FACTORS AFFECTING SUSTAINABLE URBANIZATION AMONG FIVE ASIAN HIGHLY INDUSTRIALIZED COUNTRIES (HONG KONG, SINGAPORE, SOUTH KOREA, JAPAN, CHINA)

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DECLARATION

We hereby declare that:

1) This undergraduate FYP is the end result of our own work, and that due acknowledgement has been given in the references to ALL sources of information be they printed, electronic, or personal.

2) No portion of this FYP has been submitted in support of any application for any other degree or qualification of this or any other university, or other institutes of learning.

3) Equal contribution has been made by each group member in completing the FYP.

4) The word count of this research report is 15740 words.

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DEDICATION

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LIST OF ABBREVIATIONS

ARCH	Autoregressive Conditionally Heteroscedasticity
ARDLBT	Autoregressive Distributed Lag Models with Bounds Testing
ASIAN	The Association of Southeast Asian Nations
BPLM	Breusch-Pagan Lagrange multiplier
CCR	Canonical Cointegration Regression
DCCE	Dynamic Common Correlated Effects
DIF-GMM	Differential Generalized Method of Moments
DOLS	Dynamic Ordinary Least Square
DWH	Durbin-Wu-Hausman
EDL	Economic Development Level
EKC	Environmental Kuznets Curve
EL	Education Level
FEM	Fixed Effects Model
FMOLS	Fully Modified Ordinary Least Square
GDP	Gross Domestic Product
GMM	Gaussian Mixture Model
IS	Industry Structure
IQ	Institutional Quality
LC	Low Carbon
LNEDL	Logarithm of the Economic Development Level
LNEL	Logarithm of the Education Level
LNIS	Logarithm of the Industry Structure
LNIQ	Logarithm of the Institutional Quality
NBER	National Bureau of Economic Research
OCED	Organization for Economic Co-operation and Development
OLS	Ordinary Least Squares
PCA	Principal Component Analysis
PCA-SBM	Principal Component Analysis with Slack Based Measurement Model
POLS	Pooled Ordinary Least Square
REM	Random Effect Model

SDG	Sustainable Development Goals
SU	Sustainable Urbanisation
SYS-GMM	System Generalized Method of Moments
TOPSIS	Technique for Order of Preference by Similarity to Ideal Solution
UK	United Kingdom
UNESCO	United Nations Educational, Scientific and Cultural Organization
USA	United States of America
VECM	Vector Error Correction Model
VIF	Variance Inflation Factors

PREFACE

The topic of this research is "Factors Affecting Sustainable Urbanization Among Five Highly Industrialized Asian Countries". The purpose of this research is to investigate the factors that influence sustainable urbanization in highly developed and industrialized Asian countries such as Hong Kong, Singapore, South Korea, Japan, and China. Sustainable urbanization refers to the creation of environmentally friendly, socially inclusive, and economically viable cities. It involves designing sustainable and livable cities for present and future generations.

In this research, the impacts of those factors comprising economic development level, education level, industry structure, and institutional quality on sustainable urbanization in Hong Kong, Singapore, South Korea, Japan, and China will be examined as well. Through this research, the reader will have a greater understanding of the specific factors that influence the sustainable urbanization of Hong Kong, Singapore, South Korea, Japan, and China, as well as their relative importance.

ABSTRACT

This research aims to investigate the factors that influence sustainable urbanization in highly industrialized and developed Asian countries such as Hong Kong, Singapore, South Korea, Japan, and China. In addition, this study examined the relationship between the dependent variable which is sustainable urbanization, and each factor influencing sustainable urbanization in highly industrialized Asian countries. The factors include the economic development level, education level, industry structure, and institutional quality.

This research uses annual data for the independent variables from a sample of five developed Asian countries from 2010 to 2019. The data used in this study are secondary data with a total of 50 observations. Based on the panel data, we subsequently utilized Pooled Ordinary Least Squares (OLS), Fixed Effect Model (FEM), and Random Effect Model (REM) to analyze the significance of the factors that influence sustainable urbanization. Using the Hausman Test, Redundant Fixed Effect, and Breusch-Pegan Lagrange Multiplier Test (LM), the most effective estimated model was chosen. The diagnostic checking for autocorrelation, heteroscedasticity, and multicollinearity are also conducted in order to identify any economic issues underlying the model.

CHAPTER 1: INTRODUCTION

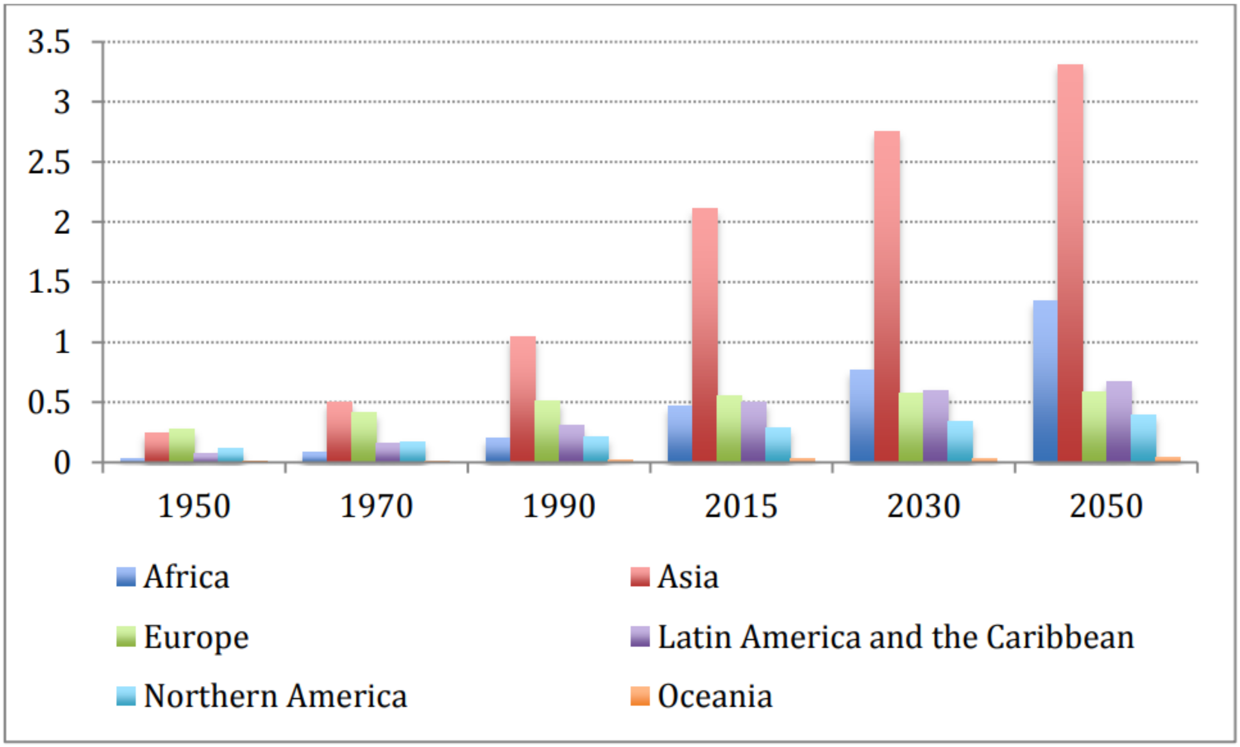
1.0 Introduction

This chapter is going to start with a short introduction to the concept of sustainable urbanization. With the research, the relationship between sustainable urbanization and the factors affecting sustainable urbanization among five highly industrialized Asian countries (Hong Kong, Singapore, South Korea, Japan, and China) from the years 2010 to 2019 will be determined. We will provide the research background, problem statement, research objective, research questions, significance of the study, and chapter layout in this chapter. In the end, we will have a conclusion summarizing the main points in Chapter 1.

1.1 Background of study

Urbanization is a mechanism that happens when a country's population changes between rural to urban areas, with the percentage of people residing in urban areas developing stronger than in rural areas. As a result, the population grows more urban overall, involving adaptation from the viewpoint of people who live in both cities and rural areas. The primary mechanism underpinning the establishment and development of cities is urbanization. Urbanization is an unavoidable long-term factor affecting countries that are both developed and developing. In other nations, specifically the United Kingdom and the Netherlands, the number is greater than 70% and rising. According to the World Bank, the world's population has rapidly increased from 3.03 billion in 1960 to an estimated 7.95 billion in 2022, with urban regions contributing to approximately 56% of the population as of 2022, or over 50 percent of the total. According to World Population Review (n.d.), as shown in Figure 1.1, by 2050, the entire world's population is predicted to expand by 68%, adding roughly 2.5 billion people to cities worldwide. Additionally, it has been projected that Asia and Africa will be responsible for 90% of this rise.

Figure 1.1: Urban Population by Region from the year 1950 to 2050



Source: UN DESA.

Rather, less-populated areas have been considered to be the most environmentally sustainable. However, from the viewpoint of the environment, what matters is the quantity of pollution and filth all cities together produce, not how green the city in question is. Big cities compact a lot of people into a tiny area, and more than twice as many people together are going to generate more pollution than one. To minimize a system of cities' overall consumption of energy, it must be determined whether to distribute the citizens across several smaller cities or focus it on a few of the biggest. The primary outcome of sustainable urbanization indicates that we could improve output while improving environmental protection (Eeckhout & Hedtrich, 2021).

Sustainable urbanization is an environmentally conscious approach to growing and developing cities that combines urbanization activities with environmentally friendly operations to generate resilient and eco-friendly urban development. It seeks to minimize harmful impacts on the environment and maximize the positive benefits of urban living by establishing an appropriate equilibrium between increasing the population and the development of urban infrastructure.

Sustainable urbanization, according to Lei et al. (2020), is a new type of urbanization that incorporates green development into urban development, addresses a range of practical challenges that arise during the urbanization process, and optimizes urban economic development as well as environmental sustainability and resource availability. Furthermore, it will achieve the simultaneous healthy growth of the urban area and the sustained development of the society. However, a quantitative analysis of the actualization of green urbanization from a variety of perspectives on economics, resources, environment, policy, and other dimensions is necessary.

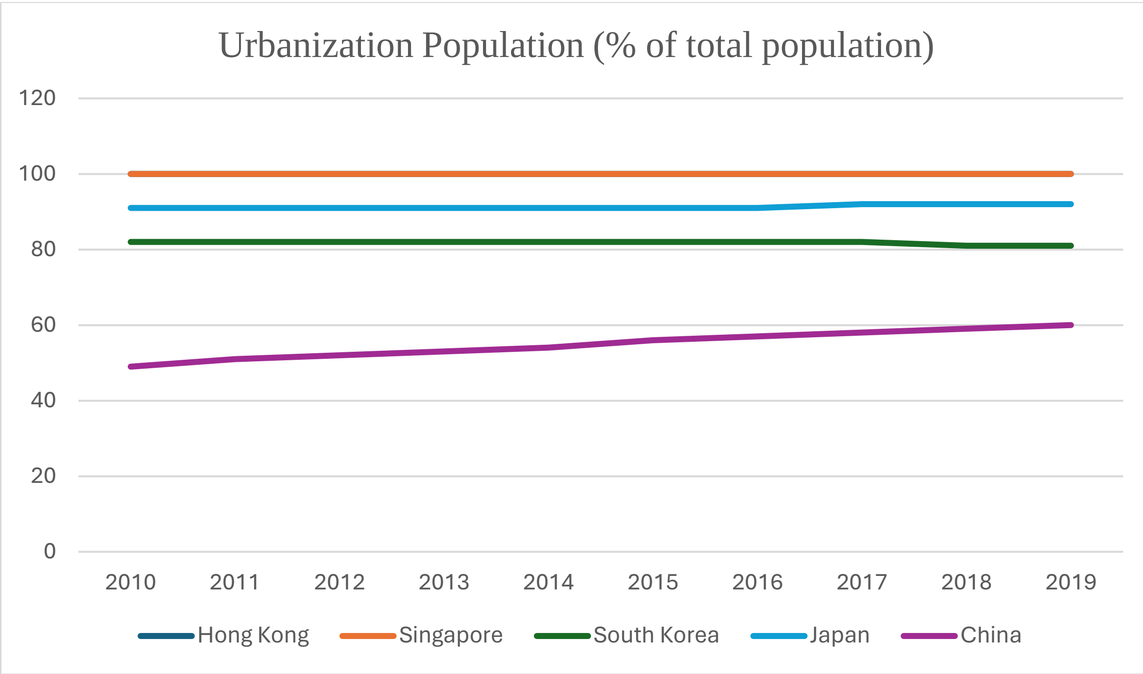
Urbanization is an enduring and long-term factor that affects countries that are both developed and developing, exerting significant implications on the natural world. Large cities require a lot of energy, frequently become contaminated, and produce a lot of waste. According to the study's findings from a strategic viewpoint, sustainable urbanization is an essential beginning for sustainable development in the contemporary era, and it must be promoted and encouraged through the implementation of green industry, green technology, and improved urban planning (Lei et al., 2020).

Urbanization has particular challenges for both individuals as well as the environment, particularly whenever a nation's population continues to increase faster than its physical infrastructure is capable of keeping up. Deterioration of the environment is one of the biggest issues facing humanity. For instance, air quality can be lowered by harmful substances from companies, power plants, and automobiles. Furthermore, poverty, which currently constitutes a serious problem in many countries, may grow worse as a consequence of the rapid growth of populations (World Population Review, n.d.).

1.1.1 Industrialized countries and sustainable urbanization

The countries that we are conducting the study are the five industrialized countries, which are Hong Kong, Singapore, South Korea, Japan, and China. We chose Asian countries to analyze because, according to OCED data, Asia accounts for 90% of the rise in urban population. Except for China, all these countries have seen significant urbanization in recent decades due to high industrialization and economic expansion; hence, we chose them as the subject of our investigation. Except for China, all of these countries are rather small in size, yet they are urbanized, crowded, and congested.

Figure 1.2: Urban Population (% of total population) by the country Hong Kong, Singapore, South Korea, Japan, China from year 2010 to 2019



Source: The World Bank.

