MASTER'S PROGRAMME IN URBAN MANAGEMENT AND DEVELOPMENT

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The Impact of Changing Bus Rapid Transport (BRT) System Lanes on the Spatial Distribution of Economic Activity within the Jakarta Metropolitan Area

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Summary

The development of the Bus Rapid Transport (BRT) system in Jakarta is assumed to give an influence on the spatial distribution of economic activity within the Jakarta Metropolitan Area. But, what kind of impact will it bring in the future? And what are the impacts of changing the sequences of the project development and the value of parameters on the economic activity in this area? These questions, in this research, are answered using the theory of geographic economics and the computer simulation developed by Brakman, Garretsen, and Van Marrewijk (2001).

In order to analyze the hysteresis of the BRT project, together with the impact of this development on the final distribution of economic activity, the long run equilibrium before and after the development of the project are calculated using several different scenarios of distances. Following these simulations, other simulations are done in order to observe the impact of changing the value of congestion cost, transport cost, elasticity of substitution, and share of income spent in manufacture parameters.

Ultimately, there are several conclusions that are drawn from this research. First, it can be concluded that hysteresis does not play an important role in determining the final distribution of mobile activity after the development of the first three corridors and the completion of the entire project. Second, the development of the project benefits Jakarta by allowing this city to attract a larger share of mobile activity. In the future, the BRT corridors will act as forces that counteract the decline of the economic activity in Jakarta due to the high congestion cost. The decline of economic activity will occur less rapidly than what it otherwise would have been done in a relative time.

Third, it is important to consider the impact of the BRT project on the welfare level of people living in the Jakarta Metropolitan Area. It is clear that the development of this project increases the welfare level of both mobile and immobile workers in all the twelve regions. It is an investment in infrastructure, and thus increases the interaction between the regions. The mobile workers gain from the reduction of the transport cost and the growth of interaction between regions. The immobile workers in the centre of the Jakarta Metropolitan Area benefit, because the increase of mobile economic activity in their regions reduces their import over some goods. The immobile workers in the outskirt of Jakarta also gain, because the goods that have to be imported from the centre can now be imported with the lower cost.

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Abbreviations

Parameters

α	Fixed cost
β	Marginal cost
γ	Share of labour force in manufactures
δ	Share of income spent on manufactured goods
ε	Elasticity of substitution
η	Speed of adjustment
θ	Miscellaneous parameter
κ	Miscellaneous parameter (for Langrangian multiplier, econometric equations and knowledge spillovers)
λ_r	Share of manufacturing labour force working in region r
μ	Capital intensity of sector A
π	Extent of comparative advantage; profits
ρ	Love of variety
σ	Threshold value of real wage difference in simulations
τ	Congestion
Φ_r	Fraction of food labour in region r

Symbols

W_r	wage in region r
w_r	real wage in region r
Y	Income
y	real income
I	exact price index of manufactures

Table of Contents

Chapter 1 Introduction

1.1 Justification of the research

As the capital city of Indonesia, the development of Jakarta has increased rapidly within the last four decades and, presumably, will continue to do so. Jakarta consists of 5 districts; North, East, South, West, and Central Jakarta. In addition, it is surrounded by 4 city districts (called Kota) and 3 rural districts (called Kabupaten). These local governments, Kota Bekasi, Kabupaten Bekasi, Kota Bogor, Kabupaten Bogor, Kota Depok, Kota Tangerang, and Kabupaten Tangerang, agglomerate and create Jakarta's Metropolitan Area. Jakarta itself has an area of 650 square kilometres, with roughly 8.4 million in population and 2% annual population growth.

The size of population of Jakarta and rapid population growth continue to create a lot of problems in the city, especially in relation to transportation, which is not, and never has been, sufficient. It also has to accommodate 3 million commuters that come from its satellite cities. Almost 51% of these people come to the city by public transport and the rest using private cars and motorbikes.

Within Jakarta itself, there are three major modes of transportation. These are public transport 49.3% (mostly done by bus, there is a commuter train system within the city but it is very limited), private car 24.5%, and motorcycle 26.2%. The problem becomes more complex due to the annual growth rate of public transport vehicles being only 2% and annual growth of private cars rising dramatically to 10%. In contrast, the growth of infrastructure (roads) is less than 2% a year. This situation brings an imbalance and creates complex congestion problems. These are some basic considerations in developing the Bus Rapid Transport (BRT) system in the city.

BRT system corridor 1 was first launched in January 2004 connecting Blok M Terminal and Kota Railway Station (12.9 km). This year, in January 2006, Jakarta Provincial Government launched corridor 2 (14.3 km), connecting Pulo Gadung to Harmoni, and corridor 3 (18.7 km), connecting Harmoni to Kalideres.[1] By the end of the year 2010, 15 corridors will have been completed with a total length of road up to 106 km. Table 1 gives an overview of the 15 corridors.

Doubtless, the development of the BRT system will have a great influence on the spatial distribution of economic activity within the Jakarta Metropolitan Area. But,

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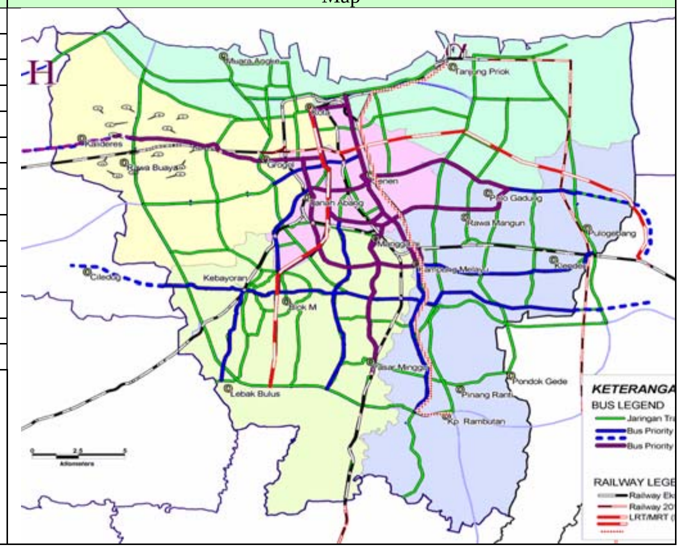
1 Detail information of the development of BRT lanes can be read in http://jkt.detik.com/adv/busway/brt.html

what kind of impact will it bring in the future in regards to the spatial distribution of economic activity in the area? It is a topic of great importance and impact, given that this simulation model of geographic economy, while already existent, has not been applied in the city context. Some adjustment may be needed to make the simulation model fit that context. That is one of the main reasons to conduct this research.

Table 1.1 BRT Lanes Corridor

Corridors	Destination	Map
1	Kota-Blok M	
2	Pulo Gadung-Harmoni	
3	Harmoni-Kalideres	
4	Pulo Gadung-Bunderan HI	
5	Kp. Rambutan-Tj. Priok	
6	Kp. Melayu-Ancol	
7	Cililitan-Grogol	
8	Cililitan-Tj.Priok	
9	Kp. Rambutan-Kp. Melayu	
10	Senayan-Tanah Abang	
11	Pulo Gebang-Kp. Melayu	
12	Warung Jati-Imam Bonjol	
13	Lebak Bulus-Kebayoran Lama	
14	Kali Malang-Blok M	
15	Ciledug-Blok M	

Source: http://jkt.detik.com/adv/busway/brt.html

1.2 Research questions

The main question in this research is how the changes on BRT system lanes development influence spatial distribution of economic activity within the Jakarta Metropolitan Area. This can be divided into several specific questions:

1. What would the simulation of BRT lanes development in the Jakarta Metropolitan Area look like?
2. What would be the impact of these developments on the spatial distribution of economic activity in Jakarta Metropolitan Area based on Jakarta's original Transportation Master Plan?
3. To what extent will changing the sequence of the BRT lanes development impact on the spatial distribution of economic activity within the area?
4. What are the impacts of altering the value of simulation parameters on the final distribution of economic activity in the Jakarta Metropolitan Area?

Accordingly, an empirical and exploratory case study of geographical economic theories on the BRT lane system will be applied to conduct this research.

1.3 Research objectives and scope

Based on the main research question, it can generally be seen that this research attempts to study several different sequences of the BRT lane system development and its impact to the spatial distribution of economic activity within the area. This main objective can be broken down into several specific objectives as can be seen in the following text:

1. Applying the core model of geographical economics into the BRT lanes plan in Jakarta's Metropolitan Area.
2. Understanding the impact of the BRT lanes development on spatial distribution of economic activity in the Jakarta Metropolitan Area based on the Jakarta Transportation Master Plan.
3. Understanding the impact of changing the sequence of the BRT lanes development on the spatial distribution of economic activity within the area.
4. Understanding the impacts of altering the value of simulation parameters on the final distribution of economic activity in the area.

As has already pointed out in the topic research, the unit of analysis of this study is the Jakarta Metropolitan Area. This area is divided into twelve administrative boundaries: North, East, South, West, and Central Jakarta, Kota Bekasi, Kabupaten Bekasi, Kota Bogor, Kabupaten Bogor, Kota Depok, Kota Tangerang, and Kabupaten Tangerang, these will be studied in this research.

1.4 Definition of variables

As has already mentioned, topic of this research is: "the impact of changing <u>BRT system lanes</u> on the <u>spatial distribution of economic activity</u> in the Jakarta Metropolitan Area". It can clearly be seen that there are two variables in this research: BRT system lanes (independent variable) and spatial distribution of economic activity (dependent variable).

<u>BRT system lane</u>

BRT system lanes is a one type of mass transport using buses that run on one lane of the road and operate on a specific schedule. BRT system lanes in Jakarta were developed based on Jakarta Transportation Master Plan. This variable can be operationalized by gathering some specific information (map) on the BRT system lanes development plan and general information on Jakarta Transportation Master Plan.

Spatial distribution of economic activity

Before explaining the concept of spatial distribution of economic activity, I will discuss briefly the concept of equilibrium. Equilibrium relationship is a condition that will tie up all loose ends and determine the spatial distribution of economic activity. Structure of the core model of geographic economics, developed by Krugman (1980), explain that the mobility of manufacturing workers and firms set size of regions and finally determine type of spatial distribution of the economic activity. There are three different type of spatial distribution of economic activity. These are: concentration, specialization and agglomeration. Concentration analyzes location across space of few well defined sectors (as an example particular industries), agglomeration analyze location across space of a much larger part of economic activity (as an example a manufacturing sector as a whole), and specialization is seen as concentration in a country level (for instance the Netherlands specializes in chemical products).[2]

1.5 Research methodology

As previously stated, the main aim of this research is finding the impact of BRT lanes development on the spatial distribution of economic activity within the Jakarta Metropolitan Area. To do so, several stages are established in order to conduct this research, as can be seen in Figure 1.1.

Stage 1 reviewing geographical economics theories

The objective of this stage is reviewing the geographical economics theories and location theories in order to build basic knowledge of this research. These theories will be used to assess and adjust the existing geographic economics model.

Stage 2 collecting data on structure of Jakarta's Metropolitan Area

Data and information needed in this research will be gathered in two different period of time, before the development of BRT system lane corridor 1 (before 2004), and after development of BRT system corridor 1 or after development of BRT system corridor 2 and 3 (2006).

These data are as follows:

- Gross Regional Domestic Product (GRDP) of each regions in the study area
- Data of economic activity in the area (divided into mobile activity, for instance food, and immobile activity, for instance manufacture)
- Demographic data, such as population and labour force data. This variable is divided into labour in immobile sector (food sector) and labour in mobile sector (manufacturing sector)

[2] See Brakman, Garretsen, and Van Marrewijk (2001) ch.5

- Data of transport cost, needed to travel from a centre of one region to a centre of the other regions.
- Size of each region
- Distances between the centre of one region to the centre of the other regions

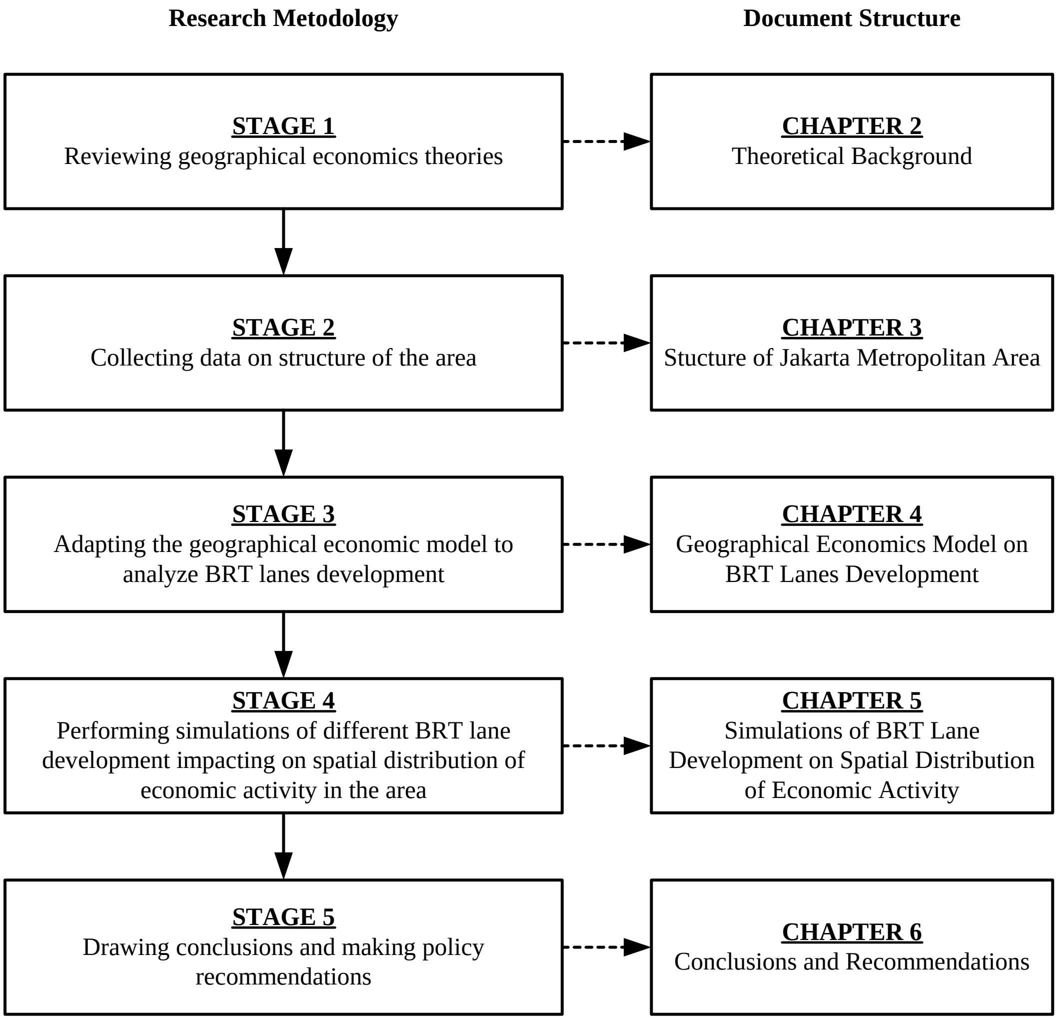


Figure 1.1 Research methodology and document structure

<u>Stage 3 adapting the geographical economic model to analyze BRT lanes development</u>

The objective of this stage is interpreting all data and information gathered in the previous stage and adapting the model in order to analyze BRT lanes development and its impact on the distribution of economic activity in the area. Thus, qualitative and quantitative analysis, using SPSS and Excel programs, will take place.

Stage 4 performing simulations of different BRT lane development impacting on spatial distribution of economic activity in the area

In the fourth stage of this research, computer simulation, using the simulation developed by Brakman, Garretsen, and Van Marrewijk (2001), will be made with some adjustment based on theories, data, and information gathered in the city. Simulations of different sequences of the BRT lane development will be presented and analyzed in order to come to conclusions.

