Transportation system impact on spatial interaction in Batang integrated industrial area

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Abstract. The structure and use of urban land have a key role in a transportation system has significant impact on Batang land use. Because it is very influential on the demand and capacity of the transportation system related to human mobility. The relationship between land use and transportation systems can be defined in terms of spatial interaction. This spatial interaction arises because of the generation and attraction activity of the movement between two important entities. The higher the activity, the stronger the interaction will be. In addition, the form of urban spatial planning also greatly influences the interactions that occur. However, the problem is that if there is a large infrastructure project, it will tend to trigger changes in land use along with the spatial interactions in it. This article will examine in more depth the possibility of spatial interactions that occur in the Batang Regency due to the activities of the Batang Integrated Industrial Estate. So that it can be seen the dynamics of land-use changes that occur due to large spatial interactions in the area. The approach used in this research is quantitative deductive. The discussion in this article consists of several stages, namely a review of literature studies on land use and spatial interactions. Furthermore, the results of the review carried out the process of modeling the spatial interaction of transportation to describe the activities that occur in the area. The results show that the spatial interaction of transportation will be oriented along the main road axis and has a high intensity. Because the main road tends to be served efficiently by public transportation. However, in an area that is not traversed by the main road axis, spatial interactions still exist with random patterns and low intensity.

Keywords: transportation system, land use, spatial interaction

1. Introduction

1.1. Background

Transportation has a key role in encouraging increased economic growth. Economic growth is the main goal of the development of an area. Therefore, each region will strive to be able to achieve its main goal. An indicator that is often used to conduct periodic assessments is the Regional Gross Domestic Product (PDRB). This indicator is published periodically by the Central Statistics Agency (BPS) [1]. But all of that still depends on the ability of each region to spur the growth of competitiveness of economic sectors in its territory [2]. In addition, development in the area must accommodate spatial structures such as urban and rural centers, lagging regions, and growth centers [3]. Current regional economic development and development policies should be prioritized by the superior sectors owned by each district or city

while still paying proportional attention to other sectors following their potential and development opportunities [4]. The development of superior sectors should be directed to create interrelationships between regions that can be implemented in the concept of spatial interaction between regions and with their growth centers. Batang Regency currently has a high attractiveness for national and international investors. This is because there is currently the development of an Integrated Industrial Zone (KIT) in Batang which is planned to accommodate large-scale industries on an international national scale.

In the theory of industrial relations and transportation activities there are three important things that need to be considered transportation, distribution, and logistics. The existence of these three things is expected to accelerate economic growth in a region. A summary of some of the results of the study shows that the transportation, distribution, and logistics (TDL) industry is one of the most important industrial sectors in the United States. According to various estimates, the TDL industry represents from 8.5% to 20% of the nation's gross domestic product, depending on how carefully the transportation and logistics-related output is calculated from all the industrial sectors. Recently, this industry has shown strong increasing trends in employment in the transportation and wholesale/distribution sectors with a favorable comparative wage differential to other industries [5]. A sponsored study by the Central Indiana Corporate Partnership found that the TDL industry plays a key role in promoting job growth in the Central Indiana region [5]. The ability of the TDL sector to coordinate and integrate the production and delivery of goods and services from raw materials to final consumers gives cost advantages to both established and startup companies. Past researchers [6] [7], industry experts, the business community, public officials, and the public have argued that the TDL industry is one of the most significant economic sectors for regional economic development. It is also argued that public support in the region is important for the TDL industry because it is an activity that affects the entire region. The different sub-sectors within the TDL industry depend on each other as well as on other industries, local governments, and residents of all the communities in the region.

2. Method

2.1. Spatial Form, Patt[illegible] and Interaction and the Environmental Impacts of Transportation

The structure of urban land use has a significant impact on transportation demand and the ability of transportation systems to meet such mobility needs [8]. There are three aspects that affect the environmental impact of transportation and land use.

- Spatial shape. Refers to the spatial arrangement of a city, especially in relation to the position and direction of its transport axis. Therefore, this form conveys the general structure of urban transport, from centralized to decentralized. The main impact was expansion and motorization. The resulting multi-central city is economically and functionally flexible but consumes more energy.
- Spatial pattern. Refers to land-use organizations associated with locations of important socio-economic functions such as housing, commerce, and industry. The predominant trend is an increase in specialization, segregation, and fragmentation between land uses. Also, several types of land use can be inconsistent with proximity to sources of added externalities. For example, the use of residential space is incompatible with the activities of most industries, manufacturing, warehousing, and transportation terminals. They create very vulnerable noise and congestion externalities for the local population. In these situations, buffers that apply various barrier effects to facilitate physical separation can help mitigate incompatible land use.
- Spatial interaction. Refers to the nature and structure of the movement generated by urban land use. The predominant trend is the increase in urban interactions in terms of quantity, complexity, and average distance.