Following the data shown above, we can see the urban population by percentage of the total population of the countries of Hong Kong, Singapore, South Korea, Japan, and China. First off, since 1989, Hong Kong has had a 100% urban population (as a percentage of the overall population), a record that has been upheld until 2019. From 2010 to 2019, the country's urban population was 100%. Next, Singapore broke away from Malaysia to become an autonomous and free country in 1965 and has always had a 100% urban population until now, so Singapore also has had a 100% urban population in this period (year 2010 to 2019). Furthermore, South Korea had an 82% urban population (% of total population) in years between 2010 to 2017 but it fell to 81% in the years 2018-2019. In addition, the urban population (% of total population) in Japan has increased from 91% in the years 2010-2016 to 92% in the years 2017-2019. Moreover, China has had a stable upward trend from 49% in the year 2010 to 60% in the year 2019; also, other research on China's urban population shows that China has had a quick upward trend in the urban population (% of total population) from 16% in the year 1960 to 64% in the year 2022, and it is expected to continue rising. To summarize, all these countries have a high urban population rate (above 80%) except China, but China has had a sharp upward trend in the past decades.

Hong Kong

According to Christine (2007), Hong Kong's environmental situation has either improved or, in some cases, deteriorated in the 10 years that have passed since the handover. Hong Kong residents continue to suffer from excessive degrees of pollution in the environment, poor nautical water quality, important dependence upon extensively loud traffic, and a rapidly dwindling space for waste disposal. Biodiversity-rich areas are under threat.

Hong Kong made tremendous strides towards green urbanization and sustainability from 2010 to 2019 in accordance with a number of environmental issues and social requirements. In addition, the government of Hong Kong released documents like "Hong Kong 2030+: Towards a Planning Vision and Strategy Transcending 2030," which established long-term planning regulations with a concentration on sustainable development and livability (Teriman et al., 2009).

Singapore

From 1965 to the 1990s, Singapore developed a reputation as an excellent nation, especially when it came to regards to urban development. According to this dual process, the city-state's economic growth trailed with its urban development. Urban characteristics unique to Singapore, represent the majority of its "urban model." In the early 1990s, a "Singaporean urban model" was established following an initial Singaporean attempt (Curien, 2017).

In 2021, the government of Singapore started its Green Plan 2030, an ambitious campaign aimed at getting every Singaporean actively engaged and motivated to contribute to transforming Singapore into a shimmering international epicenter of sustainability. Some of the Green Plan's main objectives involve setting aside 50% more land (approximately 200 hectares) for botanical gardens, and additionally planting one million additional forests around the entirety of will absorb more CO2, which will bring about cleaner air and cooler shade. Today, almost fifty percent of Singapore's land has been preserved in green space, and many of its residents have benefited from using the recreational areas that were originally put in place during the lockdowns, among the especially noteworthy during the most severe phase of the pandemic. The parks performed as the natural lungs, allowing people to breathe easier as well as offering space in an overcrowded urban areas environment (Joson, 2022).

South Korea

Since 1960, South Korea's quick industrialization has ended resulting in an urbanization rate of above 90%. As environmentally friendly infrastructure has been emphasized as a solution for contemporary urban issues like global warming, fine particles, flooding in urban areas, decline in population, and urban decline, parks, and green space policies have been evolving (Wolfram, 2018).

South Korea's president confirmed that environmentally friendly green growth will constitute the primary objective of the country's 60-year success plan. With a particular focus on exploiting renewable energy sources that are novel and environmentally friendly technologies, the Low-carbon Green Growth vision indicates a transition of the country's growth narrative from a model that is dependent on energy from petroleum to one that is quality-oriented. The Korean government announced the implementation of the Green Growth National Strategy and Five-Year Plan as an ambitious course to implement the country's national vision for environmentally friendly development to support it consistently efficiently and successfully (UNEP, n.d.).

Japan

The management of waste is one of Japan's largest environmental issues caused by the enormous volume of trash generated in modern Japanese society. The diminutive island nation of Japan lacks the area required to accommodate its substantial trash for subsequent generations due to its small size. Before suffering from air pollution problems, Japanese municipal buildings burned a lot of rubbish; however, the government was compelled to establish a strong recycling program (PWC, 2016).

Fukuoka City has been investigating ways to cope with the consequences of environmental change in its open space and urban plans since the late 1990s. The governments of municipalities in Japan have been extremely heavily engaged in the fight against climate change management since the Kyoto Protocol was put into effect in 1997, with climate change plans concentrating on minimizing the production of greenhouse gases as well as implementing renewable energy. In 2016, the Fukuoka City Government also disclosed a climate change action plan that would combine avoidance with modification, bring together climate and environmental plans, and carry out additional initiatives since the city's first local climate plan came into existence in 1994 (Mabon et al., 2019).

Japan reaffirmed that it was dedicated to working toward a low-carbon society (LC) which includes a 60%-80% reduction in its emissions of greenhouse gases by 2050. The objective for the immediate future is to decrease greenhouse gas emissions by 25% below 1990 levels by 2020, whereas the ultimate objective is achieving an 80% reduction by 2050, according to the Basic Act on Global Warming Countermeasures, and this was approved by the Cabinet of Ministers in March 2010 (UNCRD, n.d.).

China

China has gone through an unanticipated and significant transition from a rural to an urban environment. Urbanization, as a complicated system of social growth, is bringing about an extensive variety of socioeconomic and environmental changes. China has faced changes and challenges in attempting to separate environmental emissions, such as PM2.5, CO2, as well as additional contaminants, about socioeconomic prosperity, with the long-term objective of ecologically friendly growth and civilization, despite significant population growth improvements (Wang et al., 2023a).

In China, there has been a lot of research into the effects of urbanization, such as economic growth and environmental pollution. It has been found that environmental pollution significantly impedes urbanization. There continues to be additional work to be done to promote the establishment of new green urbanization since pollution in urban areas is one of China's most prominent environmental issues. Though the "new normal" unquestionably raised the significance of the preservation of the environment, environmental sustainability is possible solely through enhancing environmental governance (Wang et al., 2023a). The Chinese government implemented the "National New Type Urbanization Plan (2014-2020)" in 2014. It incorporated new rules for implementing "new urbanization" to improve the quality of development in cities in all of its components (Li & Gao, 2022).

1.2 Problem Statement

With economic and technological development, the urbanization of regions has been growing vigorously over the decades with relocation among people from rural to urban areas becoming more visible. As regional economies grow, metropolitan areas have increased in density along with advanced industrialization, enhanced infrastructure and services, improved quality of life, and more economic opportunities (Browne, 2014). The world's urbanization rate is currently 56% with roughly 4.4 billion people, which is more than half of the world's population residing in metropolitan areas (The World Bank, 2022). Urbanization brings opportunities in both the social and economic realms, but there are challenges as well. Over the decades, urbanization in numerous regions has begun to reach a saturation point, at which point issues like excessive industrialization, environmental degradation, shortage of resources, and increased population density have started becoming a growing concern (Uttara et al., 2012). In this circumstance, sustainable development has emerged as a critical concern, where sustainable or 'green' urbanization plays a vital role. Sustainable urbanization is a practice of incorporating green development with urban development and addressing a range of urbanization issues, with the aim of attaining optimal and feasible urban economic development (Lei et al., 2020). Rather than centring only on economics, sustainable urbanization prioritizes sustainable, social, and environmental dynamics in urban settings (Telsaç & Kandeger, 2022).

Sustainable urbanization is vital in the sense that it advances over conventional urbanization and aims to overcome its underlying issues (Lei et al., 2020). If sustainable urbanization practices are not effectively regulated, issues like urban sprawl, environmental degradation, and the depletion of natural resources will not be adequately handled and will continue to exist (Ismail et al., 2020). What if there is no development of sustainable urbanization? The environment, economy, and social systems—the three development pillars of the region—will be under greater pressure (Chan & Chan, 2022). Solid waste management, reduced land usage, harmed ecosystems, air and water pollution, and global warming are some of the environmental concerns. Moreover, cities will be left with economic problems like a lack of housing investment and restricted financial capacity. In terms of social systems, unpleasant urban governance, financial inequity, and crime will also become daunting issues in the urban context (Chan & Chan, 2022). If the aforementioned issues are present but not adequately addressed, they will persist and become an everlasting dilemma as new pressing problems arise.

Scarcity stems from the earth's resources being depleted by industrialized economies, as Jorgen Oerstrom Moeller once put it. Fast-growing Asian cities are inclined to face negative environmental and societal impacts from urbanization (OECD, n.d.). Over the decades, numerous Asian countries have undergone tremendous industrialization at an unprecedented rate, resulting in both positive and negative outcomes. Environmental catastrophes, public health problems, and rising financial costs are all results of pro-urban policies, increasing mobility, and rising investments in Asia (Han, 2018). Therefore, to conserve the environment and attain sustainable growth has become an urgent and critical challenge. Under the context of green growth, the long-term sustainability of countries and cities varies with respect to the income ranges of those countries and the tier ranks of those cities (OECD, n.d.). Unlike developing Asian countries like Malaysia, Vietnam, and Laos, that have immature economies and limited local capacities; developed Asian countries such as Hong Kong, Japan, and Singapore have mature economies and cutting-edge technology to support sustainable growth (OECD, n.d.). The progression to an urban society has reached its pinnacle in most developed countries (Allen & You, 2002). Developed countries have the most urbanization concerns and have the greatest need as well as the resources to foster green growth, which is why it is crucial for us to understand sustainable urbanization and the green growth of developed countries.

While education advocates the importance of sustainability and green growth (Lei et al., 2020), and institutional governance supports its development (Jahanger et al., 2022), economic efficiency and industrial structure spur the development of green technology and practices (Jong et al., 2015). Asian city governments fall short of adopting a more multi-sectoral approach to urban sustainability. Most environment ministries and related organizations are ineffective and continue to operate on the outskirts of crucial policy decisions (Ooi, 2009). This highlights the importance of studying the factors behind the development of sustainable urbanization, which are economic development level, industrial structure, education level, as well as institutional quality. Many of the earlier scholars have assessed sustainable urbanization in the context of highly urbanized cities, including cities from China, India, and some European countries; as yet there have not been a lot of research on industrialized countries. The sustainable urbanization development of countries varies by their own characteristics in terms of local development, institutional capacity and form, economic contribution, and government policies (OECD, n.d.), hence, we use panel data analysis to conduct a comparative study on the factors affecting sustainable urbanization among four highly urbanized and developed countries in Asia – Hong Kong, Singapore, South Korea, Japan, and China.

1.3 Research Objectives

1.3.1 General Objective

This study aims to determine the factors affecting sustainable urbanization among five highly industrialized Asian countries – Hong Kong, Singapore, South Korea, Japan, China.

1.3.2 Specific Objectives

1. To determine whether there is a significant relationship between economic development level and sustainable urbanization.
2. To determine whether there is a significant relationship between education level and sustainable urbanization.
3. To determine whether there is a significant relationship between industrial structure and sustainable urbanization.

4. To determine whether there is a significant relationship between institutional quality and sustainable urbanization.

1.3.3 Research Questions

1. Is there a significant relationship between economic development level and sustainable urbanization?
2. Is there a significant relationship between education level and sustainable urbanization?
3. Is there a significant relationship between industrial structure and sustainable urbanization?
4. Is there a significant relationship between institutional quality and sustainable urbanization?

1.4 Significance of the Study

To begin, the goal of studying sustainable urbanization is to gain insights into the successful implementation of environmentally friendly development practices within the context of urban expansion, while also addressing relevant concerns related to urbanization in a manner that promotes long-term sustainability. The process of urbanization contains a variety of consequences that can have positive as well as negative effects on the overall sustainability of an area. Regarding positive effects, urbanization often improves economic prospects, innovation, enhanced service accessibility, and infrastructure (Pradhan et al., 2021). This tendency could boost urban income and living circumstances. Regarding adverse effects, urbanization can harm the environment, deplete natural resources, and cause climate change (Voumik & Sultana, 2022). Rapid urbanization often causes pollution, deforestation, and habitat loss. This activity could harm biodiversity, ecosystems, air, and water quality, endangering environmental sustainability. Thus, policymakers and communities must address these issues by balancing the pros and cons of urbanization to promote sustainable cities.

Besides that, the findings of this study can be utilized by communities to enhance their engagement in public affairs. They can use the findings to educate more communities about the significance of sustainable urbanization through appropriately organized public participation. According to the research conducted by Fu and Ma (2020), public engagement is of utmost importance in the self-governance of a country and has a significant impact on achieving low-cost and sustainable urban development. On the one hand, our research can assist communities in understanding the impact and advantages of sustainable urbanization, including enhanced health outcomes, reduced environmental impact, increased economic opportunities, and so on.

Furthermore, policy makers might utilize the findings to modify current policies and formulate new ones to alleviate the consequences of urbanization issues on Hong Kong, Singapore, South Korea, Japan, and China. Our research can assist policymakers in comprehending the challenges and opportunities of sustainable urbanization and in implementing sustainable urbanization practices and policies. For example, Japan pledged that their urban policy would improve labour conditions, social welfare, and public safety (Mizuuchi, 2003). Sustainable urbanization can contribute to achieving these objectives. Hence, in the process of developing suitable policies, the government agency may take into account the outcomes of this study and other relevant research to figure out the primary factors that significantly influence sustainable urbanization. Consequently, it can devote more resources to key factors, allowing it to fulfill its goals more effectively and efficiently.

Through our research, readers and researchers can learn about the factors of sustainable urbanization in highly industrialized countries. We intend to provide communities and policymakers with enlightening information. Our research may help most individuals comprehend sustainable urbanization in highly industrialized countries, including communities and policymakers. This facilitates their ability to closely observe the factors that exert influence in this field and protects them against making poor choices. According to the findings of this study, the presence of sustainable urbanization challenges could hinder the growth and development of many countries. Consequently, this study empowers individuals to gain expertise in this field and make accurate decisions in similar circumstances.