Stage 5 drawing conclusions and making policy recommendations

In this stage, some conclusions and policy recommendations regarding the BRT lane development will be drawn in order to improve economic activity in Jakarta's Metropolitan Area.

Chapter 2 Theoretical Background

2.1 Introduction

This chapter has the objective of reviewing the geographic and economic theories, from the first insight of urban and regional economics theories (such as monocentric city model by Von Thünen and central place theory by Christaller), to international trade theories (neo-classical theory and new trade theory). This is done in order to give some basic understanding of the model of geographical economics. Following that, the main concept and the structure of the core model will be explained, including the explanation of sort-run and long-run equilibrium and the policy implication of geographical economics. At the end, some closing remarks and conclusions will be presented.

2.2 Geography and economic theory

Urban economic theory has been developed based on the stylized fact that economic activity is not evenly distributed across space. Many scholars, mainly economists and geographers, try to explain this phenomenon with different frameworks and perspectives. It starts with Von Thünen's monocentric city model with its bid rent curve that developed in 1826. Von Thünen argues that transport cost and land rent play an important role in determining the decision of farmers to locate themselves across the featureless plain. This decision gives an impact of a concentric pattern on the land use around the city. Other researchers in regional economics, such as Laundhardt (1885), Weber (1909), Christaller (1933), and Lösch (1940) analyzed the spatial organization of economic systems. Their research is also emphasized on the uneven distribution of economic activity across space. Weber (1909) studied the optimal location and size of manufacturing firms. Christaller and Lösch introduced the central place theory that tried to explain the differentiation of cities based on various functions. The last theory gained some critiques due to the unclear rational behind consumers' and firms' decision, leading to the central place outcome (Fujita, Krugman, and Venables, 1999).

Alonso (1964) replaced the city and the farmers in Von Thünen's model with central business area and commuters. Following Alonso, Mills (1967) focused on the forces that determine the size of cities and the interaction between them in the system, without taking into account the role of transport cost and the hinterland of a city. A research done by Anas, Arnold and Small (1998), shows the similarity between the monocentric model and the real urban spatial structure. In this case, they agree with the monocentric model regarding the importance of transportation costs. This agreement was drawn, based on the fact that population density had been declining as it was going further away from a central business area. But, with the fall of transportation cost in the twentieth century, people living in the western world tend to locate themselves further away from the city centre. Anas, Arnold and Small criticized the inability of the model to explain the interaction between cities in an urban system and the formation of a city. In order to cope with this limitation, 'increasing return to scale' has been introduced in the subsequent developments of geographic and economic theories.

It was Henderson (1974, 1977, 1988) who combined modern urban economics with the increasing return to scale, specifically the external economics to scale. He argues that agglomeration of particular industries in the city brings positive spillovers due to the information sharing between firms, existence of suppliers within the city, and other positive externalities. Even so, the agglomeration of economic activity within the city causes some negative external economies of scale (diseconomies of scale), labelled as congestion. Congestion can be the high commuting cost and increase of land rent in the city, and these become the spreading forces of the economic activity from the city centre to the periphery area.

The development of geographic and economic theories takes us to the international trade theory developed in the twentieth century. This theory, which will be reviewed in Section 2.3, is the foundation of geographic economics model. Neo-classical theory, by Hecksher, Ohlin, and Samuelson (1933), was developed based on the factor abundance model. In this model, they assumed that there are two countries, two tradable goods and two factors of production. Under several conditions (perfect competition, homogenous goods, no transportation cost, constant return to scale and mobility of factor of production), they concluded that inter-industry trade plays a very important role in determining the international trade between countries and thus the price of tradable goods will be equalized.

Neo-classical theory has been challenged by the development of the new trade theory by Krugman (1979). Krugman argues that trade between countries does not depend on comparative advantage. This idea is based on the fact that international trading takes place among countries with similar factor endowment. This fact shows that trade is not only inter-industry trade, as neo-classical economists argue, but also intra-industry trade. The new trade theory gives a respond to the Dixit-Stiglitz's approach (1977) by bringing together factor mobility across countries and imperfect competition. In order to understand the basic argument behind this theory, it is important to combine the increasing return to scale at the firm level that determines the size of the market, and 'love of variety' effect in consumers' preferences.

Krugman (1980) added several important insights into his previous model. First, he argues that opening up trade does not change the volume of production and the prices under the autarky. The increase of market size because of international trade does not lead to an increase of firms' scale of production. Second, he introduced transport cost as an important element in geographic economics theory. He argues that the uneven distribution of market size becomes important because of the transportation costs. Transportation cost makes firms produce varieties that have relatively high demand in the country. As he wrote: *"Countries will tend to export those kinds of products for which they have relatively large domestic demand. Notice that this argument is wholly dependent on increasing returns."*[3] The fact that a country that has a large domestic demand of a product becomes an exporter of that product is known as the home-market effect.

Davis and Wenstein (1999) support Krugman's idea of home-market effect as the model of geographic economics. It was Brakman, Garretsen, and Van Marrewijk that criticized Krugman model because of three reasons, as quoted in their book: *"First, neither firms nor workers decide anything about location in Krugman (1980). There is no mobility of firms or the factor of productions. Given their (exogenous) location, firm only make a decision about the varieties they want to produce. Second, the concentration of production of varieties (and by assumption of demand) does not allow for the agglomeration of economic activity. Third, the allocation of the market size for the varieties is not an outcome of the model but simply given (income is therefore also given). This is closely linked to the the immobility of workers (who demand the goods produced) and firms. In this respect, location in Krugman (1980) is still determined outside the model."* [4]

Krugman and Venables (1990) analyzed the consequences of Krugman (1980). In their new model, countries differ in size. Country 1 (core) is larger than country 2 (periphery) in all respects: more factor endowments (capital and labor), larger market, and larger number of firms in manufacturing sector. Under increasing return to scale and monopolistic competition, firms produce two types of tradable goods, where one product is perfectly competitive and the other is not. Firms and factor of productions cannot move between countries, as there is only inter-sectoral mobility, but firms can enter and exit the country. The result of Krugman and Venables show that with a fall of transportation cost to the intermediate level, the core share of world industry gets larger than its share of world endowments. When transport costs continue to fall, the core share of world industry starts to decrease, until a point where transport costs are equal to zero. In this point, both countries are returning to their initial condition,

[3] As quoted in Brakman, Garretsen, and Van Marrewijk (2001) p.45
[4] As quoted in Brakman, Garretsen, and Van Marrewijk (2001) p.46

where each country's share of manufacture is returning to its share in world endowments and wage in both countries is equalized.[5]

This model allows agglomeration of economic activity and uneven distribution of manufacturing activity that cannot be explained in Krugman (1980). Besides, it analyzes the effect of economic integration on the core and periphery. Even so, this model cannot explain the existence of core and periphery. Brakman, Garretsen, and Van Marrewijk (2001) then integrated this model with the dynamic of the model, dealing with the mobility of economic agents (firms and labours) as one of the factors that determine market size.

To sum up, the core model of geographic economics theory has a deep root in the new trade theory with the basic insight from Dixit and Stiglitz (1977) and Krugman (1979, 1980). The new trade theory, that complements neo-classical trade theory, argues that comparative advantage is not the only reason for countries to trade with each other. Krugman (1979, 1980) developed a model in which countries engage with intra-industry trade more than inter-industry trade. Krugman and Venables (1990) later on added some conditions that allows agglomeration of economic activity and uneven distribution of manufacturing activity and explained economic integration on the core and periphery. Brakman, Garretsen, and Van Marrewijk (2001) then complement this model with factor mobility as the dynamic of the model. All of these studies have become the core of geographic economics model.

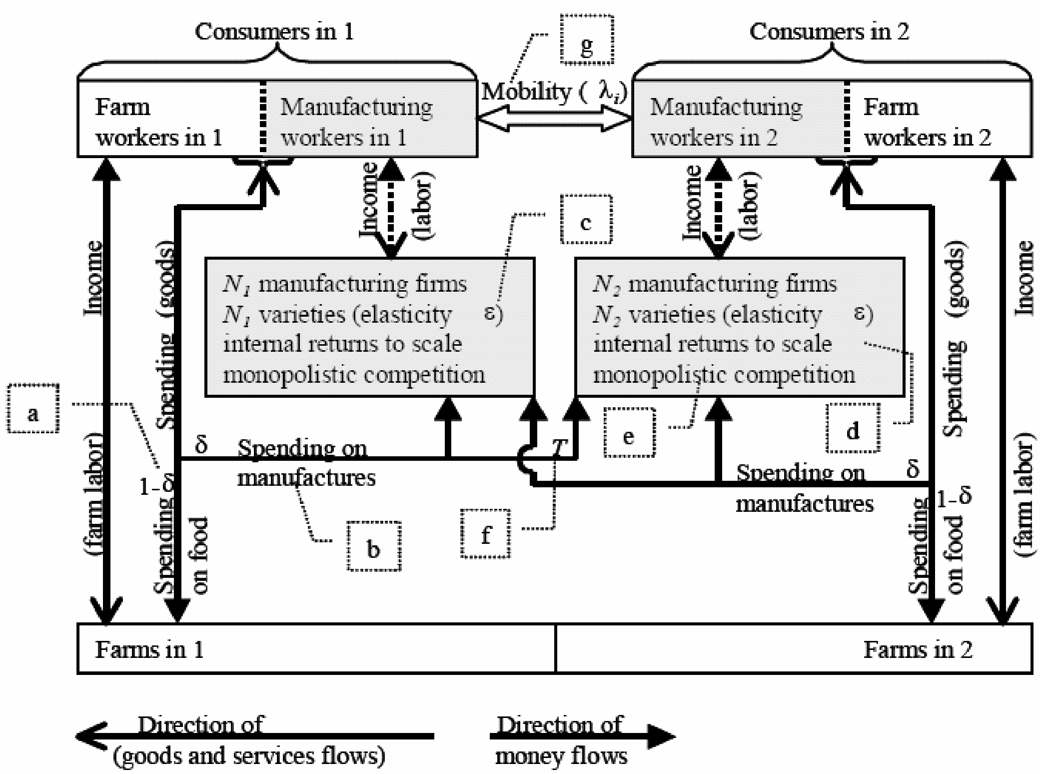
2.3 The core model of geographical economics

The model of geographic economics is built with the assumption that there are two regions, 1 and 2, with only two sectors in economy, manufacturing and food. Each region consists of farm workers and manufacturing workers that also play a role as consumers of food and manufacturing products, as can be seen in Figure 2.1.

Farm workers in each region and farmers, who own the land, receive an income as a result of working in the farming land and supplying their labour forces to the farmer in their region (bilateral transfer). Farmers produce food under constant return to scale and perfect competition and sell the food production to the customer in both regions. Because no transport cost is introduced for food production, the price of food is similar, despite of where this product is consumed. This situation implies that the wage rate of farmers is similar in both regions and the location of food production (either in region 1 or region 2) is not an important issue.

[5] See Brakman, Garretsen, and Van Marrewijk (2001) p.48 for detail explanation

Manufacturing sector consists of N_1 firms in region 1 and N_2 firms in region 2. These firms produce a differentiated and unique products using only labour under internal economies of scale. The manufacturing workers earn their income because of bilateral transfer. They supply their labour to manufacturing firms in their region as an exchange of their income. Variety of products produced by each firm makes the firm having monopolistic power, especially in regards to determination of the product price. The involvement of transportation cost for manufacturing goods give an impact to the differentiation of price in each region. This means that consumers in one region have to pay a higher price if they want to consume a manufacturing good that is produced in the other region (other things being equal). Nevertheless, consumers will keep consuming at least some units of differentiated products because of their preferences for variety.



Note:
The bidirectional arrows show bilateral transfers
The solid headed arrows show the direction of money or income flows (income and spending)
The open headed arrows show the direction of goods and services flows

Source: Brakman, Garretsen, and Van Marrewijk (2001)

Figure 2.1 Structure of the core model of geographic economics

There are several remarks that can be observed in figure 2.1. First, the introduction of several important parameters in the core model of geographic economics, such as parameter ε, δ, λ_1, and T. These parameters will be discussed in Section 2.3. Second, there are seven callouts (labelled ‘a’ to ‘g’) that play an important role in the structure of the model. These callouts are divided into the demand structure (callouts a, b, and c), supply structure (callouts d and e), role of transport cost (callout f), and dynamic of the model (callout g). Third, there are shaded and non-shaded boxes in the figure that emphasize on the importance of mobile and immobile activity in the model. The shaded boxes show the mobility of factor of production. It means that manufacture workforce can move from one region to the other regions yielding to the expansion of production in the manufacturing sector. The non-shaded boxes show the immobility of farm workers and farmers because of their dependency on land for cultivation.

2.4 Short-run and long-run equilibrium in simulation

Taken all aspects into consideration (economies of scale, imperfect competition, location, external economies, and immobile workers), the endogenous variables for each region r (income-Y_r, price index-I_r, and wage rate-W_r) can be determined with the following equations:

$$Y_r = \lambda_r W_r \gamma L + \phi_r (1-\gamma) L \tag{2.1}$$

$$I_r = \left(\frac{\beta}{\rho}\right)\left(\frac{\gamma L}{\alpha\varepsilon}\right)^{1/(1-\varepsilon)} \left(\sum_{s=1}^{R} \lambda_s T_{rs}^{1-\varepsilon} W_s^{1-\varepsilon}\right)^{1/(1-\varepsilon)} \tag{2.2}$$

$$W_r = \rho\beta^{-\rho}\left(\frac{\delta}{(\varepsilon-1)\alpha}\right)^{1/\varepsilon} \left(\sum_{s=1}^{R} Y_s T_{rs}^{1-\varepsilon} I_s^{\varepsilon-1}\right)^{1/\varepsilon} \tag{2.3}$$

Short-run equilibrium determines endogenous variables and it occurs when these three equations hold for each locations. Short-run equilibrium means that the world demand and supply of food and each variety of manufactures are equal, so that no producer is earning extra profits.

The solutions for endogenous variables depend on the specified value of exogenous variables and parameters:

λ_r : Share of manufacturing labour force working in region r

L : Labour force

α : Fixed cost

β : Marginal cost

γ : Share of labour force in manufactures

δ : Share on income spent on manufactures goods

ϕ_r : Fraction of food labour in region *r*

ρ : Love of variety

ε : Elasticity of substitution = $1/(1-\rho)$

T_{rs} : Transport cost from region *r* to region *s* (units to be shipped from region *r* to ensure 1 unit arrives in region *s*)

Given the selected value of exogenous variables and parameters of the model, the numeric value of endogenous variables (for two regions) can be calculated using the sequential iterations method by Brakman, Garretsen, and Van Marrewijk (2001), as follows:

(i) Guess an initial solution for the wage rate in two regions ($W_{1,0}, W_{2,0}$), where 0 indicates the number of the iteration.

(ii) Using ($W_{1,0}, W_{2,0}$) calculate the income levels ($Y_{1,0}, Y_{2,0}$) and the price index ($I_{1,0}, I_{2,0}$), as implied by the equations (2.1) and (2.2).

(iii) Using ($Y_{1,0}, Y_{2,0}$) and ($I_{1,0}, I_{2,0}$) as calculated in step (ii) determine a new possible solution for the wage rate ($W_{1,1}, W_{2,1}$) as implied by equation (2.3)

(iv) Repeat steps (ii) and (iii) until a solution is found.