Locations of activities such as home, work, retail, manufacturing, and distribution show the required travel needs and the average distance between activities [8]. Interactions increase proportionally due to special land-use functions and spatial separation between economic activities. The relationship between transportation, land use, and the environment can be most concisely expressed by the issue of density

[9]. The higher the density, the lower the per capita energy consumption and the relative environmental impact [10].

The amazing diversity of urban densities can be seen around the world, reflecting different geographic settings, planning frameworks, and levels of economic development. This complexity is worsened as the density changes compared to the city Centre [11]. Paradoxically, the outward expansion and suburbanization of cities have supported a relatively uniform distribution of land-use densities, especially in previously sparsely populated cities. Over the last few decades, the average density in some metropolitan areas has decreased by at least 25%. This means that added traffic is needed to support the mobility needs [12]. In addition, the separation of home and work, average commuting time, and distance are becoming increasingly stringent [13]. Supplying urban transportation services at an efficient cost is becoming increasingly difficult. It emphasizes that the future of sustainable mobility needs to consider individual mobility needs, even if this mobility is considered less sustainable than collective mobility increase.

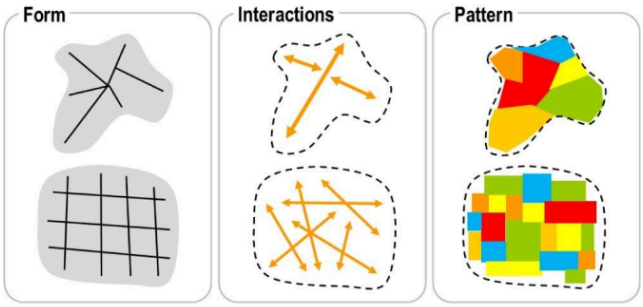

Figure 1. Spatial Form, Pattern and Interaction and the Environmental Impacts of Transportation.

The figure above shows two urban spatial structures in terms of shape, pattern, and interaction. In the former case, the city focuses on local transportation, while in the latter case, the car dominates. Spatial form. The spatial aspect of the city is related to that extent. The first case is more centralized and compact, with corridors shaping the shape of the city. The second case is grid-like with limited centrality. It is likely that in the first case, the average commuting distance is shorter than in the second. Spatial interaction. The intensity of movements between spatial entities. In the first case, interactions are oriented along major axes and have a high intensity that can be efficiently serviced by public transit. In the second case, the interaction has a random pattern and low intensity. Spatial pattern. Land use organization related to the location. In the first case, the pattern is banded, slightly radial and concentrated. In the second case, the pattern is very fragmented and scattered. In such an urban environment, it is difficult to achieve economies of scale and transit economies. Second cities can have far more environmental impacts due to land use due to their spatial structure and the transportation requirements associated with such spatial structure. However, the first cities may be more environmentally external, especially in the central region [14].

2.2. Research Method

The analytical approach is a method of conducting research aimed at achieving the goals of the research [15]. The tactic used in this analysis is a quantitative deductive analysis. This method was chosen because it aims to develop early hypotheses related to the characteristics of the study area [16]. This hypothesis is the basis for further research. In this article, we will discuss in more detail the potential for

spatial interactions in the Batang Regency due to the activities of the Batang Integrated Industrial Complex.

The variables used in the study consisted of secondary data consisting of GDP (Gross Domestic Product), the distance between regions to growth centers, and the availability of transportation options. The data analysis method used is a quantitative descriptive method, while analysis uses locational indices. The influence of j centers of influence on an area is expressed as the regional location index (Region's Location Multiplier), (LOCMij). The total influence of all centers on a given area, LOCMi, is defined as follows [17]:

$$LOCMi=\sum_{Ji}^{n} LOCMij$$

The regional to center location index j is determined by two factors: the total magnitude index j (Size Index of Centrej), SIj: and the accessibility index between the a and central regions of j,AIij. So the LOCMij Location Index is defined as:

$$LOCMij=SIj\times Alij$$

The Central Magnitude Index can be seen as a function of the central magnitude measured under a condition. Then the Central Magnitude Index, SIj, is defined as:

$$SIJ=\frac{GDPj}{GDPmax}$$

GDPj is revenue in the area j, and GDPmax is revenue of the entire region. The definition of the accessibility index, AIij, between regions i and j is more complex. This index expresses the function of the distance of the two regions from the main influence of the center with transportation costs but is also a function of spatial continuity of the region, in other words, the function of the availability of transportation with other regions. The AIij Accessibility Index is defined as:

$$AIij=TCij\times SCi=\frac{TCmin}{TCij}\times SCi$$

TCIi is transportation cost index between the middle area j, SCIi is spatial continuity index of area i, TCmin is minimum cost of transportation one unit quantity per area with the center, and TCij is transportation cost of one unit quantity between area i and the center

3. Analysis

3.1. Gross Regional Domestic Product (GDP)

Gross regional domestic product data is the initial data used to determine the locational index in this study presented in the form of a table per year in the region directly adjacent to Batang Regency. More details are explained in table 1.

