The Economic Agglomeration Effects of the Industrial and Business Sectors in Pengerang Johor, Malaysia from a Spatial Perspective

Noordini binti Che' Man* and Amirul Afiq Jamaluddin
Urban and Regional Planning, Faculty of Built Environment and Surveying,
Universiti Teknologi Malaysia, 81310 Skudai, Johor, Malaysia
*Email: b-noordini@utm.my

Abstract - The economic agglomeration effects of the industrial and business sectors refer to the positive externalities that result from the concentration of firms in a specific geographic area. These effects can take different forms, including increased productivity, better innovation, and lower firm costs. Additionally, the concentration of businesses and industries in one area can result in knowledge spillovers, where firms can benefit from the expertise and knowledge of other firms in the same field. This study aims to provide spatial visualisation of the industrial area with GIS technology within the Pengerang District. Data from the Pengerang City Council and Companies Commission of Malaysia was utilised to conduct a Getis-Ord Gi* (Hot Spot) analysis to determine the agglomeration pattern of industrial and business activities in the study area. This study identifies Bandar Penawar and Pengerang as the areas with the highest concentration of industrial and business activities. The factors or effects of the economic agglomeration in the study area include the concentration of industrial and business activities, the presence of supporting industries and services, the availability of transportation infrastructure, and the availability of skilled labour. The study also identifies the positive spillover effects of economic agglomeration, such as increased productivity, knowledge spillovers, and innovation. The analysis results can guide future strategic planning in the industrial and business sectors in Pengerang District.

Keywords - Agglomeration, Economic Impact, Spatial Analysis, GIS

1. Introduction

The economic agglomeration effects of the industrial and business sectors have been a topic of significant interest among scholars and policymakers alike (Zhang et al., 2022; Li et al., 2021). It is believed that the concentration of these sectors in particular regions can generate positive externalities, leading to increased productivity and economic growth. This has led to numerous studies exploring the effects of economic agglomeration in various contexts (Wang and Han, 2023; Du and Vanino, 2021). In the case of the Pengerang District of Malaysia, the concentration of industrial and business sectors in Bandar Penawar and Pengerang has resulted in significant economic agglomeration effects. The district has emerged as a hub for industrial development, attracting investments from domestic and foreign firms. This has led to numerous job opportunities and increased local income levels. Additionally, the development of supporting infrastructure, such as transportation and communication networks, has further facilitated the growth of the industrial and business sectors in the region.

Given the significance of economic agglomeration effects, this study seeks to explore the impact of the industrial and business sectors on the growth and development of the Pengerang District. The study will examine the factors that have contributed to the concentration of these sectors in the district and assess the extent to which they have generated positive externalities. Thus, this study aims to use GIS technology to visually represent the industrial area in a particular case study region. Spatial analysis, statistical analysis, and complexity modeling will be employed to integrate management facilities and showcase industrial and business activities in the area. The research will assess the qualitative and quantitative factors influencing property values and their connection to the surrounding neighbourhood and development. The findings of this study could have implications for policymakers, businesses, and investors looking to understand the economic potential of Pengerang and other industrial clusters in the region.

2. Industrial and Business Agglomeration in economics

In economics, the term "agglomeration" describes the concentration of economic activities, including businesses, industries, and services, in a particular location to maximise output and housing (Arita and McCann, 1998). Three factors—goods transportation costs, labour attraction power in the clustering area, and technological knowledge spillovers—impact the concentration of businesses in each area (Marshall, 1920). Agglomeration involves several externalities, such as the

amount of business or industry concentrated in one location and the services offered. Several methodologies have been suggested to determine the global scope and local density of an agglomeration pattern. The most straightforward technique to gauge the extent of agglomeration is to focus on specific businesses rather than individual employees (Nygaard et al., 2021).

The concept of urban agglomeration pertains to clustering cities in a defined geographic region with similar traits, such as a cohesive natural setting and society, substantial populations and economies, high levels of urban and industrial development, and superior infrastructure facilities. On the other hand, new economic geography is a theoretical framework that explains how economic activity is distributed across geographic regions. According to Krugman (1995), The New Economic Geography can be considered a theory of production location that explains the economic and spatial organisation changes. It suggests that factors like transportation costs, economies of scale, and product differentiation influence economic activity. The framework highlights the significance of comprehending the spatial dynamics of economic activity and how it impacts the growth and development of an economy. Xiao-lu et al. (2017) discuss the characteristics of urbanisation agglomeration. Tripathi (2012) explains the concept of new economic geography as a framework for understanding how economic activity is distributed across geographic regions.

The clustering of cities within a limited geographic area with similar characteristics, such as a cohesive natural environment and society, substantial populations and economies, high levels of urban and industrial development, and superior infrastructure facilities. Economists have studied the clustering of economic activities in a particular area since the 1990s. The concentration of businesses for a specific region is influenced by three main factors: the expenses associated with transporting goods, the ability to attract skilled workers and individuals, and the sharing of technological knowledge (Marshall, 1920). One factor contributing to the formation of clusters is the presence of specialised suppliers, service providers, and related industries, which can lower transportation costs and facilitate knowledge spillovers (Porter, 1990). The other two factors, namely the attraction power of people and the availability of skilled labour, are also frequently cited as critical components of a successful cluster strategy. Agglomeration involves two external factors: the concentration of industry or firms in a specific location and the type of services available. (Guimaraes et.al, 2000). These externalities can attract industries and firms to an area, which increases productivity.