Stopping criterion (σ) must be specified in order to stop the computer from continually jumping to the next iteration and to get numeric values as a solution to the equations. The value of this parameter must be chosen in order to come out with reliable results. Brakman, Garretsen, and Van Marrewijk (2001) describe stopping criterion as "*the condition that the relative change in wage rate should not exceed some small value σ from one iteration to the next for all regions r*". [6]

$$\left| \frac{W_{r,iteration} - W_{r,iteration-1}}{W_{r,iteration-1}} \right| < \sigma \text{, for all } r$$

Further analysis that has been done by Fujita, Krugman, and Venables (1999), shows that parameters of the size of labour forces-L, fixed cost of production-α, and

[6] See Brakman, Garretsen, and Van Marrewijk (2001) p.102

marginal cost of production-β affect the real wages of the two regions equiproportionally. Changes in these parameters do not influence the real wage and do not affect the underlying dynamics and stability analysis of the system. For the shake of simplicity, the parameters of normalization can be chosen by normalizing γ to δ ($\gamma = \delta$), β to ρ ($\beta = \rho$), L to 1 ($L = 1$), and $\alpha = \gamma L / \varepsilon$.[7] Taken these assumptions into consideration, the equation (2.1) to (2.3) can be simplified to:

$$Y_r = \delta \lambda_r W_r + (1-\delta)\phi_r \quad (2.1')$$

$$I_r = \left(\sum_{s=1}^{R} \lambda_s T_{rs}^{1-\varepsilon} W_s^{1-\varepsilon} \right)^{1/(1-\varepsilon)} \quad (2.2')$$

$$W_s = \left(\sum_{r=1}^{R} Y_s T_{rs}^{1-\varepsilon} I_s^{\varepsilon-1} \right)^{1/\varepsilon} \quad (2.3')$$

At the end of the day, the exogenous and endogenous variables are used to calculate the solutions of real wage rate (w_r) and real income (y_r) in each region *r* by using the following equations:

$$w_r = W_r I_r^{-\delta} \quad (2.4)$$

$$y_r = Y_r I_r^{-\delta} \quad (2.5)$$

Long-run equilibrium is reached when one of these three characteristic hold. First, manufacturing production is evenly spreading over the two regions (point C in Figure 2.2). Second, manufacturing production is completely agglomerated in one of the two regions (points A and E in Figure 2.2). Third, manufacturing production is partially agglomerated either in region 1 or region 2 (points B and D in Figure 2.2). The first and the third condition happen when the real wage of mobile labour force is the same in both regions ($w_1/w_2 = 1$). In this case, long-run equilibrium is the same as short-run equilibrium. The type of long-run equilibrium established, depends critically on the initial distribution of the manufacturing labour force and other structural parameters (level of transport costs, elasticity of substitution, and share of income spent on manufactures).

Long-run equilibrium can be stable or unstable. Long-run equilibrium is said to be stable when any perturbation of the mobile workforce surrounding the equilibrium

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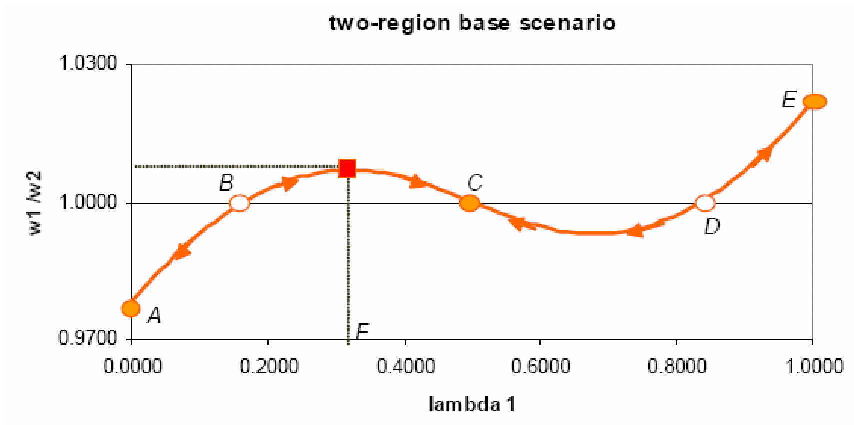
7 For detail discussion, see Brakman, Garretsen, and Van Marrewijk (2001) p.108

point (points A, C, and E in Figure 2.2) will activate economic forces back to the equilibrium point. Inversely, unstable long-run equilibrium happens when the same deviation is occurred around the equilibrium point (points B and D in Figure 2.2) and this triggers a process of adjustment leading to different stable long-run equilibrium (points A, C, and E in Figure 2.2).



Source: Brakman, Garretsen, and Van Marrewijk (2001)

Figure 2.2 The relative real wage in region 1

The graphs, showing variations of different parameters in the core model (transport cost-T, substitution parameter-ρ, share of income spent on manufactures-δ and share of labour force in manufacturing-γ), indicate the strong forces of agglomeration over spreading. It implies that economic activity is typically concentrated in one or few locations. This assumption does not hold in the modern urban economics. In reality, it can generally be observed in the centre of cities with different sizes of economic activity. This situation leads to the introduction of another parameter, called congestion (τ), that enable the existence of cities with different sizes of economic activity.

It is undoubtedly true that urban agglomeration may cause external diseconomies of scale that act as the main spreading forces of people and mobile economic activity. This happens because the agglomeration of human activity within urban area may increase some problems related to the increase of commuting cost, land rent, environmental pollution, traffic jam, and other disadvantages that rise because of crowdedness. All of these diseconomies of scale, categorized as congestion (τ), can provide an incentive for firms and mobile workforce to move away from the congested area in the centre to the urban fringe. Given that fact, congestion cost is not only the function of industry of firm, but a function of the size of the city as a whole.

Parameter of congestion (τ) is vary from -1 to 1 ($-1 < \tau < 1$). Congestion that is equal to zero ($\tau = 0$) shows that there are no location specific external economies of scale. If the parameter of congestion is negative ($-1 < \tau < 0$), it means that there are positive location specific external economies of scale, and the inverse holds if the value is positive ($0 < \tau < 1$). In the last case ($0 < \tau < 1$), manufacturing costs of production (marginal cost and fixed cost) of firms located in city *r* will be increased if other firms also decide to settle in the same city.

After some necessary adjustments, incorporating congestion modification, the equations (2.1) to (2.3) can be written as:

$$Y_r = \delta\lambda_r W_r + (1-\delta)\phi_r \qquad (2.6)$$

$$I_r = \left(\sum_{s=1}^{R} \lambda_s^{1-\tau\varepsilon} T_{rs}^{1-\varepsilon} W_s^{1-\varepsilon} \right)^{1/(1-\varepsilon)} \qquad (2.7)$$

$$W_s = \lambda_s^{-\tau} \left(\sum_{r=1}^{R} Y_s T_{rs}^{1-\varepsilon} I_s^{\varepsilon-1} \right)^{1/\varepsilon} \qquad (2.8)$$

There are several practical concerns that have to be taken into account when using parameter congestion in the core model of geographical economics. This happens in regards to the difficulty in finding the value of this parameter. Congestion is difficult to be measured, because this parameter can arise in many different ways, for instance traffic congestion, pollutions and other environment issues, decreasing in local resources, etc. Brakman, Garretsen, and Van Marrewijk (2001) give the example of calculating congestion by using the data of traffic congestion. They calculate the number of motor vehicle ownership per 1.000 inhabitants and the number of motor vehicle usage per kilometre of road.

Congestion can also be calculated by looking at the size of the city and the economy of the city as a whole. Unfortunately, with the limitation of available data, it will be difficult to determine the level of congestion in the city. In order to overcome this problem, several values of congestion parameter can be drawn and finally one value that is closer to the expected result can be chosen. The value of congestion parameter can be drawn by adjusting the model to accommodate several different values of it for each city as the input.

The challenge of using congestion rises in regards to the method that should be used to get the most reliable value of this parameter. It is not, of course, an easy task. All of the factors, such as nation, culture, and other specific characteristics of the region have to be taken into consideration when choosing the value of this parameter.

When congestion cost is not introduced in the geographic economics model, high transport cost yields to the spreading in the long-run equilibrium. Inversely, low transport cost brings in full agglomeration in the long-run equilibrium. This tendency is not very satisfactory for an empirical point of view, and brings in the congestion parameter into the model. Brakman, Garretsen, and Van Marrewijk (2001) argue that there are five different results that can be identified when congestion is introduced, as follows:

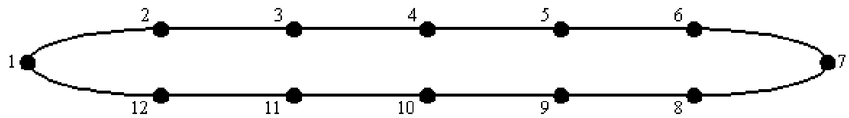
1. For very high transport costs, spreading is the only stable (and welfare maximizing) equilibrium.
2. As transport cost decrease, spreading is still a stable (and welfare maximizing) equilibrium, but there are now also two other stable equilibria with partial agglomeration.
3. Complete agglomeration in either city is a stable (and welfare maximizing) equilibrium as transport cost continues to fall.
4. As transport costs become very small, their impact relative to congestion costs is limited. Initially this implies that partial agglomeration in either city is a stable (and welfare maximizing) equilibrium.
5. For a very low transport cost, spreading is again the only stable (and welfare maximizing) equilibrium.

Ultimately, it can generally be concluded that the geographic economics model with congestion gives a wider range of possible equilibrium outcomes compared to the model without congestion. Besides, this parameter also introduces the partial agglomeration phenomenon as a stable long-run equilibrium that enables different sizes of economic activity in the city centre.

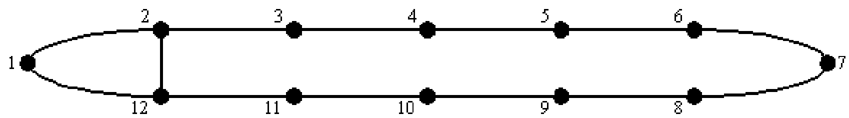
2.5 The policy implications of geographical economics

One of the most important questions arises in regards to the policy implication of the core model. Brakman, Garretsen, and Van Marrewijk (2001) give an example of the policy implication of the model in an infrastructure project, namely building a bridge that connects two out of twelve cities and reduces the distance between them. They analyze the impact of building a bridge to the spatial distribution of labour force and firms in the long-run equilibrium. Note that this project can be any infrastructure project, such as building a road or a tunnel. The example of building a bridge, also called as the pancake economy, can be seen in Figure 2.3.

No links: equivalent to racetrack economy



Link between cities 2 and 12



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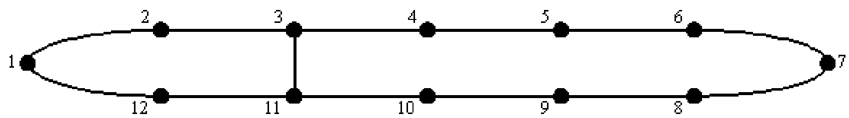
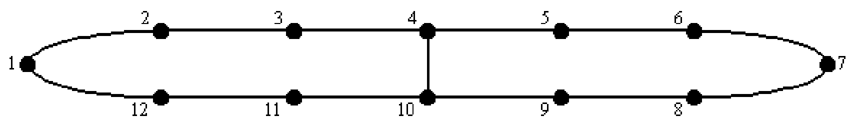


Link between cities 4 and 10



Source: Brakman, Garretsen, and Van Marrewijk (2001)

Figure 2.3 The pancake economy

In this example, Brakman, Garretsen, and Van Marrewijk assume that manufacturing labour force and farm workers are distributed over the twelve cities uniformly. The distance between cities to its neighbouring cities is equal to 1 unit. With the value of parameters: $\delta = 0.6$, $\varepsilon = 5$, $T = 1.2$, $\tau = 0.1$, they conclude that building a bridge, resulting in the reduction of distance and transportation cost, has a larger impact on the distribution of economic activity that leads to agglomeration of manufacturing production.[8] This is understandable, considering the fact that the reduction of transportation costs increases the welfare level of workers in the linked cities, because they pay the lowest transportation costs. This fact attracts other manufacturing labour force into the linked cities and enables the cities to attract a larger share of

[8] For detail discussion, see Brakman, Garretsen, and Van Marrewijk (2001) ch.11

manufacturing production. This process continues up to a point where these cities are big enough and spreading forces (congestion) make it more attractive to move to the remote markets.

2.6 Conclusions

Ultimately, the long history of geographic and economic theories has brought us to the computer simulation of the geographic economics model, developed by Brakman, Garretsen, and Van Marrewijk (2001). The example of building a bridge has shown us how this simulation model can be used to analyze the spatial distribution of economic activity over the twelve cities. Taken this fact into consideration, it will be a great challenge to use the same simulation model in the city context. In this research, the Bus Rapid Transport (BRT) project is chosen in order to study the impact that it has on the spatial distribution of economic activity within the Jakarta Metropolitan Area. The completion of this project will reduce the overall transportation costs and commuting time within this area. Some questions arise regarding the impact of transportation cost reduction to the agglomeration or spreading of economic activity over the area. This may be happen if the sequence of project development is changed. All of these questions will be studied in this research.

Chapter 3 Structure of the Jakarta Metropolitan Area

3.1 Introduction

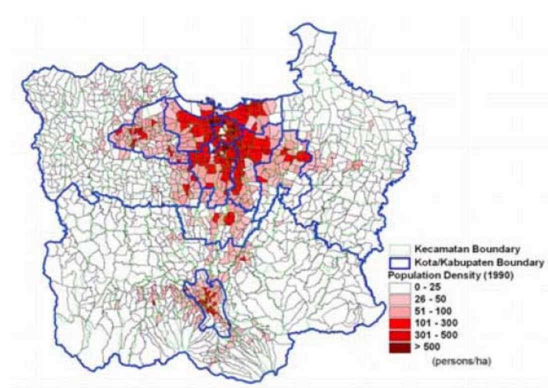
This chapter is divided into three main parts. The first part is the general description of the Jakarta Metropolitan Area. The second part reviews the development of the Bus Rapid Transport project in Jakarta and its impact on reducing commuting time, and the last part explains the economic activity occurring in the whole metropolitan area.

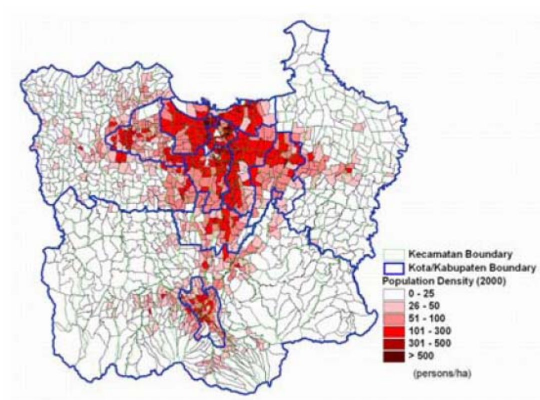
3.2 The Jakarta Metropolitan Area

Map is produced by DGIA, Ministry of Defence, United Kingdom 2003
(Some necessary adjustment is made by the writer)

Figure 3.1 Geographical location of Jabodetabek

The Jakarta Metropolitan Area, known as Jabodetabek[9], is located in the west part of Java Island (see Figure 3.1). This area is expanded to 6580 km^2 of land and is divided into several administrative boundaries: Daerah Khusus Ibukota/DKI (Capital Special Region) Jakarta[10], Kota (city district) Bekasi, Kabupaten (rural district) Bekasi, Kota Bogor, Kabupaten Bogor, Kota Depok, Kota Tangerang, and Kabupaten Tangerang. This area is a home land of about 21 million people (in 2004)[11] spreading over the whole region. Jakarta itself has about 7.5 million people in population and Bodetabek[12] area has the population of roughly 14.5 million people. These people are distributed unevenly across the space with the highest concentration in Jakarta city. The distribution of people in the Jabodetabek area and the number of people living in each region can be seen in Figure 3.2 to 3.4.