1.5 Conclusion

In conclusion, this chapter discusses the concept and importance of sustainable urbanization, which integrates green development with urban growth. It contrasts sustainable urbanization with conventional urbanization, which causes problems like environmental degradation, resource depletion, and urban sprawl. It argues that sustainable urbanization is essential for optimal and feasible urban economic development. Hence, this study aims to comprehend the determinants influencing Sustainable Urbanization in five highly industrialized Asian countries, namely Hong Kong, Singapore, South Korea, Japan, and China. The variables under this study include the economic development level, education level, industry structure, and institutional quality.

CHAPTER 2: LITERATURE REVIEW

2.0 Introduction

Chapter Two is structured in the subsequent sequence. First, the theoretical frameworks are examined and analysed. After that, the second part comprises a literature review focused on the dependent variable, namely sustainable urbanization. Furthermore, this study is focused on clarifying the relationships between the dependent variable and four independent variables, namely economic development level, education level, industry structure, and institutional quality. Subsequently, the fourth section relates to the conceptual framework. Finally, the hypotheses in this study are formulated.

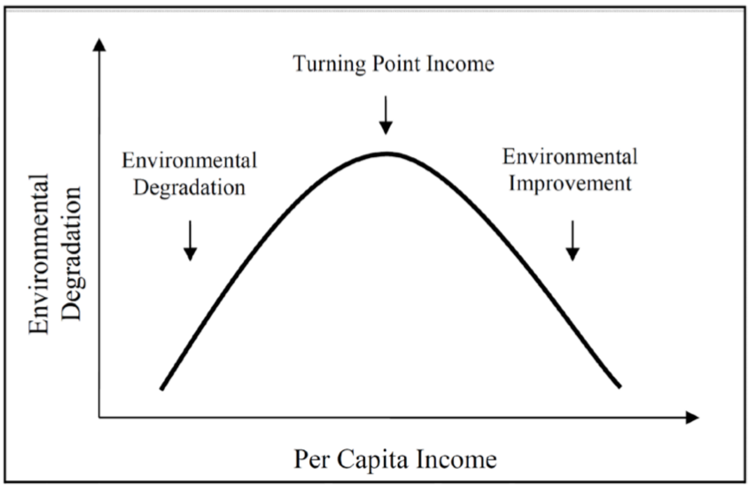
2.1 Theoretical Framework

2.1.1 Environmental Kuznets Curve Theory (EKC)

In the 1990s, the Kuznets Curve Theory was established by the American-Russian economist, Simon Kuznets, with the hypothesis of a correlation between economic expansion and income disparity, providing the groundwork for trade cycles (Stern, 2018). According to the Kuznets curve, which constitutes an inverted "U," industrializing countries are projected to experience a rise in economic inequality followed by a subsequent drop. The Environmental Kuznets Curve theory (EKC), later developed by Grossman & Krueger (1995) in NBER research and then popularised by the World Bank, has been refined and expanded in the years since 1995. In the expanded theory, industrializing countries are projected to experience a rise in environmental degradation, followed by a subsequent drop along with economic growth. Early economic expansion is accompanied by greater pollutant discharges and poorer environmental quality; however, the cycle reverses at a particular per capita income threshold, with enhanced environmental circumstances as a result of economic growth with higher income levels (Stern, 2018). The correlation between a number of environmental degradation metrics and income per capita has been proposed to adhere to the Environmental Kuznets Curve (EKC). A country's economic inclination towards sustainability is gauged by its income levels. As low- or middle-income countries advance, people will grow more conscious of environmental amenities once they pass the ‘turning point’ (Arrow et al., 1995).

Given that most of the economies of industrialized developed countries with high-income levels have passed the "turning point," they may be less likely to encounter such a pattern. Instead, owing to the growing emphasis on sustainability practices, there might be a downward sloping tendency, justifying the economy's support for sustainable growth.

Figure 2.1: Environmental Kuznets Curve (EKC)

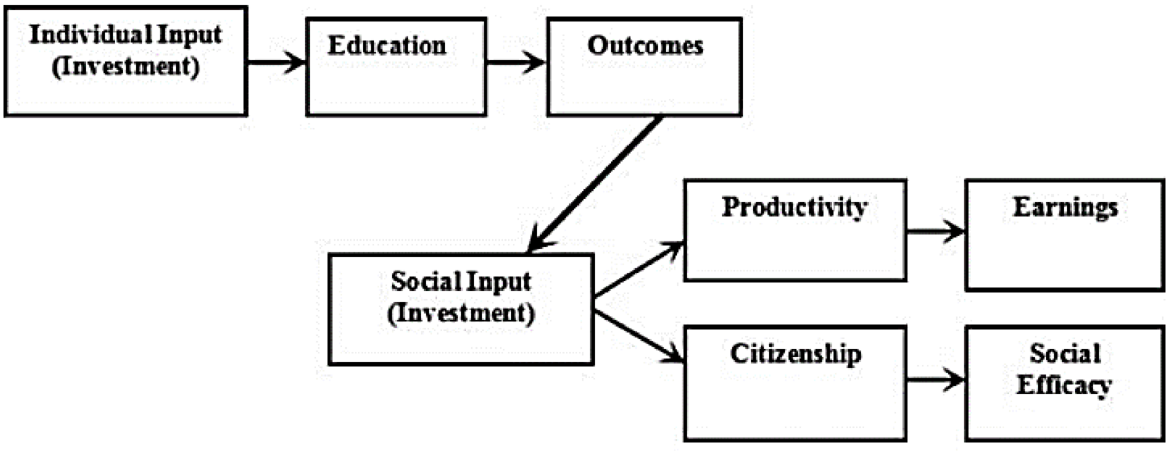


Sources: Stern (2018)

The scale effect, which conveys that the environment suffers more from higher production, the composition effect, which conveys that changes in the economic structure reduce environmental damage, and the technology effect, which conveys that technological advancement expands along with economic development, are the three elements governing the link in the EKC's relationship. Advances in technology, urbanization level, and the capacity to address societal and ecological concerns all rise along with economic expansion; as the development of technology, economy, and urbanization becomes "sustainable", adverse environmental effects can be mitigated (Saraç & Yağlikara., 2017). In the long term, encouraging economic development would gradually transform into encouraging environmental regulations, supporting sustainable urbanization (Stern, 2018). Despite the credibility and significance of EKC's theory being frequently skepticized (Jahanger, 2022), the positive quadratic term of the theory is still pertinent to our study since the samples we use are all highly industrialized and developed countries with high incomes.

2.1.2 Human Capital Theory

Figure 2.2: Human Capital Theory

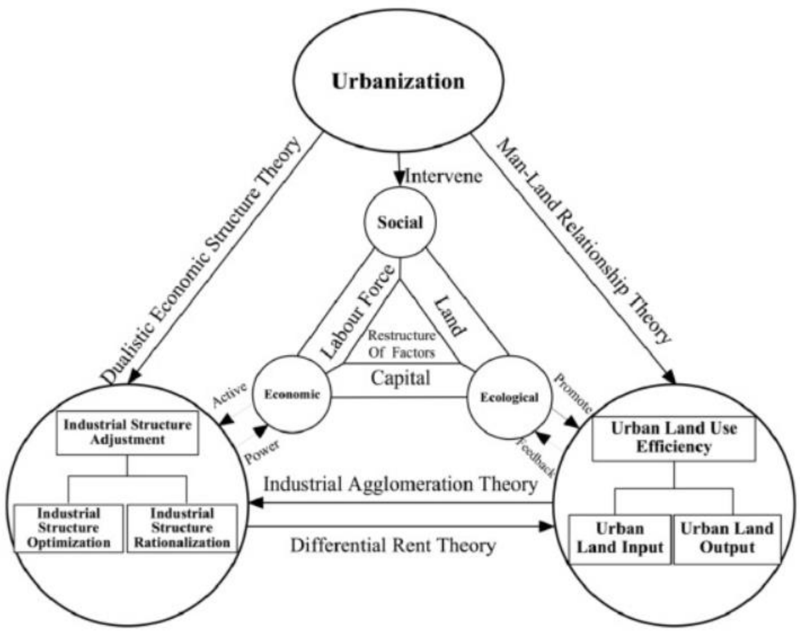


Sources: Ahmed et al. (2017)

The relationship between education level and sustainable urbanization is an essential topic to discuss. There have been numerous proposed theoretical frameworks to explain this relationship. One such framework is Human Capital Theory. According to Xu and Fletcher (2017), Becker and Rosen initially formulated the human capital theory in 1962 and 1976, respectively. The relationship between education level and sustainable urbanization is directly related to the Human Capital Theory. According to this theory, education improves a person's knowledge, skills, and abilities, making them more productive and adaptable members of humanity. In the context of sustainable urbanization, a population characterized by a higher degree of education is more likely to possess a heightened awareness of issues related to the environment, the ability to address complex challenges, and a greater propensity to embrace sustainable practices (Muhammad Mohiuddin et al., 2018). Moreover, educated individuals are more likely to comprehend the complexities of environmental issues, climate change, and urban challenges, enabling them to contribute more effectively to the development of sustainable solutions. In addition, education fosters adaptability and a desire to learn, making individuals more receptive to new ideas and innovative approaches to urban development. These characteristics are essential for addressing sustainability obstacles and responding to developing issues in urban environments undergoing rapid change.

2.1.3 Theory of industrial agglomeration and Theory of differential rent

Figure 2.3: Theory of industrial agglomeration and Theory of differential rent



Sources: Wang et al. (2023b)

The connection between industry structure adjustment and urban land use efficiency corresponds to the theories of industrial agglomeration and differential rent. In accordance with the principle of industrial agglomeration, urban land use efficiency can be facilitated through the improvement and agglomeration of manufacturing components including land, capital, and labour. According to the concept of differential rent, the requirement for industry earnings to rise as urban land use efficiency grows, resulting in industries with excellent profit margins to substitute for performing companies and promoting industry structure adjustment in the right direction of industrial structure standardization and improvement. We recommend the relationship between urbanization, industry structure adjustment, and urban land use efficiency below based on suggestions previously in circulation (Wang et al., 2023b).

The increasing rate of urbanization is the main driver of the connection between industry structure adjustment and urban land use efficiency. Either urbanization or urban land use efficiency contains relationships that would be compatible with the proposed models of man-land relationships and asymmetric systems of economics, correspondingly. The manifestation pathway to investigate the implications of urbanization on the linkages between industry structure adjustment and urban land use efficiency consists of three elements: social form, economic form, and ecological environment. Social advancement enhances urban land use efficiency by leveraging mechanisms such as property demand, development of technology, and technological services, as well as providing skills and customer groups for industry advancement. The single most important component of promoting industry structure adjustment and urban land use efficiency is economic expansion. Due to their outstanding economic conditions as well as robust R&D capacities, locations with an increased rate of growth in their economies could encourage the agglomeration of high-tech organizations, which may impact the character of the metropolitan industrial structure and the effectiveness of land use. The most effective utilization of the available building space and the synchronization of consumer demand for urban land against the not-anticipated results of the utilization of land are the primary elements of ensuring the development of an environmentally friendly atmosphere (Wang et al., 2023b).

Consequently, the development of urbanization could bring about changes in the transportation of labour, land, and capital, which will ultimately have immediate consequences on the magnitude of industrial structure optimization, industrial structure upgrade, and urban land use efficiency. Furthermore, the expanding scope of urbanization will, as time passes, have an influence on the association between industry structure adjustment and urban land use efficiency, which corresponds with the theories of industrial agglomeration and differential rent discussed above (Wang et al., 2023b).

2.1.4 Institutional Theory

The institutional theory was initially introduced by Meyer & Rowan (1977), stating institutional regulations are only accepted by organizations or institutions simply for the legitimacy of the institutional setting; then it was further expanded upon by DiMaggio & Powell (1983), suggesting that three forms of institutional pressures: normative, mimetic, and coercive, are exerted to raise the pressure on adherence to particular frameworks as well as the homogeneity of different organizational and institutional structures. Coercive pressure stems from regulations authorized and mandated by external institutions, normative pressure stems from societal acceptance in discourse, and mimetic pressure stems from prominent peers who serve as prototypes for imitation of norms and practices (Nor Azah Abdul Aziz et al., 2017). The institutional framework exerts legislative governance through broad associational networks of business, civil society, and government actors (Silva et al., 2018). Institutional settings can have a significant impact on the establishment of legal frameworks within organization and institutions. The primary claim is the notion that policymakers, financiers, and other nation-states perceive organizational structures developed in industrialized countries as indicators of progress towards contemporary institutional development (Shrum, 2001).

Matters about "green" initiatives and environmental oversight can be influenced by changes in cultural values, technological advancements, and governance, according to institutional theory (Tate et al., 2010). If economic development, technological advancement, and urbanization are the substances on which the primary aspect of legislative policies is created, then the rehabilitation of the perceived negative impacts such as societal and environmental issues asserted would be the further aspect to place emphasis on. Resources can be effectively channelled to their most efficient and productive purposes with the support of a well-organized institutional framework (Ahmed et al., 2022), in which case sustainable urbanization could be attained. The notion put forth by institutional theory is that persons in positions of authority employ their powers to advocate for the adoption of new "sustainable standards" through regulatory frameworks (Nor Azah Abdul Aziz et al., 2017).

2.2 Review of Literature

2.2.1 Definition of a Literature Review – Sustainable Urbanization

Within highly advanced economic and social settings, sustainable urbanization has become increasingly crucial in terms of resolving urbanization issues. Sustainable urbanization entails putting ecological values first while striving to ensure urban development; it aims to enhance the state of the environment, recover biodiversity, and improve inhabitants' living quality through technology and innovation (Telsaç & Kandeger, 2022). It develops structures that are eco-friendly and highly energy-efficient (Chen & Lu, 2021). As cities embody environmental technological advancements, the urban environment absorbs and integrates resources, energy, and technology into an environmentally sustainable viewpoint (Zaręba et al., 2016).

