Transportation Infrastructure Relations on Economic Growth in Sumatra Island

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Abstract. Transportation infrastructure is a stimulus in the economic growth of the region, no exception in Indonesia. But the interaction between transportation and economic development is a link to transportation's ability to magnify the impact of urbanization. This raises the question of whether the existence of transportation can explain the economic growth that is occurring. On the other hand, whether the lack of transportation infrastructure is due to the economic capabilities that exist in the region. This research aims to pay attention to the relationship between transportation and economic growth in Sumatra Island. The growth of transportation infrastructure may explain economic growth in all districts of Sumatra Island but the magnitude of those relations in the urban areas are far greater than in nonurban areas. Using the Multispatial CCM method, it appears that investment in transportation infrastructure does not directly increase the GDP of transportation in the region. This research suggests that road investment can have an impact on GDP through increasing the region's population which then provides an increase in GDP.

Keywords: Transportation Infrastructure, Multispatial CCM, Sumatera Relation, Economic Growth.

1. Introduction

The interaction between infrastructure and economic aspects has been widely discussed. In general, infrastructure development is always aimed at supporting and improving economic growth. As a reciprocity, economic growth will encourage infrastructure development. It is just that, in the perspective of the urban system, urban interactions are still being reviewed based on their respective aspects. While the connectedness between urban interaction in economic and infrastructure aspects has not been widely reviewed [1].

There are strongholds that believe economic growth is emerging as a result of the existence of transportation infrastructure and there are strongholds that believe that investment and development of physical infrastructure is the answer to the many dynamic and transformative public demand. Infrastructure development is expected to drive social change, moving on an accessibility opening opportunity that can trigger mobility to achieve economic growth and distribution in a region. Then there is the assumption that the better and adequate the existing transportation system, the higher the economic growth rate and the more evenly distributed the development in a region. The findings from Banerjee, Duflo, and Qian which tried to unravel the complexity of transportation infrastructure relations and economic growth in China over a period of 20 years (1989-2006), that better access to
transport networks does not contribute greatly to the improvement of economic performance in a region [2]. Pradhan and Bagchi in India found that economic growth was also not directly affected by the development of transportation infrastructure [3]. According to Maparu and Mazumdar urbanization is said to be the driver for the economic growth of a Region because of its inherent three types of agglomeration: industrial agglomeration in urban areas, agglomeration of business types in an industrial area, and agglomeration of production technologies [4]. Urbanization has been observed to occur faster when rural productivity is higher and transportation costs are lower, namely lower physical barriers to the movement of people and goods. According to economic geography theorists, coastal areas are more advanced and densely populated compared to inland areas [5]. Transportation and urbanization infrastructure do not follow the same between patterns of relations around the world [3].

The existence of transportation infrastructure does have a connection with urbanization and economic improvement that is attached to it. However, transportation infrastructure is not the only factor that guarantees the economic growth of a region. Many factors affect urbanization in addition to transportation infrastructure such as productivity and so on. There are even two statements from transportation and urbanization infrastructure researchers in China that better access to transportation networks does not contribute greatly to the improvement of economic performance in a region [2]. Pradhan and Bagchi in India found that economic growth was also not directly affected by the development of transportation infrastructure [3]. Therefore, the development of transportation infrastructure can be carefully planned to have a positive impact on the economic growth of a region.

Practically speaking, to provide transportation infrastructure, the need for knowledge about urban interactions that occur on the island of Sumatra is important to know. The priority of this research is to improve the accessibility of the region into a tool to assess the effectiveness of transportation infrastructure development in Sumatra Island. Through effective infrastructure it can have a positive impact on the development of regions and cities. This study seeks to look at the relationship between economic growth, urbanization, and transportation infrastructure in causality relationships between aspects.

2. Methodology

This research was conducted using the recently developed MultispatialCCM method of Clark et al. Previously, the convergence cross-mapping (CCM) method of Sugihara et al. was considered. Briefly, CCM tests for causation by measuring the extent to which historical values of Y can reliably estimate states of X, something that happens only if X causally influences Y. CCM does this by looking for a ‘signature’ of X in Y’s time series by determining if there is correspondence between a ‘library’ of points in the attractor manifold built from Y and points in the X manifold. These manifolds are built from lagged coordinates of the X and Y time series values. If the time indices of nearby points on the Y manifold can identify points on the nearby X manifold, then Y can be used to estimate X (and vice versa). Full details of the CCM method and complete algorithmic description are presented in Sugihara et al [6]. One potential issue with the classic CCM method is regarding the minimum length of the time-series. It is suggested that CCM should be used in cases where data length is > 30. Unfortunately, many of the variables used for this study have fewer than 30 measurements and, therefore, CCM is not applicable in its standard form. CCM was adapted by Clark et al. to piece together multiple replicate observations from spatially distributed plots with short time-series [7]. Although the MultispatialCCM method by Clark et al, it was built for ecological data for a short time, the use of this method in dara social science has been done before by Susnik and Zaag to see the relationship between HDI and economic growth [8].