There is a significant correlation between the migration of people from rural to urban areas and the development of agglomeration (Hafner, 2004), whereby sectoral migration influences the pattern of firm location, while interregional migration affects the planning of the country. The agglomeration of the industry is based on five aspects: output, labour, private capital, social overhead capital, and materials (Vamkadis et al.,2019; Tripathi,2012). The causes of agglomeration economies in developing countries are entrepreneurs with many workers equipped with inadequate education standards and a lack of expertise (Liang et al., 2019; Howard et al., 2016). Overall, the clustering of economic activities in a particular area can be influenced by various factors, such as transportation costs, attraction power of people and labour, technological knowledge spillovers, externalities, sectoral migration, accommodated infrastructure, and the agricultural sector.

There are challenges in measuring and analysing the pattern and concentration of agglomeration, and one of them is the clustering of economic activities in specific locations. Although various factors contributing to agglomeration have been identified, measuring it accurately is difficult. Several methods have been proposed to measure and analyse agglomeration patterns, including the cluster detection procedure, which helps to measure the global extent and local density of agglomeration patterns. The concept of agglomeration refers to the spatial concentration of economic activity in a particular geographic region. Several researchers have studied the impact of agglomeration on various countries, industries, and firms.

Guimaraes et al. (2000) examined the economies of Portugal and found that service agglomeration economies ranked first, followed by localisation economies in terms of their agglomeration effect. This indicates that concentrating services and businesses in a particular region led to greater productivity and economic growth. In their research on food manufacturing industries in the United States, Cohen and Paul (2001) discovered that agglomeration was a pivotal factor in determining the location choices of these industries due to its cost economies. This suggests that the cost advantages of being close to other related industries led to greater competitiveness and profitability. Meanwhile, a study by Fan and Scott (2003) reviewed the economic development of developing countries in East Asia, such as China, and found a significant connection between industrial clustering and industry productivity. This was particularly evident in China, where industries manufacturing computers and electronics benefited from agglomeration economies.

Boudier-Bensebaa's (2005) study investigated the significance of agglomeration effects for foreign direct investment (FDI) in Hungary. The findings revealed that regions with higher levels of job opportunities, manufacturing activity, and industrial demand were more successful in attracting FDI. Tripathi (2012) studied industries and firms in India to determine whether they were operating under increasing or decreasing returns to scale. The findings revealed that most industries and firms were operating under decreasing returns to scale, which could have negative implications for their long-term growth and competitiveness. Howard et al. (2016) study observed that entrepreneurs in developing nations exhibited less technological advancement, leading to more segregation in their trade practices. This suggests that developing countries may have opportunities to improve their economic performance through policies that support greater integration and technological innovation. Finally, Gokan et al. (2016) researched the significance of agglomeration economies on Vietnam's productivity, specifically through cluster detection at the firm level. The study revealed that the localisation economies resulting from agglomeration positively impacted firm-level productivity, especially when concentrated in a specific region. However, only foreign-owned firms seemed to benefit from urbanisation economies, while state-owned or private firms did not experience similar gains. This suggests that Vietnam may not fully utilise the potential of agglomeration economies in urbanisation.

With the continuous advancement of technology, the use of geographic information system (GIS) applications has been recognised as a crucial tool by many professions. This tool allows researchers to examine and evaluate the pattern of agglomeration. However, its use has been limited due to the lack of spatial data required for its application. As a result, some researchers have used Gini and Moran's I coefficients to measure agglomeration, which can lead to a-spatial estimation. Cao et al. (2019) conducted a study that utilised spatial econometric analysis to examine the influence of agglomeration and localisation economies on the manufacturing sector in the Pearl River Delta region of China. The research revealed that the productivity and efficiency of the manufacturing industry in the area were significantly impacted by agglomeration and localisation economies. By incorporating GIS and spatial analysis techniques, more precise and informative insights into the effects and patterns of agglomeration on various industries and regions can be obtained.

Lu and Cao (2019) conducted a study on the agglomeration patterns of the big data industry in China and the factors contributing to its growth. They used spatial analysis and GIS technology

to identify the components related to the agglomeration of the big data industry, such as the accumulation and number of universities, government financial budget for science, population, and gross domestic product of cities. GIS technology allowed researchers to map out and analyse the spatial distribution of these components across China, providing valuable insights into the patterns and factors contributing to the agglomeration of the big data industry. The study demonstrates the usefulness of GIS technology in conducting spatial analysis and identifying patterns and trends in complex data related to geographic locations. The findings revealed that the agglomeration of the big data industry was positively associated with the government's financial budget and the accumulation of universities. However, the agglomeration pattern and spillover were weak and only occurred in cities where the provinces were still developing, possibly because the big data industry is still in its early stage of development.

Additionally, the study highlighted the distinctive agglomeration patterns of three main agglomerated sectors: coking, petroleum refining, nuclear industry, construction, and finance insurance, which had different agglomeration patterns based on their location, forms, and environment. Overall, the research suggests that using spatial analysis and GIS technology can provide valuable insights into the patterns and factors of agglomeration in various industries. The findings can inform policies and strategies that aim to support the growth and development of different sectors in specific regions or areas.