Source: SISTRAMP (2004)

Figure 3.2 Population density 1990

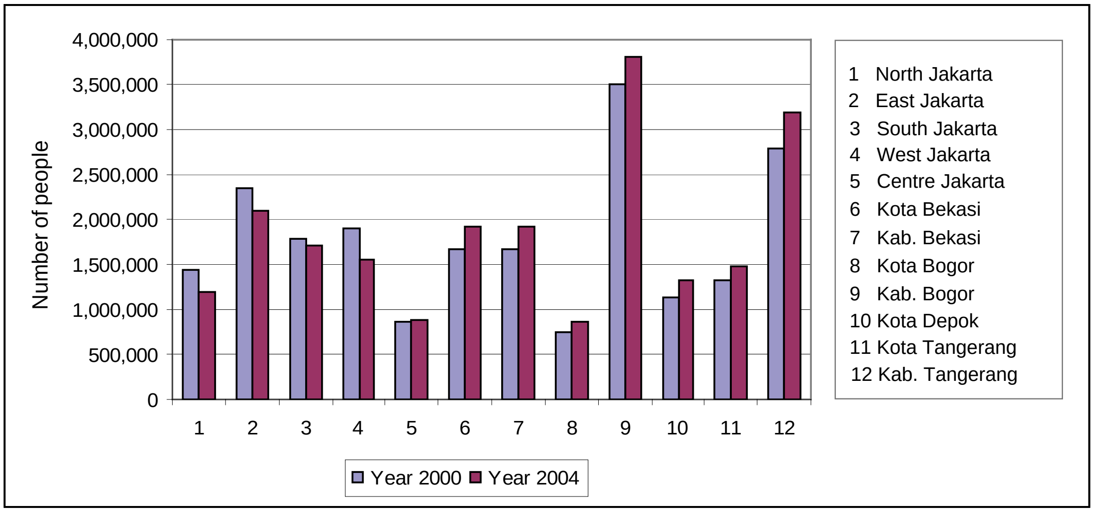
Figure 3.3 Population density 2000

9 Jabodetabek is a terminology used to describe the whole Jakarta Metropolitan Area. This word is an acronym of the name of regions that form the whole metropolitan area (Jakarta-Bogor-Depok-Tangerang-Bekasi)

10 Jakarta consist of 5 regions: North Jakarta, East Jakarta, South Jakarta, West Jakarta, and Centre Jakarta

11 Daerah Dalam Angka (2004)

12 Bodetabek is an acronym of the name of regions surrounding Jakarta (Bogor-Depok-Tangerang-Bekasi)



Source of data: Daerah Dalam Angka (2004)

Figure 3.4 Population in the Jabodetabek region (2000 and 2004)

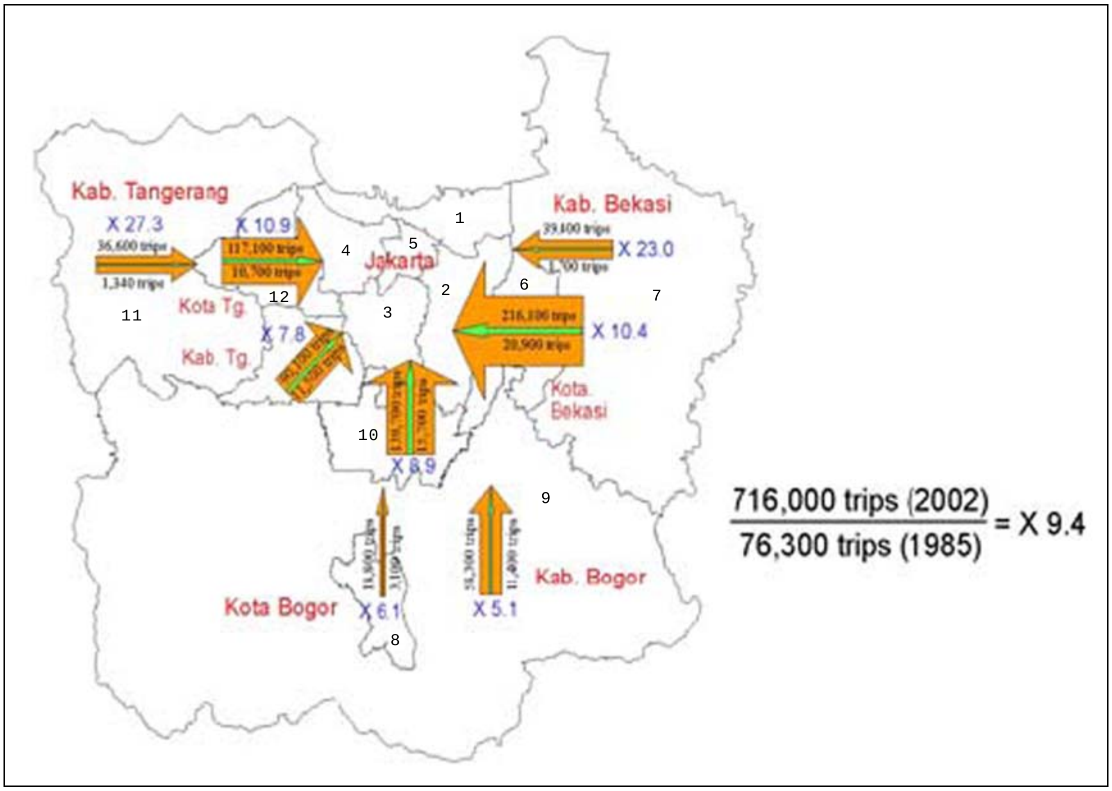
Being the capital city of Indonesia, Jakarta has a very important role as a center of political, economical and social activities. Together with the Bodetabek area, Jakarta gives a contribution of 22% of the national gross domestic product (GDP) or equal to Rp. 351.000 billion and 70% of capital (in 2002). With total employed population of about 7.5 million, the whole Jabodetabek region becomes the most important region and the heart of economic activities and urban settlement of Indonesia.

Annual population growth of Jakarta and the Bodetabek area, caused by urbanization, is equal to 0.2% and 3.7% accordingly. Based on this data, it can be projected that in the year 2020, the number of people living in the region will raise up to 26 million[13]. Taken the importance of the Jabodetabek into consideration, this research studies the whole Jabodetabek area that, later on, will be divided into twelve regions as follows: North Jakarta (1), East Jakarta (2), South Jakarta (3), West Jakarta (4), Centre Jakarta (5), Kota Bekasi (6), Kabupaten Bekasi (7), Kota Bogor (8), Kabupaten Bogor (9), Kota Depok (10), Kota Tangerang (11), and Kabupaten Tangerang (12).

From the data of population growth in the Jabodetabek, it can generally be seen that urbanization occurs more rapidly in the Bodetabek region than in Jakarta. This happens due to high living standards in Jakarta, such as high land price and land rent. These act as spreading forces of Jakarta[14]. In order to find a better quality of living, such as better environment and cheaper housing, people tend to move to the hinterland of Jakarta. This situation causes a rapid development of the Bodetabek area

[13] Based on projection by University of Indonesia, as can be read in Umamil A., Dail (2005) p.2308
[14] See again review in cp.2, p.15-17, about congestion as a spreading forces

and a dramatic increase in the number of trips from this area to Jakarta daily, as can be seen in Figure 3.5.



Source: SISTRAMP (2004)

Figure 3.5 Commuting trips to Jakarta from the Bodetabek Area in 1985 and 2002

Nowadays, there are around 700.000 trips of people travelling from their residence in the Bodetabek area to their workplace in Jakarta, and presumably this number will continue to increase in the future. Almost 51% of these people come to Jakarta by public transport and the rest using private cars and motorbikes. Within Jakarta itself, there are three major modes of transportation: public transport 49.3% (mostly done by bus), private car 24.5%, and motorcycle 26.2%[15]. The problem arises due to the annual growth rate of public transport vehicles being only 2%, and annual growth of private cars rising dramatically to 10%. In contrast, the growth of road is less than 2% a year[16]. Given these facts and without any other improvement in public transportation in Jakarta, it can be predicted that this city will face more complex problem in the future in regards to traffic congestion.

[15] In 1998, as can be read in Trans-Jakarta Bus Rapid Transport System Technical Review (2003), p.11

[16] DA, Rini (2003)

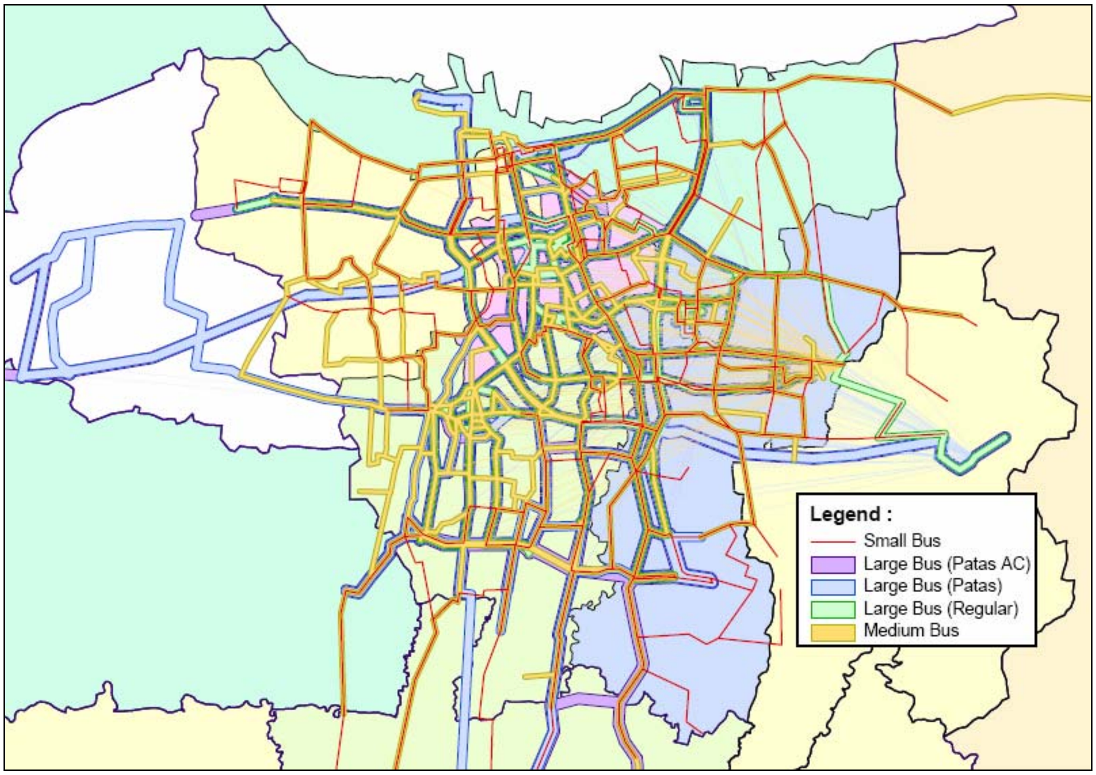
Nowadays, traffic congestion is already becoming a major problem in the Jabodetabek region. It is calculated that the economic loss caused by traffic congestion in the region is equal to $ 68 million annually, excluding the impact on the health of people in the area[17]. In order to overcome transportation problems in the region, especially in Jakarta, Jakarta Provincial Government develops the Bus Rapid Transport (BRT) system in the city. The following section will give a detailed review of the BRT Lanes development in Jakarta and its impact on reducing commuting time inside the city.

3.3 The development of Bus Rapid Transport system in Jakarta

The development of public transport system in Jakarta had been neglected by the government for many years. This happens due to the government policy that tends to adopt the provision of highways, resulting in an increase use of private cars and motorbikes. This opportunity has been used by the private sector to get profit through providing public transport services in Jakarta. Private sector has become a dominant actor in this field, while the government contributes almost nothing, neither as a provider nor as a regulator of the service. As a result, in the last three decades, public transport provision has declined dramatically, and traffic congestion has been worsened. Figure 3.6 shows the chaotic situation of the existing public transport in Jakarta.

In 2004, Jakarta Provincial Government started its commitment in developing and improving a good public transport system in Jakarta, through Jakarta Transportation Master Plan. They introduced the first Bus Rapid Transport (BRT) corridor, connecting Kota railway station (in North of Jakarta) to Blok M bus terminal and shopping district (in South Jakarta). Based on the master plan, seven BRT corridors will be developed by the year 2007 and 15 corridors will be completed by the year 2010. In 2005, the second and the third corridors, connecting Pulo Gadung terminal to Harmoni, and Harmoni to Kaliders, were launched. The development plan of BRT corridors and its routes can be seen in Table 3.1 and Figure 3.7.

[17] Dikun (2003) in Umamil A., Dail and Hidayat, Budi (2005) p.1792



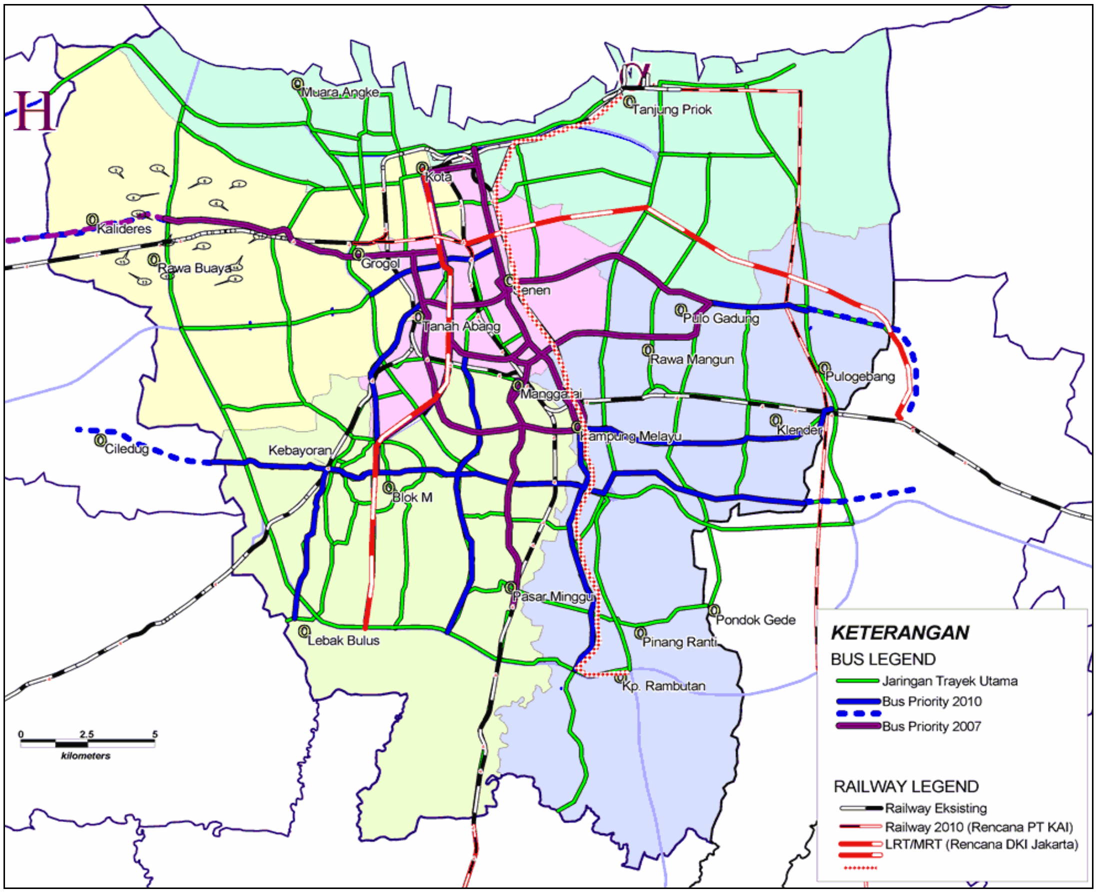
Source: Alvinsyah, Soehodho, Sutanto, and Nainggolan, Prisno J. (2005)