Though the term "sustainable urbanization" can be expressed by various assertions, its true significance and performance can be reflected upon and evaluated by a number of metrics and indicators, as many scholars have done (Bian et al., 2018). Being "green" entails engaging in eco-friendly activities, while "sustainability" combines the former with an incentive to minimize the depletion of resources (PECB, n.d.). Sustainable urbanization aims to foster the growth of long-term viability through eco-friendly, sustainable, and green operations. By utilising five systems including urban growth, social growth, economic expansion, ecological development, and urban-rural transition dynamics—Zhao & Chai (2015) have constructed an information entropy model for sustainable urbanization. Besides, Chen & Lu (2021) have employed the PCA-SBM model for assessing green urbanization by index components of environmental protection and energy usage. In addition, Lei et al. (2020) have encompassed the economy, environment, resources, and policy in the evaluation of green urbanization level by factor analysis and principal component analysis (PCA). According to Eeckhout and Hedtrich (2021), the growth of sustainability, especially in the case of major cities, is demonstrated by efforts to enhance energy efficiency and waste reduction throughout economic expansion.

Green technologies enhance service efficiency in cities by reducing waste, pollutants, and usage of resources (Laffta & Al-Rawi, 2018). Many facets of green technologies can be integrated into sustainable development, which aids in minimizing the damaging effects of various economic and societal practices on ecosystems and the environment and leading towards the adoption of sustainable systems in urban areas. On the other hand, the worldwide energy crisis has become one of the most significant urbanization threats. As a result, various countries are innovating in the energy industry to address the pertinent issues of urbanization, in which the renewable energy share in various countries has gradually increased (United Nations, n.d.). Despite that, current urban efficiency assessment in various research frequently downplays the significance of renewable energy, particularly when it comes to sustainable urbanization (Liddle & Lung, 2010). The utilization of renewable energies may be typically more labour-intensive than those utilizing fuel-based power generation, but they provide clean, non-polluting, and non-exhaustive energy sources, which contribute to sustainability (Laffta & Al-rawi, 2018). In order to reflect sustainable urbanization more comprehensively, we employ the proxy of renewable energy share in this study.

2.2.2 Economic Development Level and Sustainable Urbanization

An economic paradigm of sustainable development, 'green economy' focuses on attaining economic growth while preserving social cohesion and environmental preservation (Lin & Zhou, 2022). Reorienting a nation's economic development in the direction of "sustainable" is mandated by the Green Deal Policy and the Sustainable Development Goals (Kwilinski et al., 2023). As the coexistence of economic development and environmental sustainability remains an extensively disputed topic, the correlation between economic development and sustainable urbanization has been the focus of various studies. Economic development reflects economic structure and resource utilization in terms of environmental sustainability (Chen & Lu, 2021). Besides, economic development establishes the groundwork for green development. The fraction of environmental investments in GDP determines the degree of ecological sustainability and the state of sustainable urbanization (Lei et al., 2020).

There have been contradicting findings from the literature on the relationship between sustainable urbanization and economic development. Using GDP as the measurement, Tawiah et al. (2021) and Lei et al. (2020) have discovered a positive correlation between economic development and sustainable urbanization. In terms of methodology, they have used FEM effects OLS estimation and dynamic panel estimation model by DIF-GMM & SYS-GMM to investigate their research respectively. It is believed that as the economy grows and income rises, countries will possess sufficient resources to implement sustainable growth incentives, placing more emphasis on ecological and environmental health than merely financial wealth. Besides, according to Mikayilov et al. (2018), economic development and environmental sustainability are positively correlated over the long run, adopting the VECM model, as well as the ARDLBT, FMOLS, CCR, and DOLS cointegration methods.

However, Kwilinski et al. (2023) have discovered that economic development shows a negative influence on sustainable growth using FEM & REM effects model and GMM modelling, on the terms that urbanization driven by economic growth urges the inefficient usage of resources and the degradation of the environment, despite its sustainable incentives bringing positive effects like increasing development for environmental protection. On the other hand, from the research by Lin & Zhou (2022) and Jahanger et al. (2022), it has shown that the correlation between the primary term of economic development and sustainable growth is significantly negative, whereas the quadratic term has a positive link, validating the Environmental Kuznets Curve theory (EKC). They have utilized the entropy weighted TOPSIS system and the OLS estimation to conduct their studies on developing nations and China respectively, supporting the U-shaped association between economic development and environmental health. An array of environmental issues is spurred by the unsustainable global economic expansion. However, as economic development reaches a certain level, environmental sustainability will be prioritized, and these issues may be mitigated. The relationship between economic development level and sustainable urbanization has yielded mixed findings.

For efforts to maximize the efficacy of innovation development while striving towards environmental sustainability goals, it is essential to optimize the structure and efficiency of the economy (Lin & Zhou, 2022). In the case of sustainable growth, it is conceivable to create a synergistic impact on economic growth and the ecological goals underlying the SDGs (Kwilinski et al., 2023). In this way, urbanization could in fact become sustainable. Based on the findings, the government, policymakers, and city planners may recognize how economic expansion affects sustainable urbanization and have a broad framework for enforcing environmental protection regulations (Lei et al., 2020). This study examines the impact of economic development level on sustainable urbanization in a few industrialized and developed Asian countries.

2.2.3 Education Level and Sustainable Urbanization

There has been extensive research undertaken to study the association between education level and sustainable urbanization. Although the relationship between education level and sustainable urbanization is well established, the results are mixed.

Zhang et al. (2022) discovered a significant positive relationship between education level and sustainable urbanization. According to the research, education levels can have a significant impact on a city's capacity for innovation. Talents of the highest level and an innovative spirit can promote urban development, resulting in the emergence of innovative concepts and the advancement of cutting-edge technologies. Zhang's study employs the data collection method of observation. The study employed data collection methods based on the Onion Factors Model. In addition to this, Zhang conducted the study by utilizing the Web of Science database as the primary source of data, while also using Elsevier and Scopus as additional databases.

On the other hand, Shi et al. (2020) revealed a negative correlation between education level and sustainable urbanization. According to the research, education level has no significant impact on sustainable urbanization. This is because an increase in the number of years of education per person does not promote the development of green urbanization. Shi's research employs the data collection method of observation. The study employed data collection methods based on a Gaussian Mixture Model (GMM) model. In the study conducted by Shi, they used the entropy approach and data envelopment analysis to evaluate and measure the green urbanization indices in nine provinces located in the Yellow River Basin.

However, there has been little study on how education level influences sustainable urbanization (Zhang et al., 2022). Zhang's research pointed out that the study fundamentally establishes the foundation for future research. This is because the model of how the factors that affect urban innovation growth interact still has space for more specialization. The research highlighted that further studies should enhance the data quality and index system. Overall, there are two opposing effects of education level on sustainable urbanization. According to most of the literature, only a few studies have demonstrated insignificant correlations between education level and sustainable urbanization. Also, the different results of previous studies could be attributed to the observation methods used.

2.2.4 Industry Structure and Sustainable Urbanization

For the purpose of enhancing both the input level of exertion and the efficiency of the output of urban land, industry structure might strengthen enterprise-to-enterprise technological advancements substitution, collaborative work, investment and company atmosphere, and the collaboration of sophisticated manufacturing forms of transportation, methods of administration, along with manufacturing innovations, and additionally encouraging the development and creative thinking of technological developments (Wang et al., 2023b).

The relationship between sustainable urbanization and industry structure has formed the focal point of many research investigations. The literature on the association between industry structure and sustainable urbanization generates conflicting findings.

Wang et al. (2023b) and Tang et al. (2020) have revealed a significant relationship between sustainable urbanization and industry structure. Wang et al. (2023b) suggests that urban development sustainability can be accomplished by setting into effect the industrial structure development process of specialty and diversity, and Tang et al. (2020) claims that the industrial structure can foster sustainability and environmental friendliness in industries. Shi et al. (2020) found a contrary result: there is no substantial connection between sustainable urbanization and industry structure because environmental concerns are eventually solved by various heavy companies.

Those three studies are using the same technique to collect the data, which is secondary data. Nevertheless, they are using a different model to analyse the collected data. For example, Wang et al. (2023) used panel data vector auto regression model, Tang et al. (2020) employed empirical models, while Shi et al. (2020) used an evaluation model and a panel of dynamic variables estimation model to analyze the acquired data.

Furthermore, they are using different population sizes and years in their study. For example, Wang et al. (2023) used the percentage of the overall population with permanent residence in China and the amount of the population inhabiting municipalities for a period exceeding fifty percent of the year for the calculation of urbanization from 1978 to 2018. Tang et al. (2020) determined the population size by cities in the various regions of China. Shi et al. (2020) used demographic data from the "Yellow River Basin" in China from 2006 until 2018. Hence, the mixed results in the previous studies may be due to the distinct data analysis method employed, the different years, and the different population size used.

2.2.5 Institutional Quality and Sustainable Urbanization

As growing institutional performance is an important instrument for controlling and minimizing pollution emissions in the framework of economic development, institutional quality can help drive sustainable urbanization (Xaisongkham & Liu, 2022).

Numerous research studies are concentrating on the connection that exists between institutional quality and sustainable urbanization. Inconsistent findings have been generated by the literature on the connections between institutional quality and sustainable urbanization.

Li et al. (2022) and Chen and Zhou (2020) have the research results to support that there is a significant relationship between sustainable urbanization and institutional quality. Li et al. (2022) claimed that high-quality organizations establish an environment wherein everyone may efficiently carry out the duties they have for environmental protection, and Chen and Zhou (2020) stated that the effect of urbanization can be determined by institutional quality, which will also aid governments in enhancing their political as well as economic performance. Furthermore, Latif et al. (2023) demonstrated that institutional quality encourages sustainable urbanization by responding to the influence of economic development and elevating the emphasis on environmental quality. On the contrary, Xaisongkham and Liu (2022) had different results as compared with others, showing an insignificant relationship between sustainable urbanization and institutional quality. They suggested that in countries with high incomes, outstanding institutional quality boosts income levels; However, spending on government does not significantly go toward strengthening the sustainability of the environment.

Three of these studies used the same data collection method, which is secondary data. But they used different models to analyse. Li et al. (2022) employed nonlinear ARDL, Chen and Zhou (2020) used panel threshold model, Latif et al. (2023) constructed the DCCE approach, and

Xaisongkham and Liu (2022) adopted two-step SYS-GMM estimators. While many of the researchers have only selected one worldwide governance indicator for regression, Latif et al. (2023) have used all six of the indicators comprehensively to represent the variable.

Furthermore, three of these studies have conducted research on different populations and time periods. For instance, Li et al. (2022) chose to analyse G7 countries, which are Canada, the USA, the UK, France, Germany, Japan, and Italy, from 1986 to 2020. Chen and Zhou (2020) analysed 72 nations from 2000 to 2014. Xaisongkham and Liu (2022) opted to study 41 Asian nations from 1996 through 2015, and Latif et al. (2023) have investigated 48 Asian countries from 1996 to 2020. As a result, the inconsistent findings in earlier studies could be attributed to differences in data processing methodologies, study years, and collection countries.

2.3 Conceptual Framework

Figure 2.4: Conceptual Framework

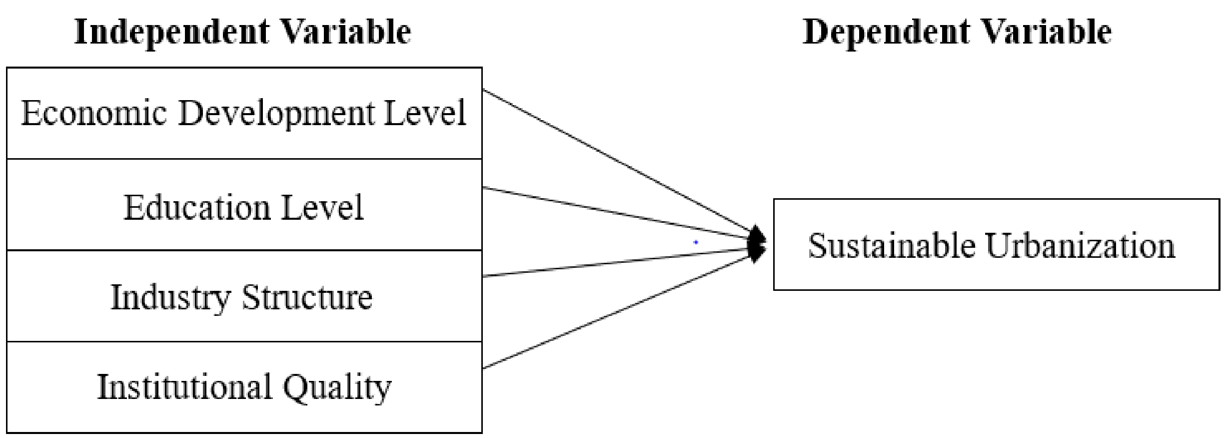


Figure 2.4 shows a conceptual framework that is based on the previously discussed theoretical models discussed in the part before it. To study the factors affecting Sustainable Urbanization among Five Highly Industrialized Asian Countries (Hong Kong, Singapore, South Korea, Japan, China). The conceptual framework involves four independent variables which are economic development level, education level, industry structure, and institutional quality. Following previous study results, these independent variables have a big impact on what contributes to affect

Sustainable Urbanization among Five Highly Industrialized Asian Countries (Hong Kong, Singapore, South Korea, Japan, China). The structure will therefore be utilized to determine when the conclusion drawn is appropriate. Consequently, the structure mentioned above will be used in constructing the presumptions in the following portion of the article.

2.4 Hypothesis Development

2.4.1 Economic Development Level and Sustainable Urbanization

The advancement of sustainable urbanization can be significantly affected by economic development. According to Lei et al. (2020), higher economic development levels result in a higher level of technological advancement and innovation, which forms a solid groundwork for sustainable urbanization. In broad terms, economic expansion promotes green growth by counterbalancing economic activities with the norms and practices of sustainability, thereby rendering initial urbanization 'green' and 'sustainable' (Tawiah et al., 2021).

Numerous researchers have investigated the relationship between economic development and sustainable urbanization among regions in highly industrialized countries through panel analysis including China (Chen & Lu, 2021; Lei et al., 2020), Ajerbaijian (Mikayilov et al., 2018) and India (Sastry, 2009), and there are also researchers who have studied the relationship between economic development and sustainable urbanization among developed and developing nations (Tawiah et al., 2021), and the results are mostly significant. Thus, the initial hypothesis proposed in this study is:

H1: There is a significant relationship between economic development level and sustainable urbanization among five highly industrialized Asian countries.