In conclusion, agglomeration refers to the clustering of economic activities in a particular geographic region, which can lead to greater productivity and economic growth. In connection with it, various factors, such as transportation costs, attraction power of people and labour, technological knowledge spillovers, externalities, sectoral migration, accommodated infrastructure, and the agricultural sector, can influence the clustering of economic activities. Thus, measuring and analysing agglomeration can be challenging, but several methods have been proposed, including GIS technology.

3. Research Methodology

The steps employed to attain the research outcome are illustrated in Figure 1. The process involved various components, including digitising non-spatial data into spatial data and performing analysis on GIS. The process is described as follows:

i) User and expert knowledge input: Input involved in the processes was obtained from different sources or parties, such as the Pengerang City Council and the Companies Commission of Malaysia, Johor branch (SSM Johor).

ii) Input from Pengerang City Council: The land use form of Pengerang District in 2018, updated from 2015 data, was obtained from Pengerang City Council and was compatible with the GIS application. The data were categorised into required types of land use and further separated into classes for each land use.

iii) Input from SSM Johor: The data obtained from SSM Johor (the Year 2019) only consisted of a list of companies with their respective addresses, so data digitisation was needed to make it compatible with the GIS application. For this data, the list of companies' data was obtained by filling out the application form on the website by asking the information on the registered company in the study area. SSM usually collects company data through various means, including mandatory company registration processes, annual returns, and other reporting requirements. The data collected by SSM is used to maintain a record of all registered companies in Malaysia. This includes the names, addresses, and other details of the companies operating in the country. This data is publicly available through various channels, including SSM's online portal. There may be limitations to the data collected by SSM, including inaccuracies or omissions due to factors such as incomplete reporting or errors in data entry. It is also possible that certain information may be restricted or protected due to legal or privacy concerns.

iv) Both data sets were stored in the GIS database before executing the Getis-Ord Gi* or Hot Spot Analysis.

v) Getis-Ord Gi* Analysis: (also known as Hot Spot analysis) Using the z-scores and p-values from the selected features, this analysis shows where and how clustered the chosen features are.

vi) The product of the analysis, the Hot Spot pattern, was then considered the agglomeration pattern of Pengerang's industrial and business activities.

vii) This pattern can be used as future guidance for strategic planning of the industrial and business sectors in Pengerang District.
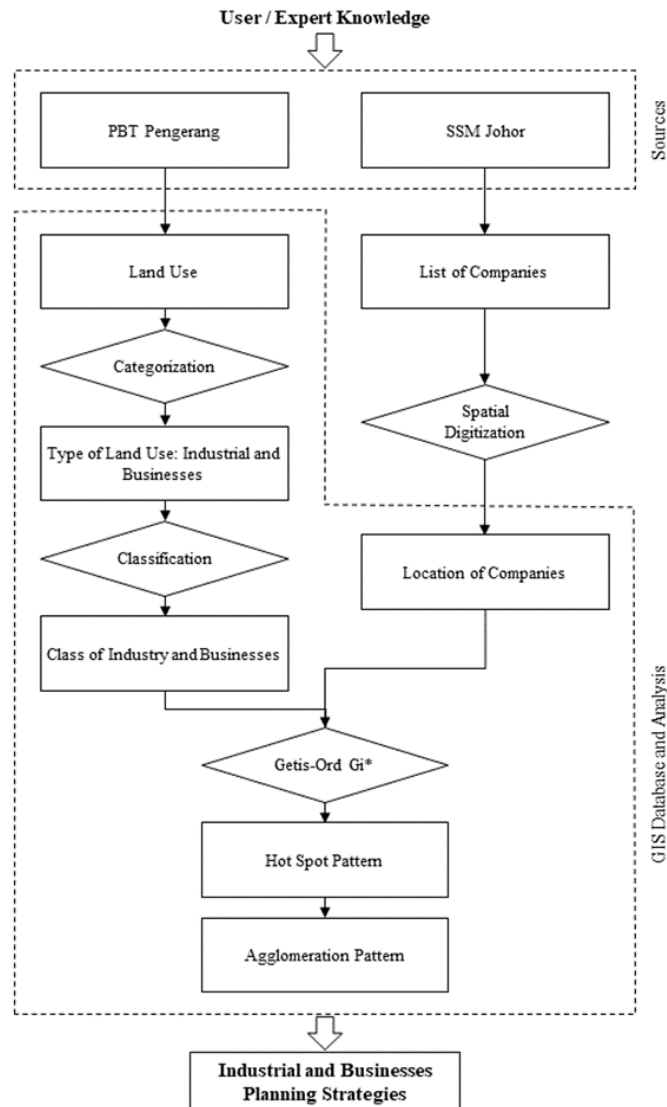
Figure 1. Research structure