Figure 3.6 The existing public transport

Table 3.1 Route of the BRT Lanes

Corridors	Destination	Route
1 (2004)	Kota-Blok M	Gajah Mada/Hayam Wuruk – Majapahit – M. Merdeka Barat – Mh. Thamrin – Jend. Sudirman – Sisingamangaraja
2 (2005)	Pulo Gadung-Harmoni	Pulo gadung – Perintis Kemerdekaan – Let Jend Suprapto – Keramat Bundar – Senen Raya – Kwini – Abdurrahman Saleh – Pejambon – Medan Merdeka Timur – Perwira – Katedral – Veteran – Gajahmada (Harmoni)
3 (2005)	Harmoni-Kalideres	Daan Mogot – Kyai Tapa – KH Ashari – Gajahmada – Hayam Wuruk – Juanda – Pos – Gedung Kesenian – Lapangan Banteng Utara – Katedral – Veteran – Gajahmada (Harmoni)
4	Pulo Gadung-Bunderan HI	Bekasi Raya – Pemuda – Pramuka – Proklamsi – Diponegoro – Imam Bonjol
5	Kp. Rambutan-Tj. Priok	
6	Kp. Melayu-Ancol	Matraman Raya – Salemba – Kramat Raya – Ps. Senen – Gn. Sahari
7	Cililitan-Grogol	
8	Cililitan-Tj.Priok	
9	Kp. Rambutan-Kp. Melayu	Matraman Raya – Salemba – Kramat Raya – Ps. Senen – Gn. Sahari
10	Senayan-Tanah Abang	Asia Afrika – Gelora – Palmerah Utara – Aipda K.S. Tubun – Kota Bambu – Jati
11	Pulo Gebang-Kp. Melayu	Jend. R.S. Sukamto – Kol. Sugiono – Jend. Basuki Rachmad – Kp. Melayu Besar
12	Warung Jati-Imam Bonjol	Warung Jati – Mampang Prapatan – Rasuna Said – HOS Cokroaminoto
13	Lebak Bulus-Kebayoran Lama	Ciputat Raya – Kebayoran Lama
14	Kali Malang-Blok M	Kali Malang – DI Panjaitan – MT Haryono – Gatot Subroto – Kpt. Tendean – W. Mongonsidi – Trunojoyo – Blok M
15	Ciledug-Blok M	Ciledug Raya – Kebayoran Baru – Kyai Maja – Blok M

Source: http://jkt.detik.com/adv/busway/brt.html



Source: http://jkt.detik.com/adv/busway/brt.html

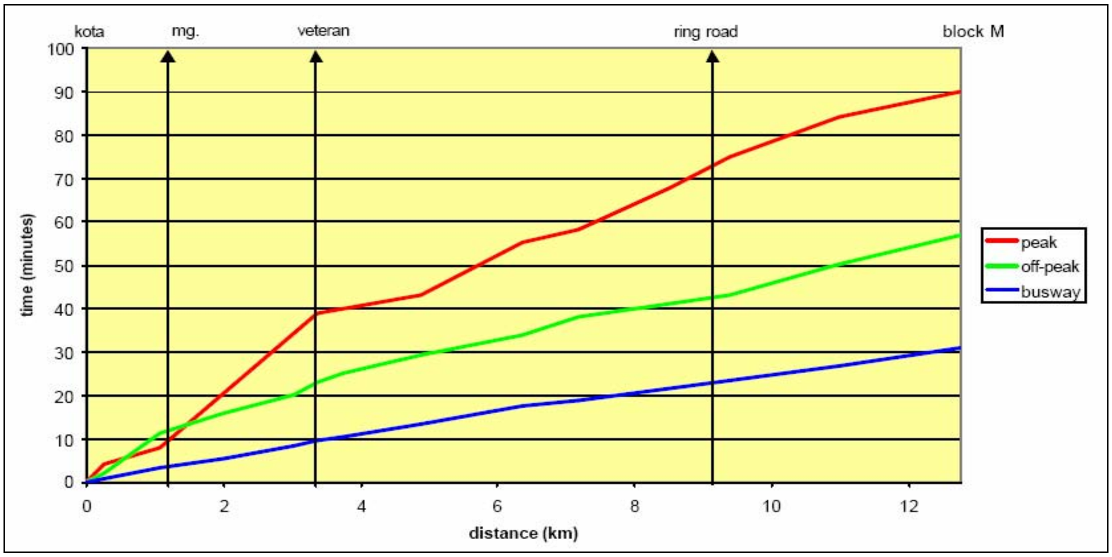
Figure 3.7 BRT Lanes Corridor

Based on the preliminary study on the 1st corridor done by JICA (2004), the amount of passengers using this corridor can reach 60.000 people daily, and this number will be increased gradually along with the completion of the whole project. The same study also shows the significant shifting of about 14% from private car users to this mode of transport. It is undoubtedly true that this mode of transport gives a great benefit in regards to time saving. Based on the technical review of the project, made by ITDP (2003), it can save around 19 minutes during the peak time and 26 minutes on the off peak time on a trip from one end of the corridor to the other. Detailed data of travel time and velocity for the 1st corridor can be seen in Table 3.2 and Figure 3.8. Later on, this data will be used to calculate time travelling between regions in this thesis.

Table 3.2 BRT lane corridor 1: travel time and velocities[18]

Link		Distances		Travel time (min)		Velocity (km/hr)		
From	To	(km)	Off Peak	Peak	BRT	Off Peak	Peak	BRT
Kota Station	Veteran	3.4	23.0	39.0	9.2	8.8	5.2	22.0
Veteran	Kebon Kacang	3.0	11.0	16.0	8.2	16.4	11.2	22.0
Kebon Kacang	Ring Road	3.0	9.0	20.0	6.0	20.0	9.0	30.0
Ring Road	Blok M	3.4	14.0	15.0	7.6	14.5	13.5	26.6
Total		12.8	57.0	90.0	31.0	13.4	8.5	24.7

Source: Trans-Jakarta Bus Rapid Transport System Technical Review (2003)



Source: Trans-Jakarta Bus Rapid Transport System Technical Review (2003)

Figure 3.8 BRT lane corridor 1 (from Station Kota to Blok M)

The implementation of the 1st corridor, in the beginning, gained some critics regarding the beneficiaries of this project. It is argued that only few people are benefited from the time saving, while in contrast, more people will suffer because the mixed traffic lanes worsen the existing traffic congestion. Nevertheless, the government believes that traffic congestion will be solved, or reduced dramatically, after the completion of the whole project, as can be seen in Bogota case when TransMilenio started operating in its full capacity.

[18] Detail data can be seen in Trans-Jakarta Bus Rapid Transport System Technical Review (2003) p.22

3.4 Economic activity within the Jakarta Metropolitan Area

The economic activity within the whole Jakarta Metropolitan area can be seen through the data of Gross Regional Domestic Product (GRDP)[19] of each region. Indonesian Statistical Bureau categorized this data into several activities according to the International Standard Industrial Classification of All Economic Activities (ISIC). These activities are: (1) agricultural, livestock, forestry and fishery, (2) mining and quarrying, (3) manufacturing industry, (4) electricity, gas, and water supply, (5) construction, (6) trade, hotel, and restaurant, (7) transportation costs, (8) financial, ownership, & business services, and (9) services (including government services). Detailed GRDP data of each region can be seen in the following table and figure.

Table 3.3 GRDP by industrial origin in 2000 for region 1 to 12 (in million rupiah)

No.	Industrial Origin	North Jkt	East Jkt	South Jkt	West Jkt	Centre Jkt	Kt. Bekasi
1	Agriculture, Livestock, Forestry & Fishery	143,810	52,763	73,986	60,222	3,117	110,339
2	Mining and Quarrying	0	0	0	0	0	0
3	Manufacturing Industry	21,931,741	14,947,260	1,093,593	3,313,890	244,621	4,306,381
4	Electricity, Gas and Water Supply	340,362	232,938	210,891	250,347	302,528	186,975
5	Construction	3,285,528	3,844,759	6,214,687	3,852,066	537,957	323,259
6	Trade, Hotel and Restaurant	7,172,628	7,761,320	9,825,500	9,566,101	4,438,014	2,575,962
7	Transport and Communication	4,031,873	2,394,799	1,994,209	2,461,037	764,855	661,738
8	Financial, Ownership & Business Services	2,653,724	5,527,145	25,456,709	10,109,071	7,109,941	323,619
9	Services	2,493,683	4,657,768	6,181,990	4,577,840	1,336,177	581,210
	Gross Regional Domestic Product	42,053,349	39,418,752	51,051,565	34,190,574	14,737,210	9,069,483
No.	Industrial Origin	Kb. Bekasi	Kt. Bogor	Kb. Bogor	Kt. Depok	Kt. Tgrg	Kb. Tgrg
1	Agriculture, Livestock, Forestry & Fishery	737,146	10,230	1,409,949	140,297	1,235,988	37,319
2	Mining and Quarrying	9,133	0	319,636	0	9,801	0
3	Manufacturing Industry	25,075,683	732,434	10,908,861	1,341,788	7,086,960	9,472,471
4	Electricity, Gas and Water Supply	402,564	80,503	689,226	121,146	733,087	227,169
5	Construction	308,784	219,288	586,424	230,202	223,375	319,959
6	Trade, Hotel and Restaurant	2,807,065	866,819	2,812,293	1,063,971	1,472,475	4,131,792
7	Transport and Communication	361,071	249,621	486,619	175,920	794,384	1,650,869
8	Financial, Ownership & Business Services	283,561	299,539	320,930	132,762	279,270	137,212
9	Services	586,234	213,172	692,606	283,227	498,062	344,953
	Gross Regional Domestic Product	30,571,242	2,671,607	18,226,545	3,489,313	12,333,401	16,321,744

[19] GRDP (based on production approach) is the total value of final goods and services produced by all production units in a region within a certain period (usually one year period).
GRDP (based on expenditure approach) is a total of final demand components, covering the consumption expenditure of households and private non profit institutions, government consumptions, gross domestic fixed capital formation, increase in stock and net export within a certain period.
GRDP (based on income approach) is a total income components of the production factors may take the form of wages or salaries, land rent, capital interest and profit margin. The profits include income tax and other direct taxes (Source: http://www.bps.go.id/sector/nra/grdp/).

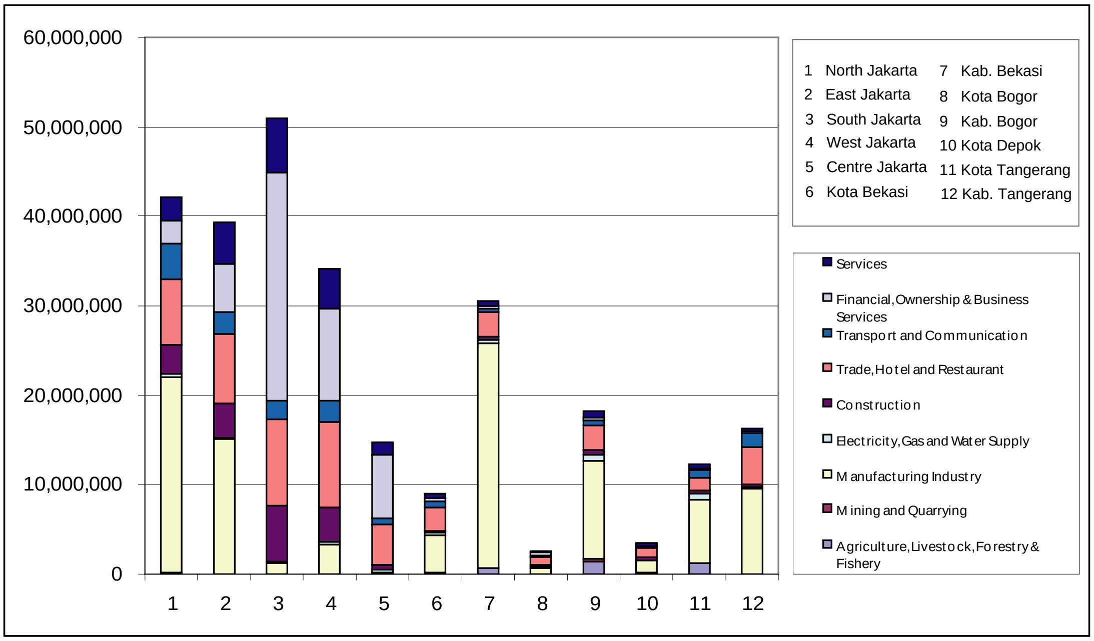


Figure 3.9 GRDP by industrial origin in 2000 for the whole Jakarta Metropolitan Area

From Tables 3.3 and Figure 3.9, it can be seen that Jakarta plays a very important role as a centre of production in the area, especially related to manufacturing industry (mostly takes place in North Jakarta and East Jakarta), construction, trading, financing, business, and services (such as government services). This may happen due to the role of this city as the capital city of Indonesia. The increase of land price in Jakarta together with government regulations, force some manufacturing activities to move to the hinterland of the city. This can be seen trough the high number of manufacturing activity in the region around Jakarta (Kota Bekasi, Kabupaten Bekasi, Kabupaten Bogor, Kota Tangerang, and Kabupaten Tangerang). All of these data, later on in this research, will be used to calculate the distribution of mobile and immobile activity in each region.[20]

[20] See the discussion in Ch. 4, Section 4.3.

Chapter 4 Geographical Economics Model on the BRT Lanes

4.1 Introduction

The objective of this chapter is applying the geographical economics model on the BRT lanes to study the impact of the project development on the spatial distribution of economic activity within the whole Jakarta Metropolitan Area[21]. To do so, it is important to determine the value of several different parameters that already discussed in Chapter 2 for the context of the research study. This chapter will review the methodology that is used to calculate the distances between regions, distribution of mobile and immobile activity, transportation cost, congestion, elasticity of substitution, and share of income spent in manufacture.

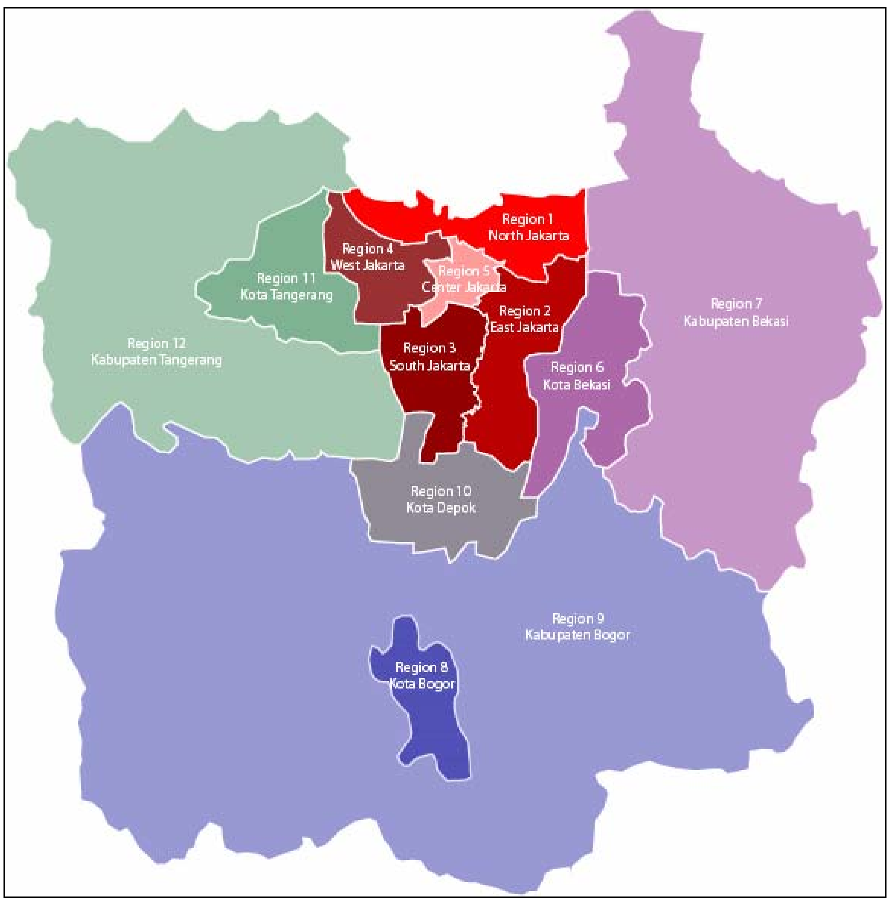


Figure 4.1 Twelve regions in the Jakarta Metropolitan Area

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[21] See again the case of building bridge in ch.2, section 2.5, p.17

As it was mentioned briefly in the previous chapter, the study area of this research is the whole Jakarta Metropolitan Area that consists of 8 regions: DKI Jakarta, Kota Bekasi, Kabupaten Bekasi, Kota Bogor, Kabupaten Bogor, Kota Depok, Kota Tangerang, and Kabupaten Tangerang. Jakarta itself will be studied as 5 regions based on administrative boundaries, because of the fact that this city plays a very important role in the economic activity of Indonesia and has the highest concentration of population in the country. The map of the twelve regions studied in this research can be seen in Figure 4.1.