2.4.2 Education Level and Sustainable Urbanization

Regarding the social aspect, the education level can greatly influence the sustainability of urban development. Galdi et al. (2016) argue that implementing a sustainable urban renewal strategy is an effective approach to attaining sustainable urban growth, especially in countries that are developing. They emphasize the need of considering the social aspects of a community, such as education levels, while planning for sustainable urbanization.

Asides from that, Apostu et al. (2023) highlighted the significant connection between urbanization, higher education, and sustainable development. The regression study examines the relationship between urbanization growth and enrolment in higher education, with urbanization growth as the dependent variable and enrolment in higher education as the independent variable. Hence, the second hypothesis formulated for this study is:

H2: There is a significant relationship between education level and sustainable urbanization among four highly industrialized countries.

2.4.3 Industry Structure and Sustainable Urbanization

Industry structure can also be significantly related to sustainable urbanization. This is a consequence of the observation that industrial structure growth beneficially impacts urban land use efficiency all throughout both the beginning and middle phases of urbanization (Wang et al., 2023). Therefore, land urbanization and urban environmental effectiveness are positively as well as partially influenced by the intermediary characteristic of industrial structure advancement (Tang et al., 2020). As a result, advancement or reform of the industry structure is likely to have an advantageous impact on sustainable urbanization.

According to certain studies, industry structure has a significant effect on industry structure in Chinese provinces (Wang et al., 2023). Furthermore, Tang et al. (2020) demonstrated the significant impact of industry structure on cities in various regions of China. Hence, the third hypothesis developed for this investigation is:

H3: There is a significant relationship between industry structure and sustainable urbanization among highly industrialized Asian countries.

2.4.4 Institutional Quality and Sustainable Urbanization

The impact of institutional quality on sustainable urban growth is important. According to Azam et al. (2021), the promotion of sustainable development is made easier by having strong institutional quality. This is because it stimulates the adoption of sustainable consumption and production patterns by reducing impulsive behavior and transaction costs.

Based on the research conducted by Li et al. (2022), it has been noted that improvements in institutional quality have a stronger impact on carbon dioxide (CO_2) emissions than deteriorations in institutional quality. The study found that there is a negative relationship between the quality of institutions and CO_2 emissions, which ultimately promotes sustainable urbanization. Thus, the fourth hypothesis established for this study is:

H4: There is a significant relationship between institutional quality and sustainable urbanization among four highly industrialized Asian countries.

2.5 Conclusion

This chapter presents a comprehensive literature review on the independent variables, including economic development level, education level, industrial structure, and institutional quality, as well as the dependent variable, sustainable urbanization. The literature gap in this chapter is the efficiency models have limits. Researchers sometimes disregard system indication and input and output slack interactions when reporting efficiency, which can lead to incorrect results. Most researchers struggle to choose explanatory variable metric indicators due to a lack of variable coverage. Additionally, some institutional and cultural components of the functions are unclear. After that, this study explains the theoretical frameworks used in previous research. In addition, the conceptual framework and hypotheses for this investigation have been formulated.

CHAPTER 3: METHODOLOGY

3.0 Introduction

The methodology employed in this study will be covered in this chapter. The study's research design will be covered first. Then, we will go over data description and data gathering techniques. Subsequently, we will discuss about the model formulation and model estimation, which are the formation of econometric models, the specification of variables, metrics, econometric procedures. Lastly, we will perform diagnostic checking to validate the model's creditability and the reliability.

3.1 Research Design

A quantitative study design, or the procedure of collecting and assessing statistical data, will be employed in this study to attain our research objectives and resolve the doubts in our research questions specified in chapter 1. The association between the dependent variable, the Sustainable Urbanization, and every independent variable, specifically real GDP (base 2015), the education index, the industrial share of GDP, and the institutional quality index, will be investigated in order to investigate the effect of independent variables on the development of sustainable urbanization among the chosen Asian highly urbanised countries.

3.2 Data Description and Collection Method

The analysis of the factors driving the development of sustainable urbanization in the five Asian highly urbanised countries is the primary subject of this study. The Sustainable Urbanization, using the proxy of the share of primary energy from renewable resources, is the dependent variable in this study. Economic development level, education level, industrial structure, and institutional quality are the four chosen independent variables for this study, with the proxies of real GDP per capita (Constant 2015 US$), gross tertiary school enrolment ratio, industrial share in GDP, and an average value of six independent measures of governance including government effectiveness, regulatory quality, control of corruption, political stability absence of violence/terrorism, rule of law, and voice and accountability, which was used by Lee et al. (2022). Furthermore, panel data for the countries Hong Kong, Singapore, Japan, South Korea, and China was utilised in this study, which spans the years 2010 to 2019. World Data Bank, OECD, as well as Our World in Data, give exact and comprehensive statistics for the 10 years, are the sources of secondary data used for all the variables.

3.3 Sources of Data

Table 3.1 below presents the sources and measurement for each variable employed in this paper.

Table 3.1: Source and Measurement of Each Variables

Variables	Indicator	Proxy	Source of Data
Sustainable Urbanisation	SU	Share of Primary Energy From Renewable Sources (%)	Our World in Data
Economic Development Level	EDL	Real GDP Per Capita (Constant 2015 US$)	World Data Bank
Education Level	EL	Gross Tertiary School Enrolment Ratio	World Data Bank
Industry Structure	IS	Industry (including construction), value added (% of GDP)	World Data Bank
Institutional Quality	IQ	Control of Corruption Government Effectiveness Political Stability and Absence of Violence/Terrorism Regulatory Quality Rule of Law Voice and Accountability	World Data Bank

3.4 Model Specification

The selected methodology for our model development involved the utilization of panel data analysis, which was applied to examine the influence of each independent variable on sustainable urbanization in five highly industrialized Asian countries. The model specification will be formulated in the following manner:

3.4.1 Econometric Model

This study aims to model and test the strong quantitative connection between four independent variables and sustainable urbanization. The choice of the econometric model is determined by its apparent suitability for studying the functional connection between the dependent and independent variables (Lau, 1986). The construction of the functional form of the model is as follows:

Sustainable Urbanization = f (Economic Development Level, Education Level, Industry Structure, Institutional Quality)

$$SU_{it} = f(EDL_{it}, EL_{it}, IS_{it}, IQ_{it}) \quad (1)$$

The variable SU_{it} serves as a proxy indicator for measuring sustainability for country i at the time t. In equation above, SU represents sustainable urbanization, EDL represents the economic development level, EL represents the education level, IS represents the industry structure, IQ represents the institutional quality, and f is a homogenous function. On the existing literature base, this study employs numerous proxy variables to estimate SU including Per capita real GDP growth rate, gross tertiary school enrollment ratio, percentage change of GDP of Industry value added, and an average of six independent measures of governance such as control of corruption, government effectiveness, political stability and absence of violence/terrorism, regulatory quality, rule of law, and voice and accountability.

In addition, the application of the log transformation is appropriate when there is a non-linear relationship between the dependent and independent variables. The log-linear model is recommended since it has the capability to generate more efficient outcomes (Amal, 2016). The log-linear model is used to modify the data before performing data analysis. Furthermore, this model would enhance the understanding and analysis of the outcomes. Therefore, the log-linear model is formulated as follows:

$$LNSU_{it} = \beta_0 + \beta_1 LNEDL_{it} + \beta_2 LNEL_{it} + \beta_3 LNIS_{it} + \beta_4 LNIQ_{it} + \mu_{it} \quad (2)$$

Whereby,

SU_{it} = Sustainable Urbanization for country i at the time t

EDL_{it} = Economic Development Level for country i at the time t

EL_{it} = Education Level for country i at the time t

IS_{it} = Industry Structure for country i at the time t

IQ_{it} = Institutional Quality for country i at the time t

μ_{it} = Error Term

i = Hong Kong, Singapore, South Korea, Japan, China

t =1, 2, 3, 4,…, 10 (2010 - 2019)

3.5 Model Estimation

3.5.1 Pooled Ordinary Least Square Method (Pooled OLS)

The pooled regression model is a particular type of model that demonstrates consistent coefficients, encompassing both intercepts and slopes (Hiestand, 2011). Using this methodology, researchers can gather and analyze all existing data by utilizing an ordinary least squares regression model. The Pooled Ordinary Least Squares (OLS) model is commonly used to estimate the constant model across many groupings. The dataset is estimated using a Pooled Ordinary Least Squares (OLS) model, which is consistent with other cross-sectional data. In this methodology, the influence of time on the fluctuations in the dimensions is disregarded. The basic idea of Pooled OLS is that it shares similarities with ordinary linear regression. These similarities include linearity, normal distribution of error terms, absence of multicollinearity, absence of autocorrelation, and constant variance of error terms (Zhang & Albert, 2010).

In the context of the Pooled Ordinary Least Squares (OLS) model, it is claimed that the intercept remains constant across the independent variable, the slopes remain constant, and there is no time effect. However, the estimation of our model using the Pooled Ordinary Least Squares (OLS) approach may not adequately capture the true relationship due to the omission of time effects. This omission can lead to a loss of essential variables that are only observable through the time effect. Moreover, the presence of heterogeneity among the observations across a specific time frame can result in biased estimated coefficients, as well as inefficiency and inconsistency in our model (Steyerberg et al., 2019). The equation estimation for the Pooled Ordinary Least Squares (OLS) model is presented below:

$$Y_{it} = \beta_0 + \Sigma\beta_i X_{it} + \mu_{it} \text{ (3)}$$

Whereby,

Y_{it} = Dependent variable in the model

β_0 = Intercept of the model

β_i = Estimated coefficient for the independent variable

X_{it} = Independent variable in the model

μ_{it} = Error term of the model

i = Cross-sectional dimensions for the model

t = Time series dimensions for the model

3.5.2 Fixed Effects Model (FEM)

The fixed effects model (FEM) is similar to the Pooled Ordinary Least Squares (OLS) model but includes extra individual-specific effects. Within the framework of this fixed effects model (FEM), it is asserted that the intercept should exhibit variation among different countries, while the slopes remain consistent and there is no time effect (Cuijpers, 2022). The fixed effect model handles heterogeneity across cross-sectional units by acknowledging that the constant term and the intercept term of the regression model may differ across these units (Hiestand, 2011). The statistics of the fixed effects model only consider individuals with multiple observations. It makes predictions about the outcomes of factors that vary across these data. The Fixed Effect Model (FEM) is preferred over the Random Effect Model (REM) primarily due to its appropriateness in estimating the average effect of a variable within a certain group. According to Farkas (2005), the underlying assumption is that the impacts of unobserved variables that remain constant across time may be accounted for using fixed individual-specific variables. Measurement error bias is typically increased in fixed-effects estimators, thereby explaining the tendency for fixed-effects estimates to be smaller compared to estimates obtained from cross-sectional data. The equation for estimating the Fixed Effect Model (FEM) is provided below:

$$Y_{it} = \Sigma\beta p X_{it} + \gamma_i + \mu_{it} \quad (4)$$

Whereby,

Y_{it} = Dependent variable in the model

βp = Constant term and the estimated coefficient associated with the independent variables

X_{it} = Independent variables in the model

γi = Unobserved constant term unique to each country in the model

μ_{it} = Error term of the model

i = Cross-sectional dimension for the model

t = Time series dimension for the model

3.5.3 Random Effects Model (REM)

The Random Effect Model assumes that the effects of each individual are randomly distributed over the cross-sectional units. In order to incorporate these various impacts, the regression model includes a constant component known as the "intercept term" (Hiestand, 2011). The Random Effect Model can be classified as a statistical model that incorporates both individual- and time-specific variations. Within the framework of the Random Effects Model (REM), it is assumed that the intercept varies among countries, while the slopes remain constant (Cuijpers, 2022). Additionally, it is assumed that the error term follows a normal distribution inside the model. The REM also mentioned the possibility that the error term has no relationship to the independent variable. Nonetheless, it may still have an effect on the countries. In the Random Effect Model (REM), there are fewer unknown factors in the REM than in the FEM. This finding demonstrates the effective mitigation of bias in the variables used in the model. The reduction in the number of variables in the study helps to alleviate any potential problems with multicollinearity that may have been present in the Pooled Ordinary Least Squares (OLS) model (Maizah Hura Ahmad et al., 2006). The equation estimation for the Random Effect Model is presented below:

$$Y_{it} = \Sigma\beta p X_{it} + \gamma_i + \mu_{it} \quad (5)$$

Whereby,

Y_{it} = Dependent variable in the model

βp = Constant term and the estimated coefficient associated with the independent variables

X_{it} = Independent variables in the model

γi = Unobserved constant term unique to each country in the model

μ_{it} = Error term of the model

i = Cross-sectional dimension for the model

t = Time series dimension for the model

3.6 Model Selection

3.6.1 Hausman Test

In a regression model, endogenous regressors are tested for and identified by applying the Hausman. The significance of endogenous parameters is influenced by additional variables in the structure of the system. Ordinary least squares estimators cannot function in the presence of naturally occurring regressors since among their fundamental assumptions is the fact that there currently is no causal connection between the variable used as a predictor and the error term. In this case, a possible approach was to use instrumental variables as estimation methods. Before deciding on the most appropriate regression method, you have to first figure out if the predicted variables are endogenous or not. The Hausman test will achieve this. The aforementioned test is also known as the enhanced regression test for endogeneity or the Durbin-Wu-Hausman (DWH) test (Wang, 2009).

The Hausman test is additionally referred to because of the model misspecification test. When evaluating panel data, the Hausman test can help you decide whether to employ a fixed or random effects model. The other possible scenario is that the majority of commonly used models have fixed effects, whereas the null hypothesis is because the preferred model has unpredictable consequences. The test essentially assesses if there is a relationship between the specific errors and the model's regression coefficients. The null hypothesis suggests that there is no relationship between the two (Stephanie, 2023).

To determine whether the result from a Hausman test within a regression model is fairly straightforward. The test uses the following null and alternative hypotheses:

$H0$: Select Random Effect Model (REM)

$H1$: Select Fixed Effect Model (FEM)

Reject the null hypothesis if the p-value is less than the significant level and conclude that select fixed effect model in the regression model.