3.1. Study Area

The Pengerang district, which falls under the administration of the Pengerang City Council, is situated in the southeastern part of Johor Malaysia within the larger Kota Tinggi district. Pengerang district is shown in Figure 2 in the context of Johor state. The district comprises three towns located in the northern, middle eastern, and southern parts, namely Sedili Kechil, Bandar Penawar, and Pengerang, respectively.
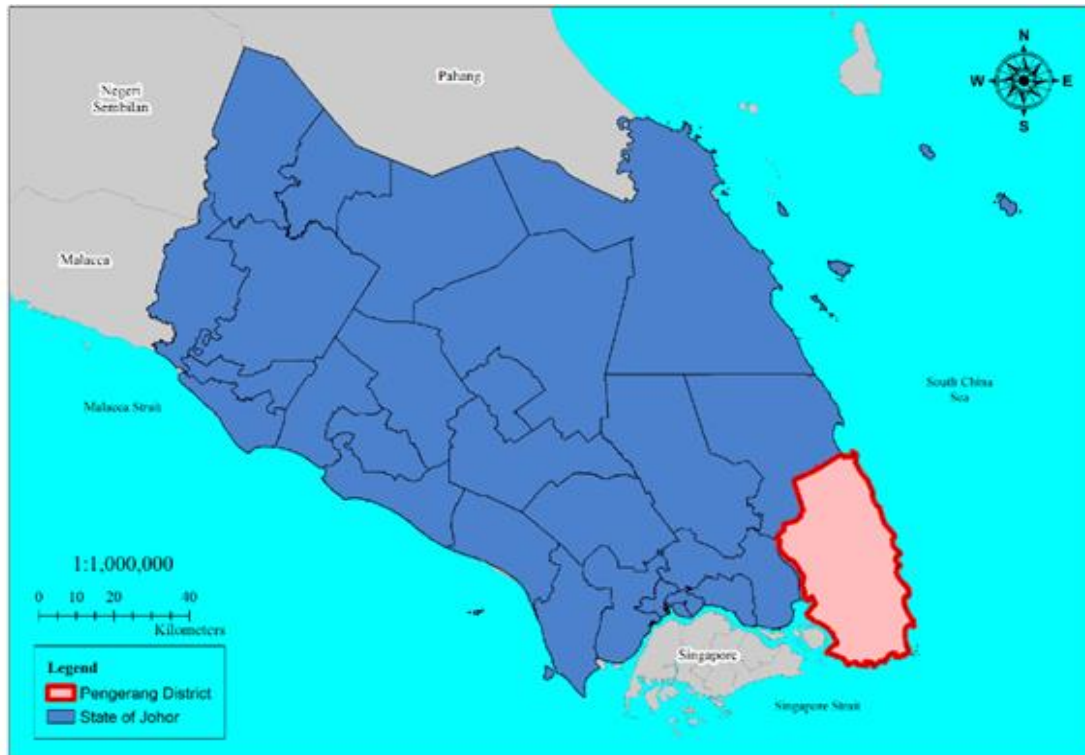
Figure 2. Pengerang district location

The Pengerang Integrated Petroleum Complex (PIPC) is a major industrial development project located in the Pengerang area of Johor. The complex includes a refinery, petrochemical plants, and storage and distribution facilities and has attracted significant investment from domestic and foreign companies. The Draft Local Plan for Pengerang (2018-2030) states that only a small portion of the total land area, precisely 4,180.15 hectares (3.38%), is zoned for industrial use, and an even smaller part of 2,065.45 hectares (1.67%) is designated for commercial use. However, despite this low percentage of land use allocation, Pengerang has gained attention for its rapid industrial growth and large-scale projects focused on oil and gas. One of these projects is the PIPC, which aims to capitalise on the available resources in the area and benefit the local community and the country. As a result, significant changes to the economic and land use landscape in Pengerang are regularly occurring.

4. Results and Discussion

The assessment of Pengerang District's land use data suggests that the number of industrial businesses in the region has expanded dramatically. The rapid growth of the industry sector in