4.2 Distance location

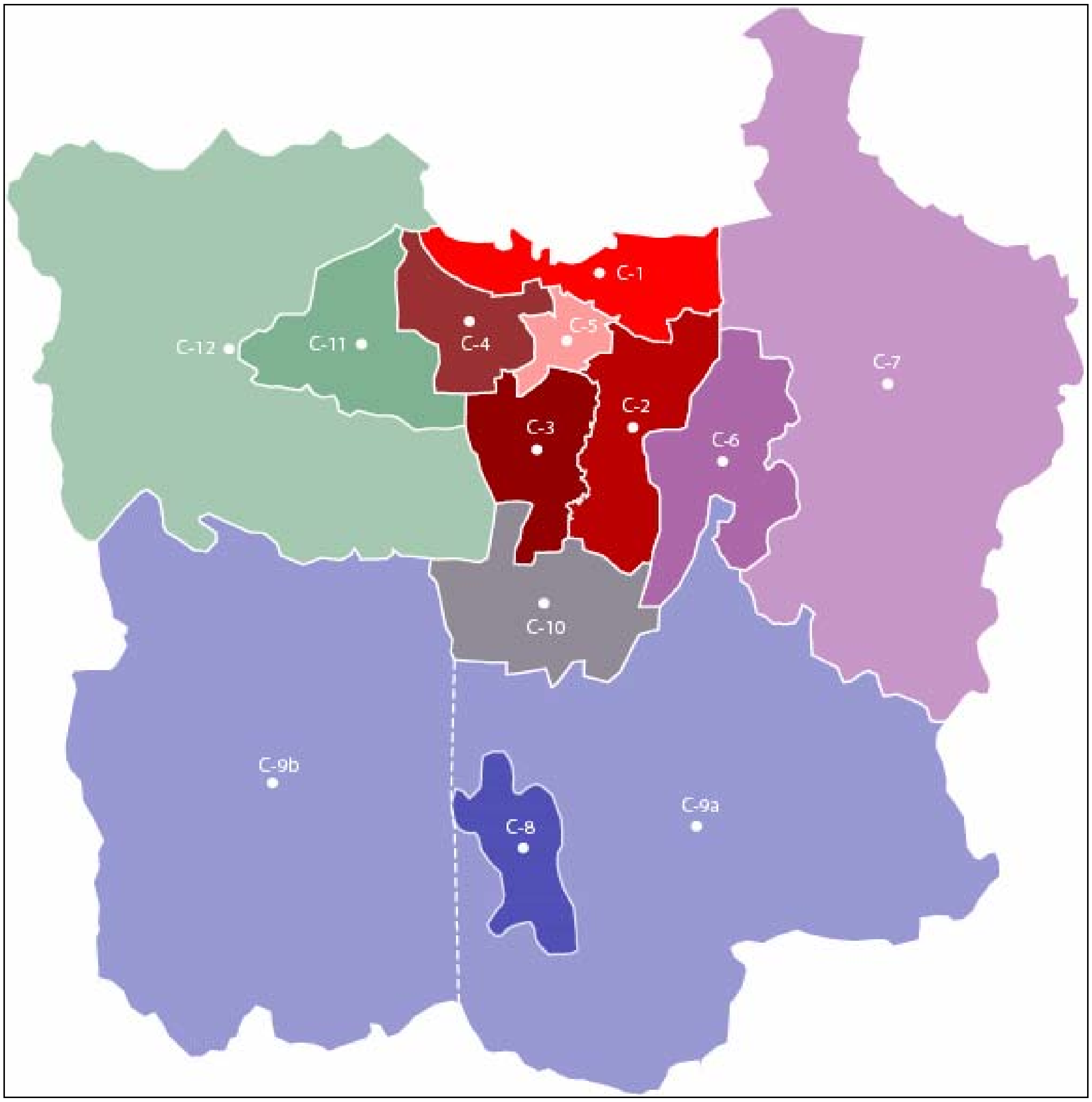
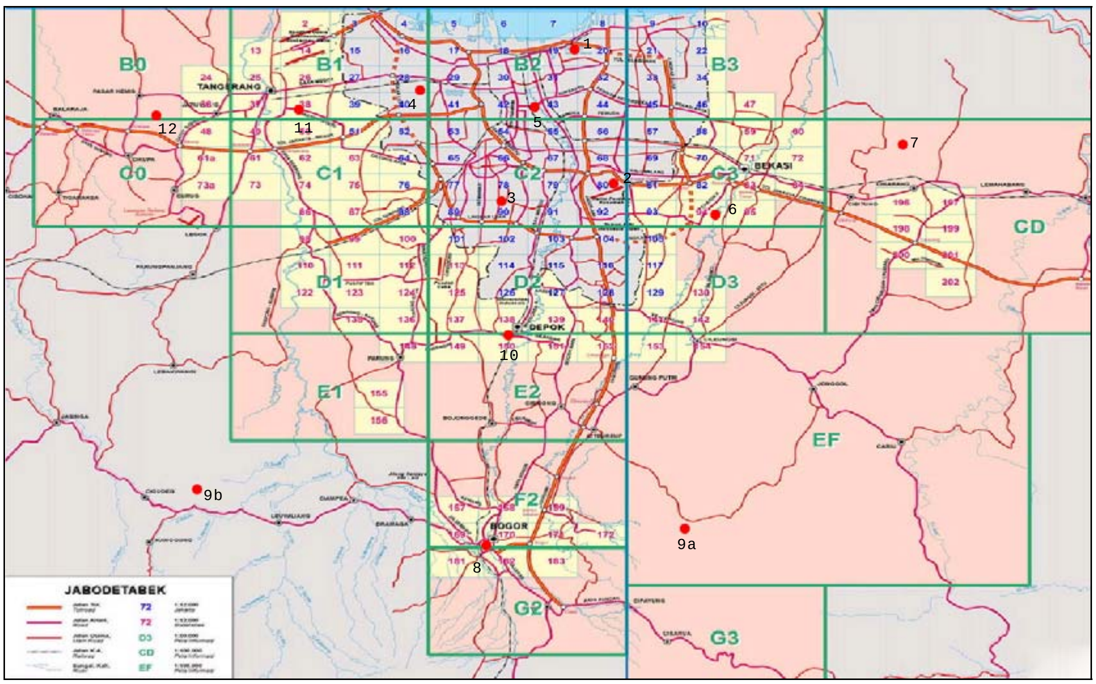


Figure 4.2 The centre of each region

The distance between regions is calculated by analyzing the centre of each region using Arc Map 9. It is assumed that people are evenly distributed across each region, implying that the centre of each region is also the centre of population and human activity. The problem rose when calculating the centre of Region-9 (Kabupaten Bogor) that fell into Region-8 (Kota Bogor), meaning that the distance between the centres of both regions is almost equal to 0. This case is not held in reality. In order to solve this problem, Region-9 is divided into two regions, 9a and 9b, with the assumption that half of population in Region-9 lives in Region-9a and the other half lives in Region-9b. The distance between this region and the rest of the regions will be calculated as the average distances. However, for other type of data collection, such as economic activity and population, this region will be treated as one entity. The result of the centroid calculation using Arc Map 9 can be seen in Figure 4.2 and Figure 4.3.



Source: Mastra, Riadika and Silalahi, S.B. (2005)
(Some necessary adjustment is made by the writer)

Figure 4.3 Jabodetabek map and its centres of population

After calculating the centroid of each region, the distances between regions are calculated by superimposing Figure 4.2 with the map of the Jabodetabek area (as it can be seen in Figure 4.3) and the map of BRT plans (Figure 3.6). Figure 4.4 gives a detail explanation of the method used to calculate the distance between Region-1 and Region-4. Using the same method, distances between all regions are calculated (using AutoCAD 2000) and the result is presented in Table 4.1 to 4.10.

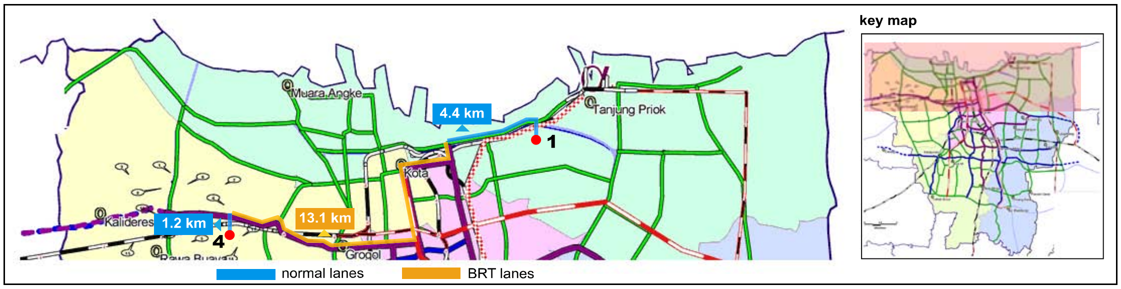


Figure 4.4 Distance from the centre of Region-1 to centre of Region-4

As it was previously stated, one of the objectives of this research is understanding the impact of changing the sequence of the BRT lanes development, also known as hysteresis, on the spatial distribution of economic activity within the area. Thus, the distances between regions are calculated in several different scenarios. First, distances between regions are calculated as if there is no development of the project. Second, it is calculated as if only the first corridor is developed. Third, it is calculated as if only the second and the third corridors are developed. Fourth, it is calculated as if the first, second, and third corridors are developed. And finally, it is calculated as if the entire project has been completed, meaning that all the fifteen corridors are fully operated. The result of these calculations can be seen in Table 4.1 to Table 4.5.

Table 4.1 Distances from one region to the others before the development of the BRT lanes

Distances (km)	1	2	3	4	5	6	7	8	9	10	11	12
1	0	20.7	22	18.7	10.1	32.6	51.1	55.9	64.1	31.7	30.4	43
2	20.7	0	15.5	24.3	12	14.3	33.7	44.1	55.3	22.3	36	48.6
3	22	15.5	0	21.7	12	27.5	46.9	37.5	48.2	15.9	22.3	38.9
4	18.7	24.3	21.7	0	12.3	36.3	55.7	55.5	65.4	33.9	14.1	26.7
5	10.1	12	12	12.3	0	24	44.1	44.7	56	23.1	24	36.6
6	32.6	14.3	27.5	36.3	24	0	26.3	40.3	58.5	30.6	42.2	58.8
7	51.1	33.7	46.9	55.7	44.1	26.3	0	59.5	72	54.2	61.6	78.2
8	55.9	44.1	37.5	55.5	44.7	40.3	59.5	0	28.3	22.4	50.1	64.5
9	64.1	55.3	48.2	65.4	56	58.5	72	28.3	0	38.4	64.3	80.9
10	31.7	22.3	15.9	33.9	23.1	30.6	54.2	22.4	38.4	0	38.3	54.9
11	30.4	36	22.3	14.1	24	42.2	61.6	50.1	64.3	38.3	0	16.6
12	43	48.6	38.9	26.7	36.6	58.8	78.2	64.5	80.9	54.9	16.6	0

Table 4.2 Distances from one region to the others if only corridor 1 is developed

	Distances (km)	1	2	3	4	5	6	7	8	9	10	11	12
1	BRT lanes	0	0	10.8	2.5	0	0	0	0	5.4	0	2.5	2.5
	Normal lanes	0	20.7	11.2	16.2	10.1	32.6	51.1	55.9	58.7	31.7	27.9	40.5
	Total distance	0	20.7	22	18.7	10.1	32.6	51.1	55.9	64.1	31.7	30.4	43
2	BRT lanes	0	0	0	1.8	0	0	0	0	0	0	1.8	1.8
	Normal lanes	20.7	0	15.5	22.5	12	14.3	33.7	44.1	55.3	22.3	34.2	46.8
	Total distance	20.7	0	15.5	24.3	12	14.3	33.7	44.1	55.3	22.3	36	48.6
3	BRT lanes	10.8	0	0	8.3	6.5	0	0	0	0	0	0	0
	Normal lanes	11.2	15.5	0	13.4	5.5	27.5	46.9	37.5	48.2	15.9	22.3	38.9
	Total distance	22	15.5	0	21.7	12	27.5	46.9	37.5	48.2	15.9	22.3	38.9
4	BRT lanes	2.5	1.8	8.3	0	1.8	1.8	1.8	3.2	2.1	3.2	0	0
	Normal lanes	16.2	22.5	13.4	0	10.5	34.5	53.9	52.3	63.3	30.7	14.1	26.7
	Total distance	18.7	24.3	21.7	0	12.3	36.3	55.7	55.5	65.4	33.9	14.1	26.7
5	BRT lanes	0	0	6.5	1.8	0	0	0	0	3.3	0	1.8	1.8
	Normal lanes	10.1	12	5.5	10.5	0	24	44.1	44.7	52.8	23.1	22.2	34.8
	Total distance	10.1	12	12	12.3	0	24	44.1	44.7	56.0	23.1	24	36.6
6	BRT lanes	0	0	0	1.8	0	0	0	0	0	0	0	0
	Normal lanes	32.6	14.3	27.5	34.5	24	0	26.3	40.3	58.5	30.6	42.2	58.8
	Total distance	32.6	14.3	27.5	36.3	24	0	26.3	40.3	58.5	30.6	42.2	58.8
7	BRT lanes	0	0	0	1.8	0	0	0	0	0	0	0	0
	Normal lanes	51.1	33.7	46.9	53.9	44.1	26.3	0	59.5	72	54.2	61.6	78.2
	Total distance	51.1	33.7	46.9	55.7	44.1	26.3	0	59.5	72	54.2	61.6	78.2
8	BRT lanes	0	0	0	3.2	0	0	0	0	0	0	0	0
	Normal lanes	55.9	44.1	37.5	52.3	44.7	40.3	59.5	0	28.3	22.4	50.1	64.5
	Total distance	55.9	44.1	37.5	55.5	44.7	40.3	59.5	0	28.3	22.4	50.1	64.5
9	BRT lanes	5.4	0	0	2.1	3.3	0	0	0	0	0.0	0.0	0.0
	Normal lanes	58.7	55.3	48.2	63.3	52.8	58.5	72	28.3	0	38.4	61.6	77.1
	Total distance	64.1	55.3	48.2	65.4	56	58.5	72	28.3	0	38.4	61.6	77.1
10	BRT lanes	0	0	0	3.2	0	0	0	0	0.0	0	0	0
	Normal lanes	31.7	22.3	15.9	30.7	23.1	30.6	54.2	22.4	38.4	0	38.3	54.9
	Total distance	31.7	22.3	15.9	33.9	23.1	30.6	54.2	22.4	38.4	0	38.3	54.9
11	BRT lanes	2.5	1.8	0	0	1.8	0	0	0	0.0	0	0	0
	Normal lanes	27.9	34.2	22.3	14.1	22.2	42.2	61.6	50.1	61.6	38.3	0	16.6
	Total distance	30.4	36	22.3	14.1	24	42.2	61.6	50.1	61.6	38.3	0	16.6
12	BRT lanes	2.5	1.8	0	0	1.8	0	0	0	0.0	0	0	0
	Normal lanes	40.5	46.8	38.9	26.7	34.8	58.8	78.2	64.5	77.1	54.9	16.6	0
	Total distance	43	48.6	38.9	26.7	36.6	58.8	78.2	64.5	77.1	54.9	16.6	0