A full description of multi-spatial CCM is that given in Clark’s research [7] can be proceeds in five main steps: (1) determine the best embedding dimension, E, for analysis. (2) test for non-linearity and noise. (3) calculate two processes’ abilities to describe each others’ dynamics. (4) use bootstrapping to leverage spatial information; and (5) test whether predictions indicate a significant causal relationship.

In this study the ‘plots’ are the countries reporting HDI and metric data and the ‘observations’ are the reported HDI and metric values. For this analysis, the code given in Clark et al. and freely available as a package in the R programming language was adapted for this study. The E dimensionality value [6,7] was determined individually for each simulation, and was always more than 2. Each computation comprises 100 bootstrapped simulations to ensure consistent and robust results.
This research conducted by showing the relation of region gross domestic product in transportation and length of road that is in good condition and population. Spatially, we collect data from 172 rural and urban districts under the administrative area of Sumatra Island. The data used in this study was collected from the official statistical report published by Statistic Indonesia (Badan Pusat Statistik). In this study, we also noticed differences in urban and non-urban characteristics. The urban areas referred to in this study are metropolitan areas as well as and their supporting areas described in the national spatial recana (RTRWN) 2008-2033. Sumatra island has 12 metropolitan areas with 24 districts included in this category.

3. Results and Discussion

The study sought to look at the correlation between good road length and GDP of transportation. Seen in Figure 1, there is no significant difference in the correlation of good road length and PDRB roads on transportation in districts on Sumatra Island. This consistently occurred throughout the observation time of 2011-2016. The relationship between decent road length and GDP of transportation is unsurprisingly positive.

![Figure 1. Correlations between GDP of transportation and road length of district in Sumatra Island; 2011-2016](image)

However, the figures are more interesting when paying attention to the correlation between good road length and GDP of transportation in urban and non-urban areas. The urban areas referred to here are cities and districts that belong to the metropolitan areas contained in the national spatial plan. When looking at the urban context, illustrated through the graph in Figure 3, it appears that the change in GDP of transportation has an impact on changes in road length that far greater than the change in road length to the value of the same change in GDP in non-urban areas. This gives the impression that the city tends to have investment in transportation GDP in the form of road improvement.
Different relationships in urban and nonurban contexts can also be seen in the correlation between GDP of transportation and population. When looking at the urban context, illustrated through the graph in Figure 3, it appears that the change in population has an impact on changes in percentage on GDP of transportation far greater than the change in non-urban areas. This gives the impression that the city tends to have investment in transportation GDP in the form of road improvement.

To shed light potential causality between the GDP of Transportation and road length, the multi-spatial convergence cross-mapping (MultispatialCCM) methodology was used. In this present analysis, the districts are analogous to spatially distributed sample plot replicates, with each ‘plot’ having 5 ‘observations’ between variables, with 5 years of annual data.

Results suggest that, there are strong causation for GDP of Transportation to length of road but not the other way around. On the other hand, both the relationship between GDP of Transportation and the population and between population and length of road must be seen bi-directional causation. When reading Figure 4, a rho value much is comparably greater than zero that is stable after the initial rise implies causation. A very rapid rise to stability can imply synchrony [6]. Population and GDP of transportation display almost equal levels of causation (side A on Figure 4). This suggests that they are tightly connected, with changes in one having a great impact on the value of the other.

![Figure 2](image)

*Figure 2. Correlations between GDP of transportation and road length of district in Sumatra Island; 2011-2016 (A) on non-urban area; (B) on urban area*
Figure 3. Correlations between GDP of transportation and population of district in Sumatra Island; 2011-2016 (A) on non-urban area; (B) on urban area
The relationship between the studied variables can be seen in Figure 5. From the picture it appears that the transportation infrastructure investment that in this study is analogous to the length of the road, has no causal relationship with the economic improvement that in this study is analogous to the GDP of transportation. The second relationship is that gdp transport results in changes in road length. The length of the road can affect transport GDP through population changes.

Figure 4. Multispatial CCM output of Sumatra Island’s (A) GDP of transportation dan road length; (B) GDP of transportation and population, and (C) population and road length. (X axis represent rho value, Y axis represent L value) [7]
4. Conclusion

This research seeks to shed light on long discussions about transportation investment and economic improvement. In this study, it appears that investment in transportation infrastructure does not directly increase the GDP of transportation in the region. This research suggests that road divestment can have an impact on GDP through increasing the region’s population, which then provides an increase in GDP. This gives the idea that investment in transportation infrastructure will have an impact on the economy only if this infrastructure is then successful in bringing about urbanization in the form of population increase.

But the results of this study need to be taken with a little caution. This research only provides an exclusive overview of variable relationships in Sumatra Island. The data used in this study was relatively small even for the multispatial CCM which is 6 observations, although Clark gave an example with 5 observations data [7]. In addition, we reduce economic improvement as a result of the urbanization of only GDP on transportation aspects regardless of the other 12 aspects calculated in regional GDP. We do not deny that the economic improvement resulting from the increase in transportation is not limited to the transportation aspect alone. In fact, this is done because it assumes that the direct impact by the economy that will be captured on GDP indicators from the road improvements will be seen in GDP in terms of transportation.

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