Pengerang District has had a significant spillover effect on neighbouring towns such as Bandar Penawar, which have evolved into centres of business and administration for the local community. Studies indicate that firms and industries tend to locate near each other to minimise costs associated with transportation and resources. This is because the location of industries and businesses affects the costs involved. A Hot Spot analysis was conducted by utilising the land use data of Pengerang District to identify clusters of firms and industries (Figure 3). The study shows that Pengerang's economy heavily depends on the industrial sector, which is highly concentrated in Bandar Penawar and Pengerang. The PIPC project in Pengerang is a significant industrial project related to petroleum and natural gasses, but due to the available land use data is outdated and inadequate to indicate the concentration of heavy industries in the area. However, a recent analysis revealed that industrial land use is clustered in Bandar Penawar and Pengerang. (Figure 4). Meanwhile, commercial land use tends to cluster around Pengerang District, with patterns primarily observed in Bandar Penawar, the leading commercial and administrative centre (Figure 5).
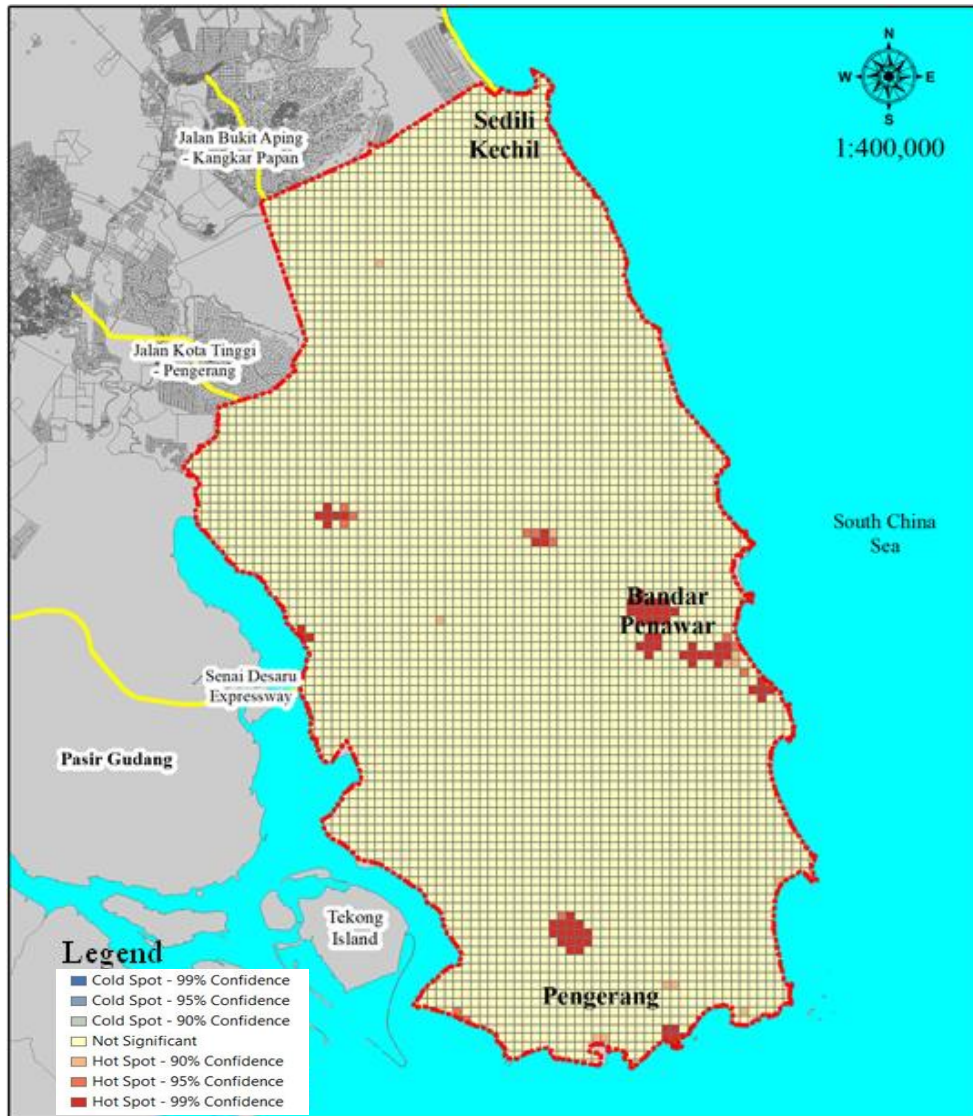
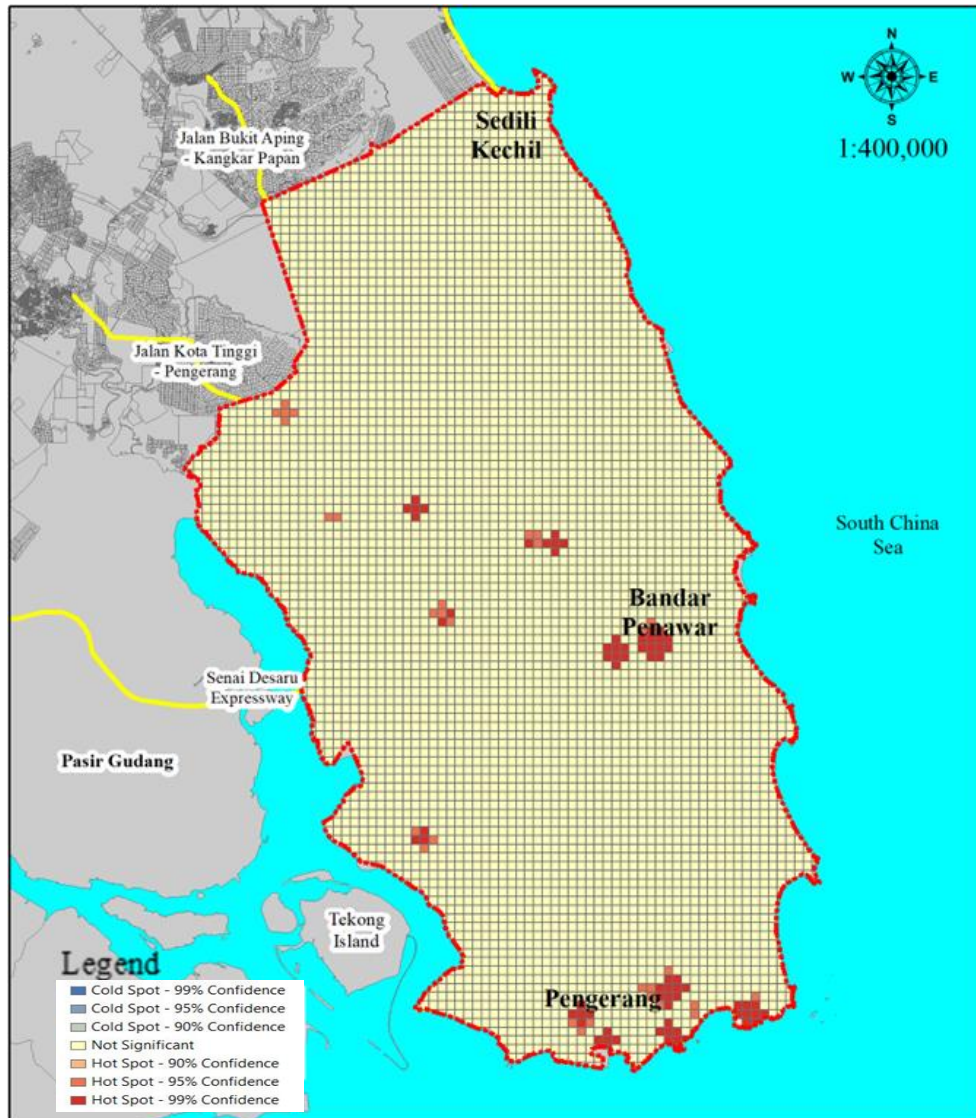**Figure 3.** Pengerang District industrial and business Hot spots Analysis