3.6.2 Redundant Fixed Effect

They are additionally known as likelihood ratios and redundant fixed effects. The likelihood ratio, a redundant fixed effect, is a suitable experiment for deciding if fixed cross-section effects should be included in the panel analysis. The fixed effects are duplicated in the test's null hypothesis. The null hypothesis will ultimately be rejected with the EViews-provided test, indicating that the fixed effects are redundant if the outcomes are significant and the P-value is smaller than the significance level. The model possesses unobserved heterogeneity, according to the above finding (Chan et al., 2017)

3.6.3 Breusch-Pagan LM Test

The Breusch-Pagan Lagrange Multiplier Test can detect huge, unexpected consequences in panel data models. The two-error structure method and error components were alternative titles for it. The implementation of dummy variables in the fixed effects model creates some conspicuous issues. Cross-sectional and time-specific elements have been added as error terms, as opposed to using variables that are dummy as in a fixed-effects model (Rehal, 2023).

The hypothesis of the test is presented as follows:

$H0$: Random effect is insignificant.

$H1$: Random effect is significant.

Decision rule: Reject null hypothesis if p-value is less than the significance level and conclude the random effects are significant

3.7 Diagnosis Checking

3.7.1 Heteroscedasticity

In the presence of heteroscedasticity in the data, the white noise component exhibits colour, indicating that the error term distinct to each individual does not possess homoscedasticity (Olawale & Adebayo, 2022). Consequently, the filtered data will exhibit non-stationarity. In addition to this, the presence of heteroskedasticity could make the estimators inadequate and may also result in inadequate covariance estimates (Olawale & Adebayo, 2022). There are various tests, including the the Autoregressive Conditionally Heteroscedasticity (ARCH) test, White test, the Breusch-Pagan test, and the Glejser test, that can be utilized to evaluate the presence of heteroscedasticity. Therefore, the ARCH test will be employed in this study because it is well-suited for panel data models.

The hypothesis of the test is presented as follows:

$H0$: There is no heteroscedasticity problem.

$H1$: There is heteroscedasticity problem.

Decision rule: Reject null hypothesis if p-value is less than the significance level. Otherwise, do not reject null hypothesis.

3.7.2 Autocorrelation

An additional econometric problem is autocorrelation, which relates to the relationship between error terms. Autocorrelation is a fundamental assumption in various parametric statistical methods, such as linear regression. This assumption argues that the mistakes associated with the models employed in the analysis are completely independent, meaning that there is no correlation between the errors. Nevertheless, in the case that the error components exhibit dependence, the issue of autocorrelation arises. If there is no correlation between the sign and size of the residuals and the subsequent residuals, it can be concluded that there is no autocorrelation. Consequently, this suggests that the errors of the model are independent. According to Clarke and Granato (2005), autocorrelated errors are more sensitive to appear when the temporal intervals between observations are extremely short, the behavioral changes in the outcome occur at a slow pace, crucial predictor variables are omitted from the model, or incorrect specification of the functional form of the relationship between the predictors and the outcome. In addition, the consideration of autocorrelation is of significance as it can impact the awareness of its existence and guide a researcher toward choosing a more suitable statistical analysis method.

The hypothesis of the test is presented as follows:

$H0$: There is no autocorrelation problem.

$H1$: There is autocorrelation problem.

Decision rule: Reject null hypothesis if p-value is less than the significance level. Otherwise, do not reject null hypothesis.

3.7.3 Multicollinearity

When analyzing survey data, it is typical for independent variables to be associated with a certain amount of interdependence in multiple regression situations. Multicollinearity happens whenever an explanatory variable has a significant linear relationship with more than one independent variable simultaneously. Although multicollinearity increases the overall variability of the regression coefficients, it does not go against the model's fundamental assumptions. The parameter estimates could be more effective because of this increase. As a result of the associated effects of explanatory variables brought about by severe multicollinearity, it is also challenging to determine the significance of any specific explanatory variable. It can be complicated to identify multicollinearity among an amalgamation of explanatory variables. Of course, we were able to gaze at the scatter plot matrix or the relationships between each of these variables, but it may cause us to overlook a greater degree of multicollinearity (Forthofer et al., 2007).

Next, there are merely a few methods for identifying multicollinearity problemsThe first has a high R2 but few meaningful t ratios. When a model has a strong R2 and a statistically significant F-ratio but more than half of the t-ratios are inconsequential, multicollinearity should be investigated (Mansfield & Helms, 1982). The variance inflation factors (VIF) of the variables that explain the variance could potentially be investigated as a last, more efficient approach. When VIF is larger than 10, it is an indication that the model has multicollinearity problems. The VIF formula is displayed as follows:

$$VIF = \frac{1}{1 - R^2}$$

3.8 Conclusion

In summary, we have covered the research methodology employed in Chapter 3 in this study. The World Data Bank, OECD, Our World in Data, and the UNESCO Institute for Statistics provided all the information used in this study. Pooled OLS, FEM, and REM tests have been run to estimate the economic models. Moreover, Hausman Test, Redundant Fixed Effect Test, and Breusch Pagan tests have been carried out to help us determine the model selection. Eventually, a few tests have been undertaken to validate the reliability of the model by performing diagnostic checks for the model's autocorrelation, heteroscedasticity, and multicollinearity. In Chapter 4, the model of regression and findings from the diagnostic testing shall be explained and assessed.

CHAPTER 4: RESEARCH RESULTS

4.0 Introduction

In Chapter 4, the analysis for the panel results has been created through applying the methodology that was demonstrated in Chapter 3. The panel data outcomes will be presented employing the following models: Pooled Ordinary Least Squares (Pooled OLS), Fixed Effect Model (FEM), and Random Effect Model (REM). Following the discussion of each model, the most appropriate model for panel data analysis will be selected. A number of tests will be utilized to decide on the model, including the Hausman test, redundant fixed effect, and Breusch-Pagan LM test. After establishing a representation, we will continue to evaluate the validity of the results using three types of tests. The autocorrelation, heteroscedasticity, and multicollinearity tests are employed for the conclusion Chapter 4.

4.1 Panel Data Analysis

Table 4.1: Descriptive Statistics

	Std. Dev.	**Minimum**	**Mean**	**Maximum**
LNSU	2.027786	-3.255358	0.122934	2.598179
LNEDL	1.455801	5.380000	7.247600	9.570000
LNEL	0.332885	3.200000	4.202000	4.600000
LNIS	0.642765	1.800000	3.146000	3.800000
LNIQ	0.330717	3.521443	4.267840	4.499148

Notes: LNEDL is Logarithm of the Economic Development Level, LNEL is Logarithm of the Education Level, LNIS is Logarithm of the Industry Structure, LNIQ is Logarithm of the Institutional Quality

Table 4.1 reports the descriptive statistics for sustainable urbanization among five ASIAN highly industrialized countries, including Hong Kong, Singapore, South Korea, Japan, and China.

From the table, the data used consists of variables such as economic development level, education level, industry structure, and institutional quality for sustainable urbanization. It is observed that the lower minimum derives from sustainable urbanization, which is -3.255358, and the higher maximum derives from economic development level which is 9.570000.

As demonstrated in Equation 2 in the preceding chapter, the linear-log model was constructed and illustrated. Table 4.2 highlights the findings for Equation 6 in each of the three models: Pooled OLS model, FEM model, and REM model. The following table is a visual representation of our Equation 6:

$$LNSU_{it} = \beta 0 + \beta 1 LNEDL_{it} + \beta 2 LNEL_{it} + \beta 3 LNIS_{it} + \beta 4 LNIQ_{it} + \mu_{it} \quad (6)$$

Table 4.2: Results of Equation

	Pooled OLS	**FEM**	**REM**
Constant	-17.94695 [-29.55051] (0.0000)***	-14.2675 [-5.037] (0.0000)***	-17.94695 [-33.75043] (0.0000)***
LNEDL	1.141552 [37.52065] (0.0000) ***	2.07995 [7.589] (0.0000) ***	1.141552 [42.85335] (0.0000) ***
LNEL	-0.087472 [-0.774756] (0.4425)	-0.352261 [-1.588] (0.1200)	-0.087472 [-0.884870] (0.3809)
LNIS	1.272279 [22.45533] (0.0000) ***	1.28485 [2.662] (0.0110) **	1.272279 [25.64684] (0.0000) ***
LNIQ	1.443666 [12.04882] (0.0000) ***	-0.760618 [-1.143] (0.2598)	1.443666 [13.76128] (0.0000) ***

Notes: The rejection of the null hypothesis resulted at the 10%, 5%, and 1% significance levels, denoted by *, **, and ***. The closed brackets provide the test statistic value for each independent variable. The spaces between the parentheses will show the p-value.

Table 4.2 above summarizes the information we discovered through Eviews. The first variable indicates the logarithm of the economic development level (LNEDL), which has been determined by applying the real GDP. The outcome findings of the Pooled OLS model appear to indicate that the economic development level shows a significant relationship at 1%, with a p-value of 0.0000, if economic development grows by 1%, sustainable urbanization will increase by 1.141552% on average. The FEM model demonstrated that economic development level shows a significant relationship at 1%, having a p-value of 0.0000. This would indicate that if economic development grows by 1%, sustainable urbanization will increase by 2.07995% on average, presuming that all other variables continue the same. The REM model additionally demonstrated a significant relationship between economic development and sustainable urbanization at the 1% level, with a p-value of 0.0000. Consequently, under the REM model, when the amount of economic growth increases by 1%, sustainable urbanization increases by 1.141552% on average, provided all else remains constant.

On the other hand, the second variable represented the logarithm of the education level (LNEL), which had been calculated by the aggregate tertiary school enrollment ratio. The results of the Pooled OLS model demonstrated that there is no relationship. The FEM model also demonstrated that education levels have no relationship with one another. The REM model additionally established that education level has no relationship with sustainable urbanization.

Furthermore, the third variable is the logarithm of the industry structure (LNIS), which was calculated by industry (including construction) and value-added (percentage of GDP). The outcome findings of the Pooled OLS model appear to indicate the industry structure indicates a significant relationship at 1%, with a p-value of 0.0000, if the industry structure increases by 1%, the average sustainable urbanization will increase by 1.272279%, on average. The FEM model demonstrated that industry structure has a significant relationship at 5%, with a p-value of 0.0110. It could mean that if the industry structure increases by 1%, the average sustainable urbanization will increase by 1.28485%, provided all else remains constant. The REM model similarly revealed a significant relationship between industry structure and sustainable urbanization at a 1% level, with a p-value of 0.0000. It additionally indicates that in the REM model, when the industry structure increases by 1%, the average sustainable urbanization increases by 1.272279%, assuming all the additional variables remain constant.

Aside from that, the final variable corresponds to the logarithm of institutional quality (LNIQ), which was calculated by control of corruption, government effectiveness, political stability and lack of terrorism and violence, the effectiveness of regulation, the rule of law, and voice and accountability. Our study uses average to combine and summarize these six informational elements through institutional quality data. Results gathered from the Pooled OLS model appear to indicate that the economic development level indicates a significant relationship at 1%, with a p-value of 0.0000. This could mean that if institutional quality increase 1%, sustainable urbanization will increase 1.443666%, on average. The FEM model demonstrated that education levels have no relationship with one another. The REM model have a significant relationship between institutional quality and sustainable urbanization at a 1% level, with a p-value of 0.0000. It additionally indicates that in the REM model, when the institutional quality increases by 1%, the average sustainable urbanization increases by 1.443666%, assuming all the additional variables remain constant.

The analysis mentioned found that the Pooled OLS model consisted of just three significant variables relating to sustainable urbanization, which was the level of economic development, industry structure and institutional quality. Alternatively, the FEM model highlighted two variables that had a significant relationship with sustainable urbanization which is economic development level and industry structure. Yet, the REM model identified three major variables that influence sustainable urbanization which is economic development level, industrial structure and institutional quality.

4.2 Model Selection

Subsequently, we will proceed with model selection to choose the most applicable model for our research's estimation. The outcomes of the three tests we conducted for model selection are shown in the Table 4.3. To determine which of the three models—Pooled OLS, FEM, and REM—used for estimation is most suited to our research, three tests were performed: the Hausman Test, Redundant Fixed Effect, and Breusch-Pagan LM Test.

Table 4.3 Results of Model Selection

Hausman Test	17.700447 (0.0014) ***
Redundant Fixed Effect Test	4.425112 (0.0046) ***
Breusch-Pagan LM Test	2.478930 (0.1154)

Notes: *, **, and ***, respectively, denote the 10%, 5%, and 1% significance levels at which the null hypothesis was rejected. The p-value will be represented by the value in parenthesis.

H_0: $Cov(\mu_{it}/X_{it}) = 0$ (REM)

H_1: $Cov(\mu_{it}/X_{it}) \neq 0$ (FEM)

The results of Hausman Test show a p-value (0.0014) less than three of the significance levels at 10%, 5%, and 1%. Therefore, the null hypothesis is rejected, suggesting that the FEM model is preferable to the REM model since FEM remains consistent and efficient when a correlation between independent variables and error terms is in existence.

H_0: $\mu_i = 0$ (POLS)

H_1: $\mu_i \neq 0$ (FEM)

The results of Redundant Fixed Effect Test show a p-value (0.0046) less than three of the significance levels at 10%, 5%, and 1%. Therefore, the null hypothesis is rejected, suggesting that the FEM is preferable to the POLS model since there are independent effects present in the model and the general assumptions of OLS estimators have been disregarded.

$H : \sigma^2\mu = 0$ (POLS)

$H : \sigma^2\mu \neq 0$ (REM)

The outcomes of Breusch-Pagan LM Test show a p-value (0.1154) greater than three of the significance levels at 10%, 5%, and 1%. Therefore, the null hypothesis is not rejected, suggesting that the POLS is preferable to the REM model; since the variances of the error terms are zero and homoscedasticity exists.

In summary, given the three tests performed throughout the model selection process, we have determined that the FEM model is the best appropriate regression model for estimation to unravel the relationship between economic development level, industrial structure, education level, and institution quality with sustainable urbanization in our study.