Table 4.3 Distances from one region to the others if only corridors 2 and 3 are developed

Distances (km)		1	2	3	4	5	6	7	8	9	10	11	12
1	BRT lanes	0	0	0	7.9	1.1	1.1	9	1.1	0.6	1.1	13.1	13.1
	Normal lanes	0	20.7	22	10.8	9	31.5	42.1	54.8	63.5	30.6	17.3	29.9
	Total distance	0	20.7	22	18.7	10.1	32.6	51.1	55.9	64.1	31.7	30.4	43
2	BRT lanes	0	0	0	11.3	0	0	0	0	0	0	13.1	13.1
	Normal lanes	20.7	0	15.5	13	12	14.3	33.7	44.1	55.3	22.3	22.9	35.5
	Total distance	20.7	0	15.5	24.3	12	14.3	33.7	44.1	55.3	22.3	36	48.6
3	BRT lanes	0	0	0	7.9	0	0	0	0	0	0	0	0
	Normal lanes	22	15.5	0	13.8	12	27.5	46.9	37.5	48.2	15.9	22.3	38.9
	Total distance	22	15.5	0	21.7	12	27.5	46.9	37.5	48.2	15.9	22.3	38.9
4	BRT lanes	7.9	11.3	7.9	0	7.9	7.9	19.2	7.9	7.4	7.9	5.2	5.2
	Normal lanes	10.8	13	13.8	0	4.4	28.4	36.5	47.6	58	26	8.9	21.5
	Total distance	18.7	24.3	21.7	0	12.3	36.3	55.7	55.5	65.4	33.9	14.1	26.7
5	BRT lanes	1.1	0	0	7.9	0	0	18.6	0	0	0	7.9	7.9
	Normal lanes	9	12	12	4.4	0	24	25.5	44.7	56.0	23.1	16.1	28.7
	Total distance	10.1	12	12	12.3	0	24	44.1	44.7	56.0	23.1	24	36.6
6	BRT lanes	1.1	0	0	7.9	0	0	0	0	0	0	0	0
	Normal lanes	31.5	14.3	27.5	28.4	24	0	26.3	40.3	58.5	30.6	42.2	58.8
	Total distance	32.6	14.3	27.5	36.3	24	0	26.3	40.3	58.5	30.6	42.2	58.8
7	BRT lanes	9	0	0	19.2	18.6	0	0	0	0	0	0	0
	Normal lanes	42.1	33.7	46.9	36.5	25.5	26.3	0	59.5	72	54.2	61.6	78.2
	Total distance	51.1	33.7	46.9	55.7	44.1	26.3	0	59.5	72	54.2	61.6	78.2
8	BRT lanes	1.1	0	0	7.9	0	0	0	0	0	0	0	0
	Normal lanes	54.8	44.1	37.5	47.6	44.7	40.3	59.5	0	28.3	22.4	50.1	64.5
	Total distance	55.9	44.1	37.5	55.5	44.7	40.3	59.5	0	28.3	22.4	50.1	64.5
9	BRT lanes	0.6	0	0	7.4	0	0	0	0	0	0.0	0.0	0.0
	Normal lanes	63.5	55.3	48.2	58	56.0	58.5	72	28.3	0	38.4	61.6	77.1
	Total distance	64.1	55.3	48.2	65.4	56.0	58.5	72	28.3	0	38.4	61.6	77.1
10	BRT lanes	1.1	0	0	7.9	0	0	0	0	0.0	0	0	0
	Normal lanes	30.6	22.3	15.9	26	23.1	30.6	54.2	22.4	38.4	0	38.3	54.9
	Total distance	31.7	22.3	15.9	33.9	23.1	30.6	54.2	22.4	38.4	0	38.3	54.9
11	BRT lanes	13.1	13.1	0	5.2	7.9	0	0	0	0.0	0	0	0
	Normal lanes	17.3	22.9	22.3	8.9	16.1	42.2	61.6	50.1	61.6	38.3	0	16.6
	Total distance	30.4	36	22.3	14.1	24	42.2	61.6	50.1	61.6	38.3	0	16.6
12	BRT lanes	13.1	13.1	0	5.2	7.9	0	0	0	0.0	0	0	0
	Normal lanes	29.9	35.5	38.9	21.5	28.7	58.8	78.2	64.5	77.1	54.9	16.6	0
	Total distance	43	48.6	38.9	26.7	36.6	58.8	78.2	64.5	77.1	54.9	16.6	0

Table 4.4 Distances from one region to the others when corridors 1, 2 and 3 are developed

	Distances (km)	1	2	3	4	5	6	7	8	9	10	11	12
1	BRT lanes	0	0	10.8	10.4	1.1	1.1	9	1.1	6	1.1	15.6	15.6
	Normal lanes	0	20.7	11.2	8.3	9	31.5	42.1	54.8	58.1	30.6	14.8	27.4
	Total distance	0	20.7	22	18.7	10.1	32.6	51.1	55.9	64.1	31.7	30.4	43
2	BRT lanes	0	0	0	13.1	0	0	0	0	0	0	14.9	14.9
	Normal lanes	20.7	0	15.5	11.2	12	14.3	33.7	44.1	55.3	22.3	21.1	33.7
	Total distance	20.7	0	15.5	24.3	12	14.3	33.7	44.1	55.3	22.3	36	48.6
3	BRT lanes	10.8	0	0	16.2	6.5	0	0	0	0	0	0	0
	Normal lanes	11.2	15.5	0	5.5	5.5	27.5	46.9	37.5	48.2	15.9	22.3	38.9
	Total distance	22	15.5	0	21.7	12	27.5	46.9	37.5	48.2	15.9	22.3	38.9
4	BRT lanes	10.4	13.1	16.2	0	9.7	9.7	21	11.1	9.5	11.1	5.2	5.2
	Normal lanes	8.3	11.2	5.5	0	2.6	26.6	34.7	44.4	55.9	22.8	8.9	21.5
	Total distance	18.7	24.3	21.7	0	12.3	36.3	55.7	55.5	65.4	33.9	14.1	26.7
5	BRT lanes	1.1	0	6.5	9.7	0	0	18.6	0	3.3	0	9.7	9.7
	Normal lanes	9	12	5.5	2.6	0	24	25.5	44.7	52.8	23.1	14.3	26.9
	Total distance	10.1	12	12	12.3	0	24	44.1	44.7	56.0	23.1	24	36.6
6	BRT lanes	1.1	0	0	9.7	0	0	0	0	0	0	0	0
	Normal lanes	31.5	14.3	27.5	26.6	24	0	26.3	40.3	58.5	30.6	42.2	58.8
	Total distance	32.6	14.3	27.5	36.3	24	0	26.3	40.3	58.5	30.6	42.2	58.8
7	BRT lanes	9	0	0	21	18.6	0	0	0	0	0	0	0
	Normal lanes	42.1	33.7	46.9	34.7	25.5	26.3	0	59.5	72	54.2	61.6	78.2
	Total distance	51.1	33.7	46.9	55.7	44.1	26.3	0	59.5	72	54.2	61.6	78.2
8	BRT lanes	1.1	0	0	11.1	0	0	0	0	0	0	0	0
	Normal lanes	54.8	44.1	37.5	44.4	44.7	40.3	59.5	0	28.3	22.4	50.1	64.5
	Total distance	55.9	44.1	37.5	55.5	44.7	40.3	59.5	0	28.3	22.4	50.1	64.5
9	BRT lanes	6	0.0	0.0	9.5	3.3	0	0	0	0	0	0	0
	Normal lanes	58.1	55.3	48.2	55.9	52.8	58.5	72	28.3	0	38.4	61.6	77.1
	Total distance	64.1	55.3	48.2	65.4	56.0	58.5	72	28.3	0	38.4	61.6	77.1
10	BRT lanes	1.1	0	0	11.1	0	0	0	0	0	0	0	0
	Normal lanes	30.6	22.3	15.9	22.8	23.1	30.6	54.2	22.4	38.4	0	38.3	54.9
	Total distance	31.7	22.3	15.9	33.9	23.1	30.6	54.2	22.4	38.4	0	38.3	54.9
11	BRT lanes	15.6	14.9	0	5.2	9.7	0	0	0	0	0	0	0
	Normal lanes	14.8	21.1	22.3	8.9	14.3	42.2	61.6	50.1	61.6	38.3	0	16.6
	Total distance	30.4	36	22.3	14.1	24	42.2	61.6	50.1	61.6	38.3	0	16.6
12	BRT lanes	15.6	14.9	0	5.2	9.7	0	0	0	0	0	0	0
	Normal lanes	27.4	33.7	38.9	21.5	26.9	58.8	78.2	64.5	77.1	54.9	16.6	0
	Total distance	43	48.6	38.9	26.7	36.6	58.8	78.2	64.5	77.1	54.9	16.6	0

Table 4.5 Distances from one region to the others when the entire project has been completed

Distances (km)		1	2	3	4	5	6	7	8	9	10	11	12
1	BRT lanes	0	12.6	13.4	13.1	5.7	21.1	22.6	17.8	19	15.5	20.5	20.5
	Normal lanes	0	8.1	8.6	5.6	4.4	11.5	28.5	38.1	45.1	16.2	9.9	22.5
	Total distance	0	20.7	22	18.7	10.1	32.6	51.1	55.9	64.1	31.7	30.4	43
2	BRT lanes	12.6	0	8	19.4	8.3	4.4	7.8	6.7	10.9	6.8	26.8	26.8
	Normal lanes	8.1	0	7.5	4.9	3.7	9.9	25.9	37.4	44.4	15.5	9.2	21.8
	Total distance	20.7	0	15.5	24.3	12	14.3	33.7	44.1	55.3	22.3	36	48.6
3	BRT lanes	13.4	8	0	16.3	7.8	16.6	20	0	0	0	11.5	11.5
	Normal lanes	8.6	7.5	0	5.4	4.2	10.9	26.9	37.5	48.2	15.9	10.8	27.4
	Total distance	22	15.5	0	21.7	12	27.5	46.9	37.5	48.2	15.9	22.3	38.9
4	BRT lanes	13.1	19.4	16.3	0	11.1	28	31.4	21	21.1	21	7.4	7.4
	Normal lanes	5.6	4.9	5.4	0	1.2	8.3	24.3	34.5	44.3	12.9	6.7	19.3
	Total distance	18.7	24.3	21.7	0	12.3	36.3	55.7	55.5	65.4	33.9	14.1	26.7
5	BRT lanes	5.7	8.3	7.8	11.1	0	16.9	20	11.3	12.9	11.3	18.5	18.5
	Normal lanes	4.4	3.7	4.2	1.2	0	7.1	24.1	33.4	43.2	11.8	5.5	18.1
	Total distance	10.1	12	12	12.3	0	24	44.1	44.7	56	23.1	24	36.6
6	BRT lanes	21.1	4.4	16.6	28	16.9	0	0	0	11.8	0	28.1	28.1
	Normal lanes	11.5	9.9	10.9	8.3	7.1	0	26.3	40.3	46.7	30.6	14.1	30.7
	Total distance	32.6	14.3	27.5	36.3	24	0	26.3	40.3	58.5	30.6	42.2	58.8
7	BRT lanes	22.6	7.8	20	31.4	20	0	0	0	0	18.7	31.5	31.5
	Normal lanes	28.5	25.9	26.9	24.3	24.1	26.3	0	59.5	72	35.5	30.1	46.7
	Total distance	51.1	33.7	46.9	55.7	44.1	26.3	0	59.5	72	54.2	61.6	78.2
8	BRT lanes	17.8	6.7	0	21	11.3	0	0	0	0	0	0	0
	Normal lanes	38.1	37.4	37.5	34.5	33.4	40.3	59.5	0	28.3	22.4	50.1	64.5
	Total distance	55.9	44.1	37.5	55.5	44.7	40.3	59.5	0	28.3	22.4	50.1	64.5
9	BRT lanes	19	10.9	0	21.1	12.9	11.8	0	0	0	0	12.5	12.5
	Normal lanes	45.1	44.4	48.2	44.3	43.2	46.7	72	28.3	0	38.4	49.1	64.7
	Total distance	64.1	55.3	48.2	65.4	56	58.5	72	28.3	0	38.4	61.6	77.1
10	BRT lanes	15.5	6.8	0	21	11.3	0	18.7	0	0	0	19.5	18.5
	Normal lanes	16.2	15.5	15.9	12.9	11.8	30.6	35.5	22.4	38.4	0	18.8	36.4
	Total distance	31.7	22.3	15.9	33.9	23.1	30.6	54.2	22.4	38.4	0	38.3	54.9
11	BRT lanes	20.5	26.8	11.5	7.4	18.5	28.1	31.5	0	12.5	19.5	0	0
	Normal lanes	9.9	9.2	10.8	6.7	5.5	14.1	30.1	50.1	49.1	18.8	0	16.6
	Total distance	30.4	36	22.3	14.1	24	42.2	61.6	50.1	61.6	38.3	0	16.6
12	BRT lanes	20.5	26.8	11.5	7.4	18.5	28.1	31.5	0	12.5	18.5	0	0
	Normal lanes	22.5	21.8	27.4	19.3	18.1	30.7	46.7	64.5	64.7	36.4	16.6	0
	Total distance	43	48.6	38.9	26.7	36.6	58.8	78.2	64.5	77.1	54.9	16.6	0

It is undoubtedly true that the development of the BRT project will reduce the time needed to travel from one region to the other regions. The data conducted by ITDP (2003) from the operational of the 1st corridor shows that during peak and off peak hours, the bus can move with the steady speed of 24.7 km/hr, while normal buses and cars only can move with the velocity of 13.4 km/hr (during off peak hours) and 8.5 km/hr (during peak hours)[22]. Based on the assumption that this data is also applicable to the rest of the corridors, the travel time needed from one region to the other regions can be calculated by using the same data. At the end of the day, the time needed to travel from one region to the rest of the regions is calculated as the average time between the peak and off peak hours. The result of the calculation (in kilometres and minutes) can be seen in the following table (Table 4.6 to Table 4.10).