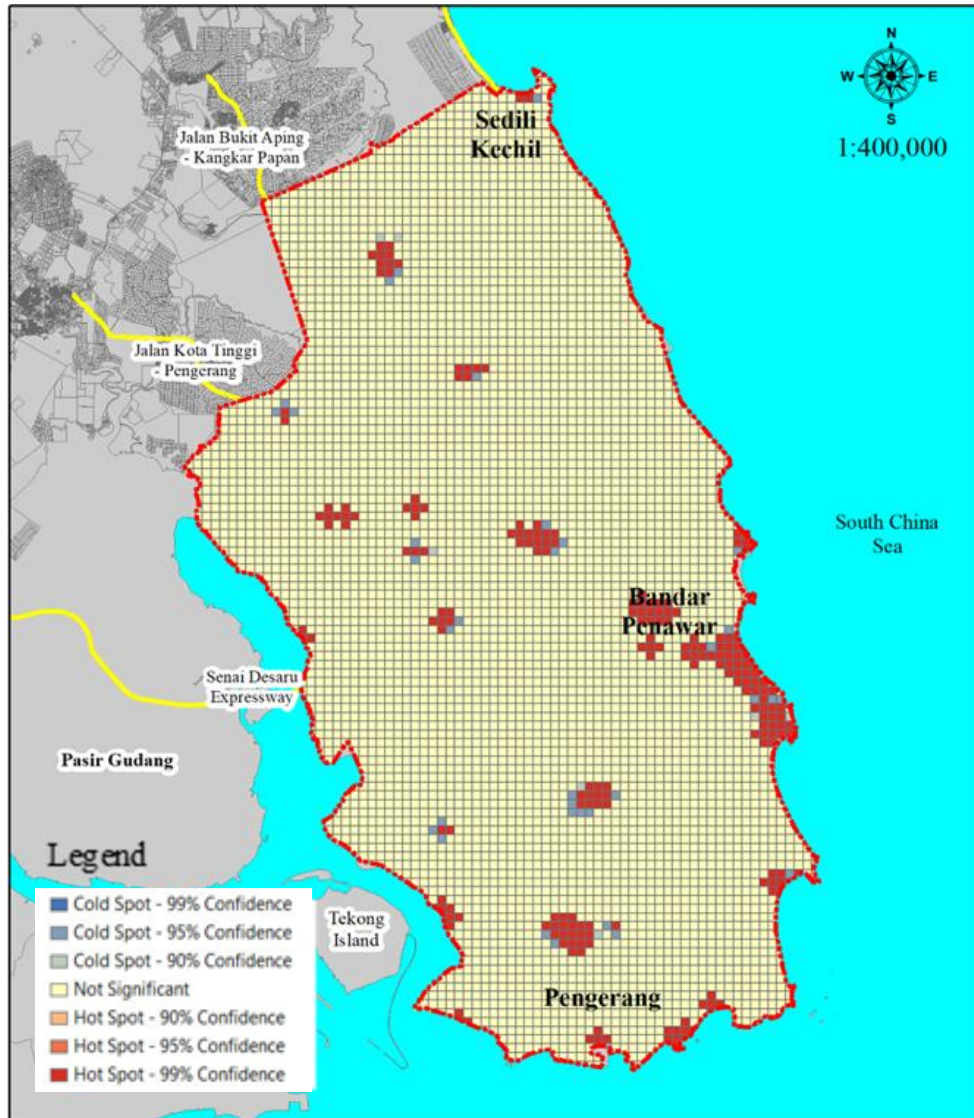**Figure 4.** Pengerang District industrial sector Hot spots Analysis

Figure 5: Pengerang District business sector Hot spots analysis

The study utilised SSM Johor's list of registered companies, and a Hot Spot analysis was performed. The information included the company's name, industry, and asset worth, but several owners omitted their firm address and asset value, which made it challenging to digitise the information in a map form. Moreover, most of the data showed that the firm was located outside the boundaries of Pengerang District, which was under the local authority of Kota Tinggi previously. Only 25 out of 157 listed companies were found within Pengerang District. Despite this limitation, the clustering pattern of companies and asset value can still be examined. The analysis showed that companies tended to cluster around Bandar Penawar (Figure 6), which is consistent with the clustering pattern observed in the land use data analysis of Pengerang District.