Table 1. Gross Regional Domestic Product 2017 – 2021.

Region	GDP Per Capita on a Constant Price Basis (Million Rupiah)				
	2017	**2018**	**2019**	**2020**	**2021**
Batang Regency	18.080.000	18.950.000	19.910.000	18.790.000	19.530.000
Pekalongan Regency	14.679.128	15.525.050	16.356.350	16.047.511	16.615.065
Pekalongan City	6.706.278	7.087.915	7.477.425	7.337.833	7.601.486

Table 1 shows that the GDP of Batang Regency has increased every year. But in 2019 to 2020 there was a significant decline. This happened because of the effects of the Covid-19 pandemic which made the regional economy weaken. In a crisis situation like this, the economic sector needs special attention

from the government because if left unchecked it will have a big impact on GDP [18]. This form of attention was shown in 2021 slowly the GDP of Batang Regency began to increase.

3.2. Central Distance growth and Availability of Modes of Transportation

The location of the growth center is Semarang City which is the capital of Central Java Province. After it is known, the distance has then identified the availability of transportation modes originating from Batang Regency. More details are explained in Table 2.

Table 2. Distance and Transportation Options to The Growth Center

Region	Distance (Km)	Mode Choice
Batang Regency	93	Train, Bus and etc
Pekalongan Regency	100	Train, Bus and etc
Pekalongan City	100	Train, Bus and etc

Table 2 shows that transportation is available at research sites, namely trains and land vehicles (public buses). The results of calculations in the research conducted [1] the value of the mode of transportation is 1 so that the maximum number of modes of transportation for each region is four and at least 1.

3.3. Locational Index Calculation Results

The results of calculations in the research conducted [1] showed that the highest locational index value was in Pekalongan Regency. Then the results are compared with the results of calculations this year. More is explained in Table 3.

Table 3. Comparison of Locational Index Results.

Year	Locational Index		
	Batang Regency	Pekalongan Regency	Pekalongan City
2009	0.03250	0.04161	0.02656
2010	0.03250	0.04134	0.02670
2011	0.03275	0.04158	0.02696
2012	0.02545	0.03234	0.02109
	Re-Update		
2017	0.03280	0.04158	0.02694
2018	0.03285	0.04168	0.02697
2019	0.03290	0.04188	0.02699
2020	0.03295	0.04190	0.02690
2021	0.03285	0.04195	0.02695

The value of the locational index indicates the interrelationship between agglomeration regions in specialization in the industrial world. If the locational index value is close to 1, the area is related to a large agglomeration region [19]. Table 3 shows that the locational index value of Batang Regency tends to stagnate from the previous year. This indicates that currently, concentrations and spatial interactions in this agglomeration region have not occurred.

Spatial Concentration and Interaction will create benefits in the form of localization savings and urbanization savings which are driving factors for strengthening in the agglomeration area [20]. Spatial concentration and interaction can arise due to the favorable availability of labor. In addition, it can increase efficiency in meeting the needs of better and cheaper specialized inputs. Distance reduced by spatial concentration will facilitate the flow of logistics, distribution of information, and knowledge

(knowledge spillover) at that location [21]. This should have been considered from the beginning before the construction of the Batang Integrated Industrial Zone. The existence of a strong interaction between land use and transportation systems has been widely known by planners. However, this concept is very rarely used in planning implementation. Basically, this interaction concept combines the regional development policy contained in the RTRW Regional Spatial Plan (national, provincial, district / municipal level) with a transportation network system that will accommodate the movements generated by the land use activities. Actually, land use has a causal relationship (reciprocity) with the transportation network system (highways, railroads, and others). A quantitative model has been developed that links the interaction between RTRW and transportation network systems (especially highways) so that the policy of developing transportation network systems has actually anticipated and accommodated changes due to regional development [22].

4. Conclusion & Discussion

Batang Integrated Industrial Area, at this time, has no influence on spatial interaction, especially in the transportation sector. This is predicted because currently, the Batang Integrated Industrial Zone is not fully operational. In the future, if the Integrated Industrial Zone is fully operational, then consideration of the choice of transportation modes in carrying out its distribution must be done. Because if viewed from the locational value index the industry will choose areas that have the availability of transportation options. It is related to the economic value of the industry which has options for the efficiency and effectiveness of the company.

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