4.3 Diagnostic Testing

In this part, we will perform diagnostic tests to evaluate the dependability and coherence of the research's results.

4.3.1 Heteroscedasticity

Table 4.4: Static Panel Regression Models

Variables	**Fixed Effect Model**	**Fixed Effect Robust**
Constant	-14.2675 (0.000) ***	-14.2675 (0.0855) *
LNEDL	2.07995 (0.000) ***	2.07995 (0.0928) *
LNEL	-0.352261 (0.1200)	-0.352261 (0.6044)
LNIS	1.28485 (0.0110) **	1.28485 (0.0728) *
LNIQ	-0.760618	-0.760618

	(0.2598)	(0.5916)
Diagnostic Tests		
Heteroscedasticity Test	64.9566 (0.000)	
Autocorrelation Test	55.8981 (0.0017)	

Note: *, **, ***, indicates significance level of 10%, 5% and 1% respectively.

The null hypothesis asserts that the model is without heteroscedasticity in this study, whereas the alternative hypothesis asserts the presence of heteroscedasticity in this study. The decision rule is to reject the null hypothesis if the probability value is lower than the significance level; otherwise, the null hypothesis is not rejected. Based on the information provided in Table 4.4, the p-value (0.000) is smaller than the significance level of 5%. This indicates that there is sufficient evidence to conclude that the model exhibits heteroscedasticity. In order to tackle these issues, we recalculated our chosen fixed effects model using the robust standard-error technique. The outcomes of the robust standard-error approach are displayed in the final column of Table 4.4. The results of our study suggest a positive relationship between economic development level, industry structure, and sustainable urbanization.

4.3.2 Autocorrelation

The null hypothesis states that the model in this study does not exhibit autocorrelation, whereas the alternative hypothesis states the presence of autocorrelation in the study. The decision rule is to reject the null hypothesis if the probability value is lower than the significance level; otherwise, the null hypothesis is not rejected. According to the data in Table 4.4, the result indicates that we should reject the null hypothesis because the p-value (0.0017) is lower than the significance level of 5%. Hence, we have identified the problem of autocorrelation in our model. In order to tackle these issues, we recalculated our chosen fixed effects model using the robust standard-error technique. The outcomes of the robust standard-error approach are displayed in the final column of Table 4.4. The results of our study suggest that there is a positive relationship between economic development level, industry structure, and sustainable urbanization.

4.3.3 Multicollinearity

Subsequently, the relationship between the independent variables and the Variance Inflation Factor (VIF) has been employed to evaluate if the model is influenced by multicollinearity.

Table 4.5: Variance Inflation Factor Table

Variable	**Centered VIF**
LNEDL	3.605170
LNEL	2.595767
LNIS	2.437253
LNIQ	2.885547

From Table 4.5, it displays the centered VIF values for each of the independent variables. According to the results, the centered VIF for economic development level, education level, industry structure, and institutional quality is less than 10. This observation suggests the absence of multicollinearity. Thus, there was no multicollinearity problem in our model estimation.

4.4 Conclusion

According to the evaluation provided above, the three models generated using Eviews showed significant outcomes. However, whenever we went through the model selection stage, the findings showed that the FEM model would be chosen as a more suitable framework for approximating the results we obtained through multiple analyses. Aside from that, diagnostic checking eliminates the possibility of autocorrelation, heteroscedasticity, and multicollinearity issues in our model.

CHAPTER 5: DISCUSSION AND CONSLUSION

5.0 Introduction

The earlier study from the initially published four chapters culminates in this chapter. In this chapter, the discussion shall primarily concentrate on the main findings, the implications for whoever will benefit, the limitations of our study, and the recommendations for additional investigations based on what was discovered in the chapter that preceded it.

5.1 Discussion on Major Findings

Table 5.1: Summary of the Statistical Findings

Independent Variable	**t-statistics**	**P-value**	**Results**
Economic Development Level	2.199	0.0855	Significant
Education Level	-0.5615	0.0928	Insignificant
Industry Structure	2.419	0.0728	Significant
Institutional Quality	-1.5824	0.5824	Insignificant

According to Table 5.1, economic development level and industry structure have a significant relationship with sustainable urbanization. In addition, education level and institutional quality have an insignificant relationship with sustainable urbanization. Therefore, the independent variables of economic development level and industry structure are strong predictors of sustainable urbanization among five ASIAN highly industrialized countries including Hong Kong, Singapore, South Korea, Japan, and China.

5.1.1 Key Determinants of Sustainable Urbanization

5.1.1.1 Economic Development Level and Sustainable Urbanization

The findings of the panel data suggest that economic development level and sustainable urbanization are significantly associated, which is consistent with this study's hypothesis. The economic development level provided for estimation is determined by the real GDP (constant 2015) for estimation. Results reveal that growth in the real GDP, equivalent with to the expansion of the nation's economic growth, will positively have an effect on the development of sustainable urbanization. The relationship's significant outcome in this study corresponds with the likewise significant results obtained by Tawiah et al. (2021) and Lei et al. (2020). Along with urbanization, economic growth fosters green knowledge and facilitates modern sustainable technology, increasing the accessibility of sustainable practices among activities of individuals, operations of organizations, and the undertakings of institutions (Kwilinski et al., 2023).

5.1.1.2 Education Level and Sustainable Urbanization

Moreover, the second independent variable in our result estimation was the education level. The education level in our data estimation was being applied by using the gross tertiary school enrollment ratio. The panel data analysis revealed that there was no statistically significant relationship between sustainable urbanization and education level when employing the Pooled OLS, Fixed Effect Model, and Random Effect Model. Based on the choice of the Fixed Effect Model for the model estimate, it can be concluded that there is no statistically significant relationship between education level and sustainable urbanization. According to Shi et al. (2020), education level played an insignificant role in the development of sustainable urbanization, which is similar to our study results. Furthermore, the quality of talent is substandard as a result of inadequate higher education, which causes a serious brain drain, which will in turn obstruct sustainable urbanization.

5.1.1.3 Industry Structure and Sustainable Urbanization

Furthermore, the industry structure was the third independent variable that we employed to arrive at the outcomes. The industrial structure in the information we provided has been determined by the number of industries (including construction) and value-added (percentage of GDP). The panel data results demonstrated how industrial structure is important in evaluating the relationship with sustainable urbanization by applying the Pooled OLS, FEM and REM. Considering our research utilized FEM for our model estimation, this indicates the industrial structure has a significant relationship with the results of our research. The findings demonstrate that increased industry structure contributes to greater and more sustainable urbanization. According to Wang et al. (2023) and Tang et al. (2020), the view that industry structure played an essential influence on the growth of sustainable urbanization corresponds with our findings. Therefore, industry structure and sustainable urbanization are significantly related to each other.

5.1.1.4 Institutional Quality and Sustainability Urbanization

Other than that, the last independent variable in our result estimation was institutional quality. The institutional quality in our data estimation was being applied by using control of corruption, government effectiveness, political stability and absence of violence/terrorism, regulatory quality, rule of law, and voice and accountability. Our report uses average to combine and summarize these six data points. The panel data results demonstrated that institutional quality remained an important consideration in determining the relationship with sustainable urbanization employing the Pooled OLS and REM. Whereas the FEM showed no relationship between institutional quality and sustainable urbanization. Considering we have chosen FEM as our suitable model estimation method; this implies that institutional quality is insignificant to our study. Research results pointed out that in economies with high incomes, strong institutions improve revenue, but investments by governments have no impact on environmental quality. According to Xaisongkham and Liu (2022), institutional quality does not have an impact in enhancing sustainable urbanization, which is consistent with what we found. Therefore, institutional quality and sustainable urbanization are insignificantly related to each other.

5.2 Implication of Study

In light of the results of this paper's findings, individuals, groups, governments, and legislators are able to determine the important factors playing a part in the development of sustainable urbanization. The findings of the research enable those involved to carry out their respective roles, take pertinent action, and implement the optimal plans in order to foster and support sustainable urbanization in the most effective manner.

According to the research's findings, the first independent variable – economic development level has a positive influence on sustainable urbanization. A nation is more likely to accomplish its objectives when it possesses greater wealth. The emergence of sustainable technology and green innovation resulting from investment in R&D and technological advancement, together with the nation's urbanization, are all supported by economic growth. Policymakers should implement viable economic policies to strengthen the nation's economy to generate sufficient wealth and resources to support sustainable urbanization. In tandem with economic growth, policymakers should also directly establish policies and funding programs as a means to boost the evolution of industrial and energy structures, enhance energy efficiency, improve environmental protection, and preserve natural capital (Atalla et al., 2022). For instance, the government should incentivize the financing of green production and infrastructures by providing subsidies for R&D institutions to encourage innovation and game-changing technologies that facilitate sustainable urbanization. Along with the encouragements, adverse practices that are unsustainable should be discouraged as well. For instance, governments should disincentivize financing for environmentally detrimental activities and unsustainable assets. Additionally, to deter unsustainable projects, non-green initiatives should account for carbon costs (Arup, n.d.).

Furthermore, the second independent variable – education level has an insignificant influence on sustainable urbanization. The poor quality of higher education has resulted in a scarcity of highly educated people, causing an extensive brain drain that may not help the development of sustainable urbanization. The phenomenon of brain drain hinders the ability of education advances to effectively promote sustainable urbanization. Despite recognizing that our results are insignificant, some implications should be suggested given that the majority of studies have produced significant findings. To tackle this problem, education institutions and management teams might implement a decision support system that finds the most efficient method to improve the overall quality of academic programs and overall performance (Lazić et al., 2021). This can help to prevent brain drain, improve education quality, and contribute to sustainable urbanization. Apart from that, it is crucial to ensure that the development of sustainable urbanization is in harmony with the environmental conditions and available resources of the region (Zhang et al., 2022). Various locations need to adopt different kinds of sustainable urbanization strategies according to their education levels (Zhang et al., 2022). For instance, higher education institutions located in cities with abundant resources, such as a highly skilled labor force and easy access to investment capital, are better positioned to support larger-scale sustainable urbanization. On the other hand, regions with limited resources might allocate priority to using alternative strategies to draw in highly skilled or educated foreign labor, which will promote the advancement of sustainable urbanization.

The following independent variable is industry structure: The association between industry structure and sustainable urbanization is a significant relationship. This suggests that industry structure has an advantageous influence on sustainable urbanization. A powerful industrial structure improves competency, and the efficacy of technical advancement, and encourages urban creativity and economic growth. Aside from that, industrial reorganization encompasses the redirection of innovative resources, resulting in the creation of a new innovative industry. In this way, innovation components are moved from low- to high-innovation industry. Policymakers should execute industrial reorganization to allow the effective deployment of creativity factor resources and boost growth in urban areas standards (Zhang et al., 2022). Government officials ought to formulate national industrial plans with adequate approaches that can facilitate sustainable urbanization. The types of businesses that will be transported throughout the city should be determined in the future, as the inventiveness network will circulate via the industry chain. Consequently, the industrial chain is going to be built within the innovation chain. Since technology is the biggest gap in urban industrial redevelopment, industrial restructuring encourages the development of technological innovation in cities, which successively facilitates sustainable urbanization (Li et al., 2022).

Lastly, the fourth independent variable which is institutional quality has an insignificant influence on sustainable urbanization. It is challenging for institutions to attain conflicting objectives simultaneously. While increasing FDI and economic growth is typically the goal of institutional quality, social responsibility from a broader viewpoint is often unprioritized, resulting in pollutants and discouraging sustainable urbanization (Brännlund et al., 2016). Institutional quality does not contribute to sustainable urbanization if it is not appropriately emphasized. Many researchers have generated positive findings in the correlation between institutional quality and sustainable urbanization, even when we have produced inconsequential results. Thus, here we would propose implications, for uncapable regions to make the appropriate measures to contribute institutional quality to sustainable urbanization. Institutions' effectiveness and appropriate regulatory structures regarding sustainability should be reinforced by policymakers in order to alleviate environmental harm and attain environmental sustainability. According to Carey (2011), reorganization of institutions can guarantee integration, productivity, consistency, and effectiveness in implementing policies related to sustainable urbanization. In this instance, governments and institutions should restructure their frameworks and procedures, as well as reselect the goals and objectives—particularly regarding sustainable urban planning, in order to contribute to sustainable urbanization. With a decent institutional framework, expenditures are allocated to areas with the greatest requirements and in keeping with long-term urban development objectives (Bridges, 2016). Besides, policymakers must enhance institutional frameworks to bring about their importance in advancing sustainable development, particularly the formulation of strategies focused on enhancing governance structures, regulatory frameworks, and institutional capacities to facilitate sustainable urbanization efforts (Perveen et al., 2017).

5.3 Limitations of Study

Following completion of the whole research, certain limitations have been identified in this study that may, in part, affect how the results are interpreted and how reliable the research is. Therefore, it is necessary to rise up and overcome these constraints. As the subject of our research — sustainable urbanization is relatively wide and fresh, the problem of data limitation exists. First of all, the proxies that we have employed to depict our dependent variable – sustainable urbanization is obviously insufficient and incompetent to thoroughly capture and convey the fundamental essence of the variable. However, due to the lack of accessible appropriate data, we are forced to use it exclusively. On the other hand, in order to better reflect one of our independent variables – institutional quality, we have utilized the average value of six metrics of governance to integrate the six different aspects and comprehensively portray the variable. However, in averaging, all the metrics are equally weighted, ignoring data variability, which can result in information loss and distortion of the variable, leading to unreliable regression results.

While panel data analysis allows us to investigate correlations between variables throughout periods, there are shortcomings that are hard to avoid. There are data inconsistencies and value gaps among the data of the variables from different countries throughout different periods that might result in biases and errors in the findings, hence, the time span that we have chosen for our study is only 10 years, which is insufficient to significantly reflect anything truly invaluable. Furthermore, the time period that we have selected is 2010-2019, which fails to incorporate the most recent data as those are not yet accessible. Due to these influences, the size of our research is limited, and has decreased the model's predictive capacity.