Construction and wholesale and retail businesses dominated the listed companies. The density of asset value among listed companies was highest at Bandar Penawar (Figure 7), where the darker the tone of colour, the higher the value of the asset and Lotus Desaru Beach Resort & had the highest asset value per company. This luxury accommodation and recreational facility is located at Desaru, a famous coastal area.
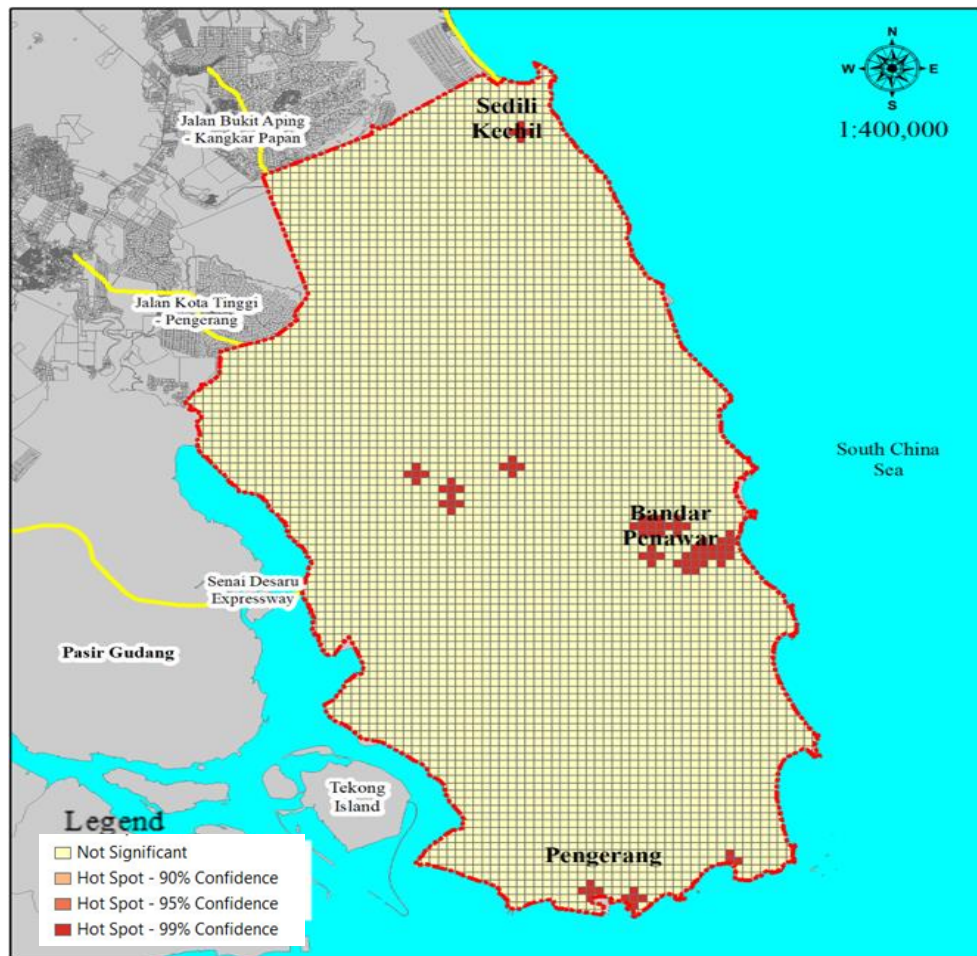

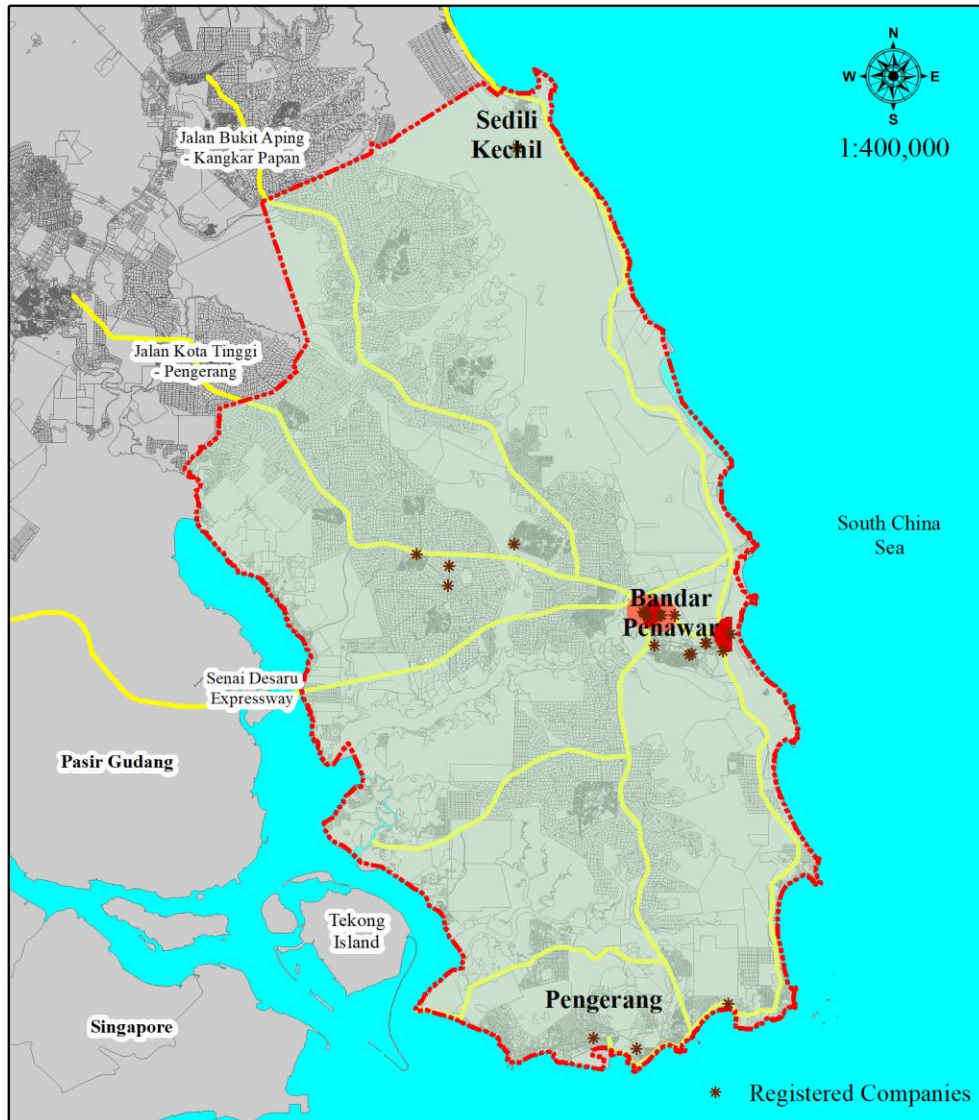**Figure 6**: Pengerang District registered companies Hots spot analysis

