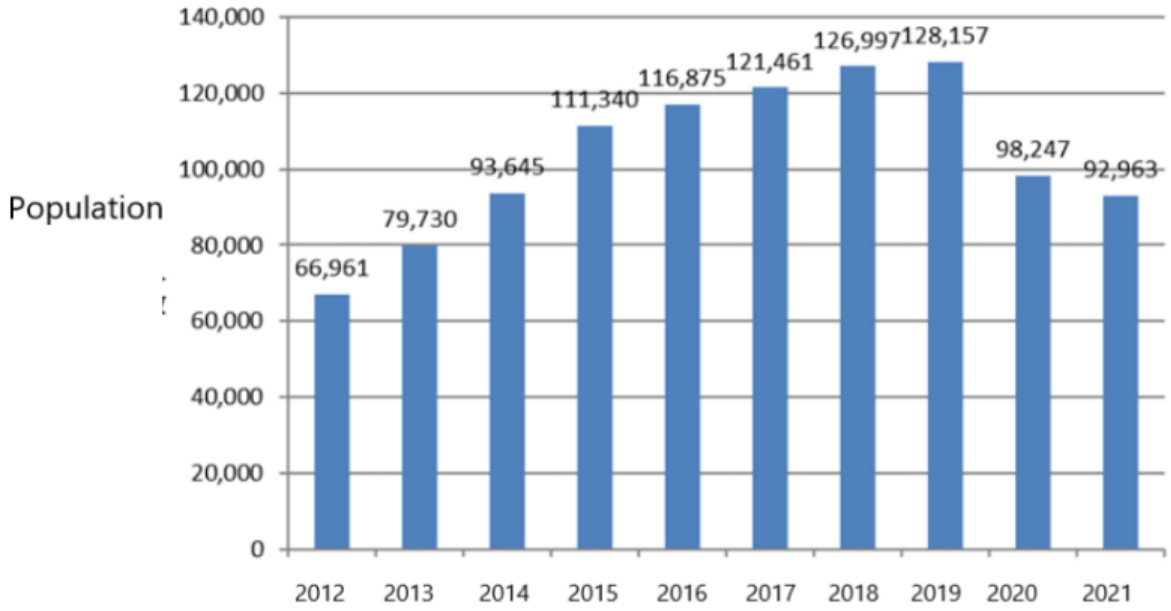

Figure 4 The number of foreign students admitted to Taiwan in the past ten years (from Ministry of Education Statistics Database)

CONCLUSIONS AND RECOMMENDATIONS

Faced with the imbalance between working forcessupply and demand, the Ministry of Education, has at least two options. One option is continuing the current policy direction. The direction of the current policy is not to make the technical vocational system continue to play their educational role of training technical human resources to ensure a lower shortage of industrial talents. Rather, the policy tends to make those colleges with insufficient students to withdraw from this educational market. The disappearance of a tertiary institute means that the college teachers and the existing teaching facilities will no longer continue to play its educational role, making the problem of insufficient industrial human resources even worse.

Another option is to consolidate the tertiary vocational institutes' survival opportunities, expand the admissions of international students to study in Taiwan, to strengthen teachers' teaching capacities for teaching international students, to assist the administrative units to serve international students After completing their college education, those international students have the advantages of bilingual ability, academic education and professional skills, that will help promote the future international development of Taiwanese industries. How to continue to make good use of existing educational resources and ensure the quality and quantity of the industrial human supply chain under the social trend of low birthrate and aging population in Taiwan will test the foresight and wisdom of the educational authorities.

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Author Guidelines

For Paper Submission and Manuscript Preparation

General Instructions

The Journal of Supply Chain and Sustainability Research (SCSR) accepts research papers, academic articles, and review articles written in Standard British or American English, not a mixture. Poorly written English may result in rejection or return of the submission for language editing. The articles must fall within the aim and scope of the journal, that is, science, social science, technology, management, and related issues (see about Journal).