Apart from that, our study examines the relationship between variables at the country-level, ignoring the likelihood that estimates derived from within-country data may be skewed due to masking. As an instance, variations in the degree of sustainable urbanization among Chinese cities, such as Shenzhen and Xinjiang, may be veiled by the country's overall level of sustainable urbanization. The aggregation of data may lead to potential sampling errors or sampling biases. In this instance, the issue of substance may be ignored, leading to unreliable data and misinterpretation of findings.

5.4 Recommendations for Research

Given the limitations in this study that have been identified, we have an overall idea of how future research should be carried out and how to avoid the obstacles that we have encountered.

As the dependent variable of the study–sustainable urbanization is a vast subject that cannot be accurately represented with a single proxy, more indicators should be incorporated into the depiction of it in order to provide a more precise assessment. In this case, the dependent variable can be better portrayed, and the study's significance may be better conveyed. On the other hand, in order to better reflect the independent variable–institutional quality, the method of principal component analysis (PCA) may be applied to provide a better representation on the variable, as it allows dimensionality reduction and decorrelation by assigning weights to each metrics, allowing a more accurate capture on the metrics, and leading to more reliable results (Avcontentteam, 2024).

Secondly, in order to eliminate sampling biases and errors while also enhancing the efficacy of the outcomes, future researchers should incorporate more variable units or more spans of years in their sample size; as a bigger sample size enables more accurate results and stronger population representation (Andrade, 2020). Additionally, future researchers should employ the most up-to-date information available for statistical procedures in order to achieve greater efficiency.

Lastly, for a more accurate representation, it is advised for future researchers to perform panel data analysis evaluating not just different nations but also the comparisons of specific individual cities to prevent concerns with masking that could lead to biased and unreliable results. In this way, not only are the misrepresentations and disputes eliminated, but the study can also provide a more narrow and comprehensive view of the research areas.

5.5 Conclusion

The ultimate goal of this study project is to explore the factors impacting sustainable urbanization in five ASIAN highly industrialized countries (Hong Kong, Singapore, South Korea, Japan, China). In order to gather the data, we use secondary data to evaluate the outcomes. The illustrates how economics development level, education level, industry structure and institutional quality have a major impacting on sustainable urbanization. The results of these studies have been thoroughly examined and some interpretations are provided. Finally, the investigation's shortcomings are explored, and recommendations for further research are made.

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Appendix

Appendix 1: Descriptive Statistic

Date: 04/05/24 Time: 17:26
Sample: 2010 2019

	LNSU	LNEDL	LNEL	LNIS	LNIQ
Mean	0.122934	7.247600	4.202000	3.146000	4.267840
Median	0.605823	7.250000	4.200000	3.350000	4.455365
Maximum	2.598179	9.570000	4.600000	3.800000	4.499148
Minimum	-3.255358	5.380000	3.200000	1.800000	3.521443
Std. Dev.	2.027786	1.455801	0.332885	0.642765	0.330717
Skewness	-0.357224	0.134879	-1.211391	-1.190357	-1.384368
Kurtosis	1.628469	1.480494	4.362402	2.903664	3.187396
Jarque-Bera	4.982361	4.961806	16.09585	11.82725	16.04378
Probability	0.082812	0.083668	0.000320	0.002702	0.000328
Sum	6.146721	362.3800	210.1000	157.3000	213.3920
Sum Sq. Dev.	201.4840	103.8485	5.429800	20.24420	5.359318
Observations	50	50	50	50	50

Appendix 2: Pooled OLS Model

Dependent Variable: LNSU
Method: Panel Least Squares
Date: 04/05/24 Time: 17:07
Sample: 2010 2019
Periods included: 10
Cross-sections included: 5
Total panel (balanced) observations: 50

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-17.94695	0.607331	-29.55051	0.0000
LNEDL	1.141552	0.030425	37.52065	0.0000
LNEL	-0.087472	0.112903	-0.774756	0.4425
LNIS	1.272279	0.056658	22.45533	0.0000
LNIQ	1.443666	0.119818	12.04882	0.0000

R-squared	0.994045	Mean dependent var	0.122934
Adjusted R-squared	0.993515	S.D. dependent var	2.027786
S.E. of regression	0.163291	Akaike info criterion	-0.691924
Sum squared resid	1.199881	Schwarz criterion	-0.500722
Log likelihood	22.29810	Hannan-Quinn criter.	-0.619113
F-statistic	1877.850	Durbin-Watson stat	0.504575
Prob(F-statistic)	0.000000		

Appendix 3: Fixed Effect Model

```
Model 1: Fixed-effects, using 50 observations
Included 5 cross-sectional units
Time-series length = 10
Dependent variable: LNSU

             coefficient   std. error   t-ratio   p-value
  --------------------------------------------------------
  const      -14.2675      2.83270     -5.037    9.97e-06 ***
  LNEDL        2.07995     0.274081     7.589    2.46e-09 ***
  LNEL        -0.352261    0.221867    -1.588    0.1200
  LNIS         1.28485     0.482633     2.662    0.0110   **
  LNIQ        -0.760618    0.665591    -1.143    0.2598

Mean dependent var   0.122934   S.D. dependent var   2.027786
Sum squared resid    0.838070   S.E. of regression   0.142971
LSDV R-squared       0.995841   Within R-squared     0.686113
LSDV F(8, 41)        1226.998   P-value(F)           2.90e-46
Log-likelihood       31.26998   Akaike criterion    -44.53996
Schwarz criterion   -27.33175   Hannan-Quinn        -37.98697
rho                  0.718876   Durbin-Watson        0.465578

Joint test on named regressors -
  Test statistic: F(4, 41) = 22.4051
  with p-value = P(F(4, 41) > 22.4051) = 7.27478e-10

Test for differing group intercepts -
  Null hypothesis: The groups have a common intercept
  Test statistic: F(4, 41) = 4.42511
  with p-value = P(F(4, 41) > 4.42511) = 0.00458287
```

Appendix 4: Fixed Effect Model Robust

```
Model 2: Fixed-effects, using 50 observations
Included 5 cross-sectional units
Time-series length = 10
Dependent variable: LNSU
Robust (HAC) standard errors

             coefficient   std. error   t-ratio   p-value
  --------------------------------------------------------
  const      -14.2675      6.27853     -2.272    0.0855  *
  LNEDL        2.07995     0.945943     2.199    0.0928  *
  LNEL        -0.352261    0.627377    -0.5615   0.6044
  LNIS         1.28485     0.531090     2.419    0.0728  *
  LNIQ        -0.760618    1.30608     -0.5824   0.5916

Mean dependent var   0.122934   S.D. dependent var   2.027786
Sum squared resid    0.838070   S.E. of regression   0.142971
LSDV R-squared       0.995841   Within R-squared     0.686113
Log-likelihood       31.26998   Akaike criterion    -44.53996
Schwarz criterion   -27.33175   Hannan-Quinn        -37.98697
rho                  0.718876   Durbin-Watson        0.465578

Joint test on named regressors -
  Test statistic: F(4, 4) = 19.3953
  with p-value = P(F(4, 4) > 19.3953) = 0.00697637

Robust test for differing group intercepts -
  Null hypothesis: The groups have a common intercept
  Test statistic: Welch F(4, 21.9) = 0.110048
  with p-value = P(F(4, 21.9) > 0.110048) = 0.97771
```

Appendix 5: Random Effect Model

Dependent Variable: LNSU
Method: Panel EGLS (Cross-section random effects)
Date: 04/05/24 Time: 17:11
Sample: 2010 2019
Periods included: 10
Cross-sections included: 5
Total panel (balanced) observations: 50
Swamy and Arora estimator of component variances

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-17.94695	0.531755	-33.75043	0.0000
LNEDL	1.141552	0.026639	42.85335	0.0000
LNEL	-0.087472	0.098853	-0.884870	0.3809
LNIS	1.272279	0.049608	25.64684	0.0000
LNIQ	1.443666	0.104908	13.76128	0.0000

Effects Specification

	S.D.	Rho
Cross-section random	7.21E-07	0.0000
Idiosyncratic random	0.142971	1.0000

Weighted Statistics

R-squared	0.994045	Mean dependent var	0.122934
Adjusted R-squared	0.993515	S.D. dependent var	2.027786
S.E. of regression	0.163291	Sum squared resid	1.199881
F-statistic	1877.850	Durbin-Watson stat	0.504575
Prob(F-statistic)	0.000000		

Unweighted Statistics

R-squared	0.994045	Mean dependent var	0.122934
Sum squared resid	1.199881	Durbin-Watson stat	0.504575

<u>Appendix 6: Hausman Test</u>

Correlated Random Effects - Hausman Test
Equation: Untitled
Test cross-section random effects

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	17.700447	4	0.0014

Cross-section random effects test comparisons:

Variable	Fixed	Random	Var(Diff.)	Prob.
LNEDL	2.079952	1.141552	0.074411	0.0006
LNEL	-0.352261	-0.087472	0.039453	0.1825
LNIS	1.284845	1.272279	0.230473	0.9791
LNIQ	-0.760618	1.443666	0.432005	0.0008

Cross-section random effects test equation:
Dependent Variable: LNSU
Method: Panel Least Squares
Date: 04/05/24 Time: 17:12
Sample: 2010 2019
Periods included: 10
Cross-sections included: 5
Total panel (balanced) observations: 50

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-14.26745	2.832701	-5.036695	0.0000
LNEDL	2.079952	0.274081	7.588830	0.0000
LNEL	-0.352261	0.221867	-1.587712	0.1200
LNIS	1.284845	0.482633	2.662160	0.0110
LNIQ	-0.760618	0.665591	-1.142771	0.2598

Effects Specification

Cross-section fixed (dummy variables)

R-squared	0.995841	Mean dependent var	0.122934
Adjusted R-squared	0.995029	S.D. dependent var	2.027786
S.E. of regression	0.142971	Akaike info criterion	-0.890799
Sum squared resid	0.838070	Schwarz criterion	-0.546635
Log likelihood	31.26998	Hannan-Quinn criter.	-0.759739
F-statistic	1226.998	Durbin-Watson stat	0.518671
Prob(F-statistic)	0.000000		

Appendix 7: Redundant Fixes Effects Test

Redundant Fixed Effects Tests
Equation: Untitled
Test cross-section fixed effects

Effects Test	Statistic	d.f.	Prob.
Cross-section F	4.425112	(4,41)	0.0046
Cross-section Chi-square	17.943763	4	0.0013

Cross-section fixed effects test equation:
Dependent Variable: LNSU
Method: Panel Least Squares
Date: 04/05/24 Time: 17:11
Sample: 2010 2019
Periods included: 10
Cross-sections included: 5
Total panel (balanced) observations: 50

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-17.94695	0.607331	-29.55051	0.0000
LNEDL	1.141552	0.030425	37.52065	0.0000
LNEL	-0.087472	0.112903	-0.774756	0.4425
LNIS	1.272279	0.056658	22.45533	0.0000
LNIQ	1.443666	0.119818	12.04882	0.0000

R-squared	0.994045	Mean dependent var	0.122934
Adjusted R-squared	0.993515	S.D. dependent var	2.027786
S.E. of regression	0.163291	Akaike info criterion	-0.691924
Sum squared resid	1.199881	Schwarz criterion	-0.500722
Log likelihood	22.29810	Hannan-Quinn criter.	-0.619113
F-statistic	1877.850	Durbin-Watson stat	0.504575
Prob(F-statistic)	0.000000		

Appendix 8: Breusch Pagan Lagrange Multiplier Test

Lagrange Multiplier Tests for Random Effects
Null hypotheses: No effects
Alternative hypotheses: Two-sided (Breusch-Pagan) and one-sided (all others) alternatives

	Test Hypothesis		
	Cross-section	Time	Both
Breusch-Pagan	2.478930 (0.1154)	0.481537 (0.4877)	2.960467 (0.0853)
Honda	-1.574462 (0.9423)	0.693929 (0.2439)	-0.622631 (0.7332)
King-Wu	-1.574462 (0.9423)	0.693929 (0.2439)	-0.925109 (0.8225)
Standardized Honda	-0.492599 (0.6889)	0.753620 (0.2255)	-3.395263 (0.9997)
Standardized King-Wu	-0.492599 (0.6889)	0.753620 (0.2255)	-4.051816 (1.0000)
Gourieroux, et al.	--	--	0.481537 (0.4404)

Appendix 9: Heteroscedasticity Test

```
Distribution free Wald test for heteroskedasticity:
 Chi-square(5) = 64.9566, with p-value = 1.14424e-012

Pooled error variance = 0.0167614

 unit    variance
    1   0.0157959  (T = 10)
    2   0.0268605  (T = 10)
    3   0.0271515  (T = 10)
    4  0.00679710  (T = 10)
    5  0.00720203  (T = 10)
```

Appendix 10: Autocorrelation Test

```
First differenced equation (dependent, d_y):

              coefficient   std. error   t-ratio   p-value
  ---------------------------------------------------------
  d_LNEDL       1.47107      0.667584      2.204    0.0923  *
  d_LNEL       -0.130146     0.300130     -0.4336   0.6869
  d_LNIS        0.578617     0.220992      2.618    0.0589  *
  d_LNIQ       -0.440462     0.632815     -0.6960   0.5247

  n = 45, R-squared = 0.3374

Autoregression of residuals (dependent, uhat):

              coefficient   std. error   t-ratio   p-value
  ---------------------------------------------------------
  uhat(-1)     0.166872     0.0891956     1.871    0.1347

  n = 40, R-squared = 0.0359

Wooldridge test for autocorrelation in panel data -
  Null hypothesis: No first-order autocorrelation (rho = -0.5)
  Test statistic: F(1, 4) = 55.8981
  with p-value = P(F(1, 4) > 55.8981) = 0.00171103
```

Appendix 11: Multicollinearity Test

Variance Inflation Factors
Date: 04/05/24 Time: 17:19
Sample: 2010 2019
Included observations: 50

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
C	0.368851	691.6650	NA
LNEDL	0.000926	94.78187	3.605170
LNEL	0.012747	424.6458	2.595767
LNIS	0.003210	62.01547	2.437253
LNIQ	0.014356	493.2342	2.885547