Figure 7: An analysis of the asset value of companies in the Pengerang District based on density

The analysis results suggest that the economic agglomeration in Pengerang, Johor is influenced by different factors, which can be grouped into three main categories: geographic, institutional, and industry-specific. A similar study, conducted on the economic agglomeration effects in the Yellow River Basin in China discovered that economic agglomeration is influenced by various factors, including the concentration of industrial activities, the availability of transportation infrastructure, and the existence of supporting industries and services (Song et al., 2023). Another study on the agglomeration of the automotive industry in Mexico found that the availability of skilled labour and the presence of supporting industries and services are key factors that contribute to economic agglomeration (Cota, 2021). These findings suggest that the factors that contribute to economic

agglomeration are similar across different regions and industries. The concentration of activities, transportation infrastructure, availability of skilled labor, and supporting industries and services are consistently found to be important factors that contribute to economic agglomeration.

Pengerang's strategic location close to the Malacca Strait's international shipping lanes is a key geographic factor, providing easy access to inclusive markets. The region's natural deep-water port has also made it a popular location for shipping and logistics businesses, while the presence of significant natural resources such as oil and gas reserves has contributed to the growth of the petrochemical industry. Meanwhile, institutional factors have played an important role in supporting economic agglomeration in Pengerang, with the Malaysian government implementing policies such as tax incentives, streamlined business registration processes, and investment in infrastructure development to attract foreign investment. Lastly, industry-specific factors have also played a role in driving economic agglomeration in Pengerang. For example, the concentration of firms in the petrochemical industry has created a cluster effect, providing benefits such as knowledge spillovers, access to specialised labour, and shared infrastructure.

The analysis conducted in this study provides several advantages and important insights. Firstly, the use of spatial mapping and analysis techniques allowed for a comprehensive understanding of the agglomeration patterns of industries and businesses in the region. The Getis-Ord Gi* analysis used in this study provided a precise way of identifying hotspots and clusters, which can aid in strategic planning and decision-making for the development of the industrial and business sectors in the study area. Furthermore, the study sheds light on the complex factors driving economic agglomeration in the region, including geographic location, institutional support, and industry-specific factors. This knowledge is crucial for policymakers and businesses looking to invest in the region, as it provides insight into the potential benefits of clustering and the specific factors that can contribute to the success of such clusters. In terms of knowledge novelty, this study is unique in its focus on the Pengerang area, which has seen significant growth in recent years due to the development of the petrochemical and shipping industries which also can be valuable for policymakers and businesses operating in the region. However, one limitation of this study is its reliance on secondary data sources, which may not be completely accurate or up to date. Additionally, although the study provides insight into the factors driving agglomeration in Pengerang, it does not explore the potential negative effects of clustering, such as increased competition and decreased modernisation.

5. Conclusion

This study aimed to use GIS technology to visually represent the industrial area in a particular case study region. The analysis conducted has determined the clustering pattern of industrial and commercial businesses within the Pengerang District using land use data and the list of registered companies from 2018 and 2019, respectively. The industrial sector was observed to cluster at Bandar Penawar and Pengerang, while the commercial sector was mostly concentrated at Bandar Penawar. The data on registered companies obtained from SSM Johor indicated a higher asset value of property in Bandar Penawar than in other towns in Pengerang District. However, the small amount of data obtained and the lack of transparency regarding registered companies limit the significance of the analysis. Despite these challenges, the study's findings can help with future planning for the industrial and commercial sectors of Pengerang District, particularly in terms of determining the type and location of businesses to optimise land use and resource and product supply chains. Industry 4.0 is implemented, governments should focus on big data around the country, as digital information is crucial for the current age of technology. The concept of a Smart City is an ideal that many stakeholders strive to achieve, as it is resilient, energy efficient, and a countermeasure to the current worldwide issue of climate change. Technologies are often applied to achieve better and more efficient energy management, but these usually only apply on a small scale. For further study, the implementation of BIM-GIS software seems able to cover development at both the macro and micro scale, resulting in improved management and facilities for cities. This is achieved by the seamless transfer of precise information between parties. Luckily, advances in technology have made this concept achievable, with tools and applications provided by Esri ArcGIS to create Smart Cities.

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