Please note that papers in these areas in order to be published in the SCSR journal Research or academic papers must be 15-20 pages in length inclusive of references, tables, graphs, charts, and figures.

For research papers, the author is advised to include all elements of the structure below:

- **Title** of paper must be clear, concise, and informative, all in uppercase within three typeset lines.
- **Abstract** (150-250 words) Abstracts must include sufficient information for readers to judge the nature and significance of the topic, the adequacy of the investigative strategy, the research results and conclusions. The abstract should summarize the major results of the work and not merely list topics to be discussed. It is an outline or brief summary of your paper in a well-developed paragraph, should be exact in wording, and understandable to a wide audience.
- **Keywords** (3-5)**,** immediately after the abstract**,** keywords are for indexing purposes, and should be different from the title.
- **Introduction** This section provides necessary background of the paper and a brief review the existing knowledge, and importance of the problem.
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Example: Maslow (1970) asserts that……; ……. (Maslow, 1970)
Wang and Pettit (2021).....; ..... (Wang & Pettit, 2021)
Hisrich et al. (2020)……;……. (Hisrich et al., 2020)
Novack et al. (2018)……; ……. (Novack et al., 2018)

- **Research Methodology** This section indicates clear research objectives, conceptual framework(s) (if any), research question(s), hypotheses, population and sample, research instruments, and the data collection process. This section provides clear steps used in conducting your research. It means all procedures need to be described in sufficient detail to allow someone to replicate it.
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For academic articles, we recommend the structure below:

1. **Introduction**
2. **Discussion**
   - **2.1 subheading**
   - **2.2 subheading**
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The author is advised to follow a logical, understandable point of argument. Break your main argument into sub-headings and present them in an outline at the end of the Introduction.

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Authors are welcome to submit their manuscripts.

All submissions will be given an initial check by our editorial team, within **6-8 weeks after submission date** you will be notified of the initial check result on thaijo system. Only the article which passes the initial check will proceed to the review process (6 -8 weeks). The author will be kept informed of the current status of their paper.

Articles being currently considered for publication by other journals will not be accepted by The Journal of Supply Chain and Sustainability Research (SCSR). If the author withdraws or sending a manuscript to other journals any time after the manuscript has been sent to peer review till the final decision, the Journal will charge the author a penalty fee for its time and resources spent. The authors must always pay the page charge even if the withdrawal is permitted.

Specific Instructions:

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- **Font Size and Type**. Browallia New font (20 pts. bold for title; 14 pts. for author(s) and affiliation; 16 pts. bold for headings and 16 pts. bold subheadings; and 14 pts. for text)
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- **Headings** should be in bold type, in 16 point Browallia New font. First-level headings should be aligned to the left with initial caps. One line space should separate headings from the preceding text.
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- Include only those sources you have cited in your paper.
- Position the first line of each reference flush left, with subsequent lines wrapping with a ½-inch (hanging) indent.
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Wang, Y., & Pettit, S. (2021). *E*- Logistics (2nd ed). U.S.A.: Kogan page.

- **Tables and Figures**
  - Line drawings should be of high resolution and high contrast. For color or grayscale photographs (halftones), use a minimum of 300 dpi (.JPG).
  - Provide captions to figures
  - Use the table function of Microsoft Word.
  - Figure and tables should be placed as close as possible to where they are mentioned in the text
- **Page Numbering**: Number all pages of the paper, beginning with the title page. The number is in the bottom right corner (1 inch from right and ½ inch from the bottom page edges).

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3. Where available, URLs for the references must be provided.
4. Research or academic papers must be 15-20 pages in length inclusive of references, tables, graphs, charts, and figures.
5. The text must be double-spaced; (a 14-point font Browallia New; italics rather than underlining except for URL addresses); and all illustrations, figures, and tables must be placed within the text at the appropriate points, rather than at the end.

6. The text adheres to the stylistic and bibliographic requirements outlined in the Author Guidelines.
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