Table 4.6 Time travel from one region to the others before the development of BRT lanes (in 100 minutes)

Distances	1	2	3	4	5	6	7	8	9	10	11	12
1	0	1.19	1.27	1.08	0.58	1.88	2.95	3.22	3.69	1.83	1.75	2.48
2	1.19	0	0.89	1.4	0.69	0.82	1.94	2.54	3.19	1.29	2.08	2.8
3	1.27	0.89	0	1.25	0.69	1.59	2.71	2.16	2.78	0.92	1.29	2.24
4	1.08	1.4	1.25	0	0.71	2.09	3.21	3.2	3.77	1.96	0.81	1.54
5	0.58	0.69	0.69	0.71	0	1.38	2.54	2.58	3.23	1.33	1.38	2.11
6	1.88	0.82	1.59	2.09	1.38	0	1.52	2.32	3.37	1.77	2.43	3.39
7	2.95	1.94	2.71	3.21	2.54	1.52	0	3.43	4.15	3.13	3.55	4.51
8	3.22	2.54	2.16	3.2	2.58	2.32	3.43	0	1.63	1.29	2.89	3.72
9	3.69	3.19	2.78	3.77	3.23	3.37	4.15	1.63	0	2.21	3.71	4.67
10	1.83	1.29	0.92	1.96	1.33	1.77	3.13	1.29	2.21	0	2.21	3.17
11	1.75	2.08	1.29	0.81	1.38	2.43	3.55	2.89	3.71	2.21	0	0.96
12	2.48	2.8	2.24	1.54	2.11	3.39	4.51	3.72	4.67	3.17	0.96	0

Table 4.7 Time travel from one region to the others if only corridor 1 is developed (in 100 minutes)[23]

Distances	1	2	3	4	5	6	7	8	9	10	11	12
1	0	1.19	0.91	1	0.58	1.88	2.95	3.22	3.51	1.83	1.67	2.4
2	1.19	0	0.89	1.34	0.69	0.82	1.94	2.54	3.19	1.29	2.02	2.74
3	0.91	0.89	0	0.97	0.48	1.59	2.71	2.16	2.78	0.92	1.29	2.24
4	1	1.34	0.97	0	0.65	2.03	3.15	3.09	3.7	1.85	0.81	1.54
5	0.58	0.69	0.48	0.65	0	1.38	2.54	2.58	3.12	1.33	1.32	2.05
6	1.88	0.82	1.59	2.03	1.38	0	1.52	2.32	3.37	1.77	2.43	3.39
7	2.95	1.94	2.71	3.15	2.54	1.52	0	3.43	4.15	3.13	3.55	4.51
8	3.22	2.54	2.16	3.09	2.58	2.32	3.43	0	1.63	1.29	2.89	3.72
9	3.51	3.19	2.78	3.7	3.12	3.37	4.15	1.63	0	2.21	3.55	4.45
10	1.83	1.29	0.92	1.85	1.33	1.77	3.13	1.29	2.21	0	2.21	3.17
11	1.67	2.02	1.29	0.81	1.32	2.43	3.55	2.89	3.55	2.21	0	0.96
12	2.4	2.74	2.24	1.54	2.05	3.39	4.51	3.72	4.45	3.17	0.96	0

[22] See again Table 3.2 in p.27
[23] See Appendix 1 for detail data

Table 4.8 Time travel from one region to the others if only corridor 2 and 3 are developed (in 100 minutes)[24]

Distances	1	2	3	4	5	6	7	8	9	10	11	12
1	0	1.19	1.27	0.81	0.55	1.84	2.65	3.19	3.68	1.79	1.32	2.04
2	1.19	0	0.89	1.02	0.69	0.82	1.94	2.54	3.19	1.29	1.64	2.37
3	1.27	0.89	0	0.99	0.69	1.59	2.71	2.16	2.78	0.92	1.29	2.24
4	0.81	1.02	0.99	0	0.45	1.83	2.57	2.94	3.53	1.69	0.64	1.37
5	0.55	0.69	0.69	0.45	0	1.38	1.92	2.58	3.23	1.33	1.12	1.85
6	1.84	0.82	1.59	1.83	1.38	0	1.52	2.32	3.37	1.77	2.43	3.39
7	2.65	1.94	2.71	2.57	1.92	1.52	0	3.43	4.15	3.13	3.55	4.51
8	3.19	2.54	2.16	2.94	2.58	2.32	3.43	0	1.63	1.29	2.89	3.72
9	3.68	3.19	2.78	3.53	3.23	3.37	4.15	1.63	0	2.21	3.55	4.45
10	1.79	1.29	0.92	1.69	1.33	1.77	3.13	1.29	2.21	0	2.21	3.17
11	1.32	1.64	1.29	0.64	1.12	2.43	3.55	2.89	3.55	2.21	0	0.96
12	2.04	2.37	2.24	1.37	1.85	3.39	4.51	3.72	4.45	3.17	0.96	0

Table 4.9 Time travel from one region to the others when corridors 1, 2 and 3 are developed (in 100 minutes)[25]

Distances	1	2	3	4	5	6	7	8	9	10	11	12
1	0	1.19	0.91	0.73	0.55	1.84	2.65	3.19	3.5	1.79	1.23	1.96
2	1.19	0	0.89	0.96	0.69	0.82	1.94	2.54	3.19	1.29	1.58	2.31
3	0.91	0.89	0	0.71	0.48	1.59	2.71	2.16	2.78	0.92	1.29	2.24
4	0.73	0.96	0.71	0	0.39	1.77	2.51	2.83	3.46	1.58	0.64	1.37
5	0.55	0.69	0.48	0.39	0	1.38	1.92	2.58	3.12	1.33	1.06	1.79
6	1.84	0.82	1.59	1.77	1.38	0	1.52	2.32	3.37	1.77	2.43	3.39
7	2.65	1.94	2.71	2.51	1.92	1.52	0	3.43	4.15	3.13	3.55	4.51
8	3.19	2.54	2.16	2.83	2.58	2.32	3.43	0	1.63	1.29	2.89	3.72
9	3.5	3.19	2.78	3.46	3.12	3.37	4.15	1.63	0	2.21	3.55	4.45
10	1.79	1.29	0.92	1.58	1.33	1.77	3.13	1.29	2.21	0	2.21	3.17
11	1.23	1.58	1.29	0.64	1.06	2.43	3.55	2.89	3.55	2.21	0	0.96
12	1.96	2.31	2.24	1.37	1.79	3.39	4.51	3.72	4.45	3.17	0.96	0

[24] See Appendix 2 for detail data
[25] See Appendix 3 for detail data

Table 4.10 Time travel from one region to the others when the entire project has been completed (in 100 minutes)[26]

Distances	1	2	3	4	5	6	7	8	9	10	11	12
1	0	0.77	0.82	0.64	0.39	1.18	2.19	2.63	3.06	1.31	1.07	1.8
2	0.77	0	0.63	0.75	0.42	0.68	1.68	2.32	2.83	1.06	1.18	1.91
3	0.82	0.63	0	0.71	0.43	1.03	2.04	2.16	2.78	0.92	0.9	1.86
4	0.64	0.75	0.71	0	0.34	1.16	2.16	2.5	3.07	1.25	0.57	1.29
5	0.39	0.42	0.43	0.34	0	0.82	1.88	2.2	2.8	0.96	0.77	1.49
6	1.18	0.68	1.03	1.16	0.82	0	1.52	2.32	2.98	1.77	1.5	2.45
7	2.19	1.68	2.04	2.16	1.88	1.52	0	3.43	4.15	2.5	2.5	3.46
8	2.63	2.32	2.16	2.5	2.2	2.32	3.43	0	1.63	1.29	2.89	3.72
9	3.06	2.83	2.78	3.07	2.8	2.98	4.15	1.63	0	2.21	3.13	4.03
10	1.31	1.06	0.92	1.25	0.96	1.77	2.5	1.29	2.21	0	1.56	2.55
11	1.07	1.18	0.9	0.57	0.77	1.5	2.5	2.89	3.13	1.56	0	0.96
12	1.8	1.91	1.86	1.29	1.49	2.45	3.46	3.72	4.03	2.55	0.96	0

4.3 Distribution of mobile and immobile activity

In order to calculate the distribution of mobile and immobile activity, economic activities in Table 3.3 are grouped into immobile and mobile activity. Some of the economic activities, (1) agriculture, livestock, forestry, and fishery, and (2) mining and quarrying, are considered to be more immobile, while the rest of the activities are considered to be more mobile. Economic activities no. 1 and 2 are believed to be immobile because of the relation of these activities to natural resources that are immobile. It is realized that some of the activity above has mixed characteristics between mobile and immobile, but as all of the data is calculated using the same method, the result of the calculation maintains the same errors. Later on, these errors are adjusted in parameter δ (the share of income spent in manufacture). The table below shows the result of GRDP calculation based on Table 3.3.

Table 4.11 GRDP based on immobile and mobile activity for region 1 to 12

	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7
Immobile (I_GRDP)	143,810	52,763	73,986	60,222	3,117	110,339	746,279
Mobile (M_GRDP)	41,909,539	39,365,989	50,977,579	34,130,352	14,734,093	8,959,144	29,824,963
GRDP	42,053,349	39,418,752	51,051,565	34,190,574	14,737,210	9,069,483	30,571,242

	Region 8	Region 9	Region 10	Region 11	Region 12	Total GRDP 12 regions
Immobile (I_GRDP)	10,230	1,729,585	140,297	1,245,789	37,319	4,353,736
Mobile (M_GRDP)	2,661,377	16,496,960	3,349,016	11,087,612	16,284,425	269,781,049
GRDP	2,671,607	18,226,545	3,489,313	12,333,401	16,321,744	274,134,785

[26] See Appendix 4 for detail data

The share of immobile and mobile activity is calculated by using Equation 4.1 and 4.2, and the result of this calculation can be seen in Table 4.13.

$$\phi_n = \frac{I\_GRDP_n}{\sum_{n=1}^{12} I\_GRDP_n} \qquad (4.1)$$

$$\phi_n = \frac{M\_GRDP_n}{\sum_{n=1}^{12} M\_GRDP_n} \qquad (4.2)$$

Table 4.12 Actual share and calculated share of immobile activity (initial)

location	1	2	3	4	5	6
distribution **immobile** activity	0.0330	0.0121	0.0170	0.0138	0.0007	0.0253
initial distribution **mobile** activity	0.1553	0.1459	0.1890	0.1265	0.0546	0.0332
pop distribution 2004	1182	2104	1707	1566	893	1914
actual share	0.054	0.096	0.078	0.071	0.041	0.087
calculated share	0.071	0.069	0.073	0.067	0.072	0.059
difference	-0.017	0.027	0.005	0.005	-0.031	0.029
location	7	8	9	10	11	12
distribution **immobile** activity	0.1714	0.0023	0.3973	0.0322	0.2861	0.0086
initial distribution **mobile** activity	0.1106	0.0099	0.0611	0.0124	0.0411	0.0604
pop distribution 2004	1915	867	3798	1324	1489	3194
actual share	0.087	0.039	0.173	0.060	0.068	0.145
calculated share	0.098	0.034	0.188	0.064	0.167	0.040
difference	-0.011	0.006	-0.015	-0.003	-0.099	0.106

When examining the distribution of economic activity (mobile and immobile) using the population distribution in the year 2004 (see Table 4.12), it can be seen that the differences between the actual share and calculated share for most of the regions are still high (except for region 3, 4, 8 and 10 with the absolute difference less than 1%). Implying that, for most of the regions, the value of immobile activity in Table 4.12 has not really described the real situation in the study area. This happens due to the isolation of all regions studied in this research from their neighbouring regions using artificial boundaries. Regions that are located in the centre (in this case regions within Jakarta area) can interact with all neighbouring regions while regions located in the fringe (for instance region 7, 8, 9, and 12) cannot interact with all the hinterland regions (because some of these regions are located outside the research boundaries), as illustrated in Figure 4.5.

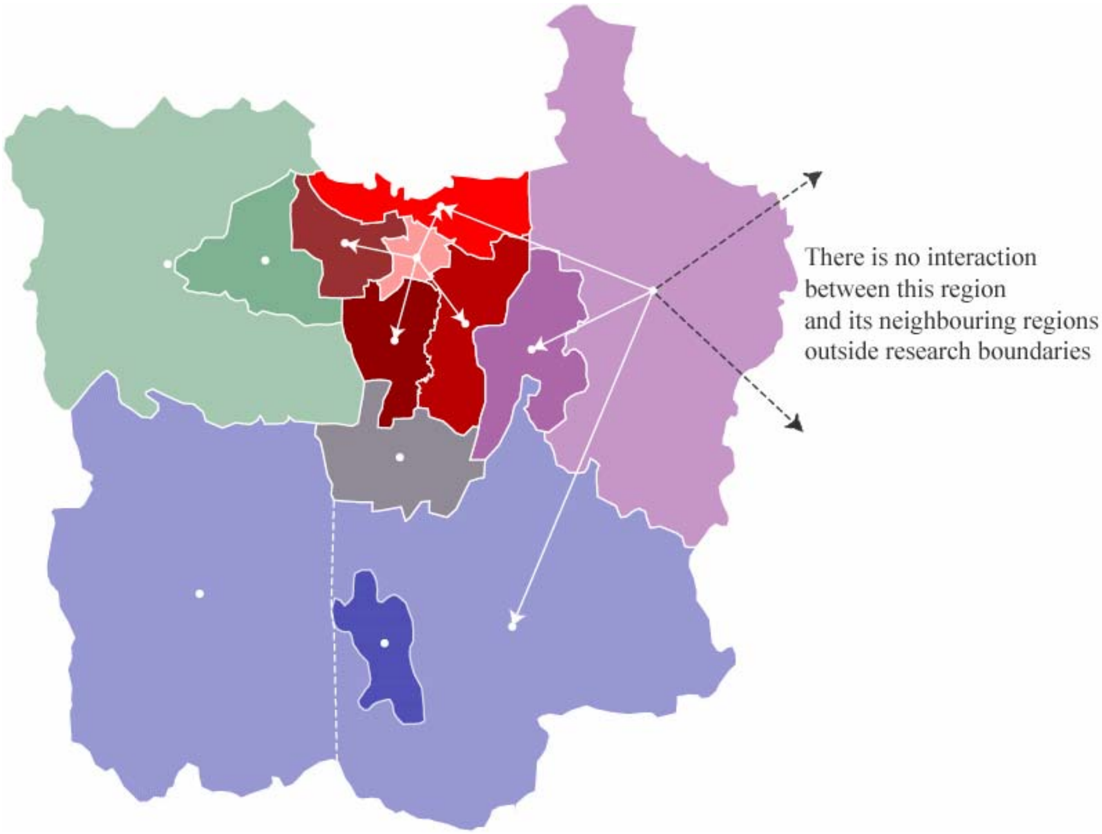


Figure 4.5 Interaction between regions inside research boundaries

In order to overcome this problem, some artificial adjustment is needed when determining the distribution of immobile activity in the simulation. Using the initial distribution of immobile activity in Table 4.12, the share of immobile activity in some regions is reduced and accordingly in some other regions is increased until there is only a slight deference between the absolute value of actual share and calculated share. Due to time limitation on conducting this research, the process of calibrating the benchmark is stopped when the difference between the actual and calculated share is less than 1 percent, with the exceptional for region 5 and 6. The initial distribution of immobile activity for region 5 is already very low and it is impossible to adjust this value anymore. The result of the calibration can be seen in Table 4.13. Using this value, the difference between the actual share and calculated share can be seen in the same table.

Table 4.13 Actual share and calculated share of immobile activity (final)

location	1	2	3	4	5	6
distribution **immobile** activity	0.0100	0.1001	0.0400	0.0408	0.0007	0.0453
pop distribution 2004	1182	2104	1707	1566	893	1914
actual share	0.054	0.096	0.078	0.071	0.041	0.087
calculated share	0.053	0.100	0.077	0.072	0.065	0.066
difference	0.000	-0.004	0.000	-0.001	-0.025	0.021
location	7	8	9	10	11	12
distribution **immobile** activity	0.1214	0.0023	0.3073	0.0142	0.0361	0.2816
pop distribution 2004	1915	867	3798	1324	1489	3194
actual share	0.087	0.039	0.173	0.060	0.068	0.145
calculated share	0.081	0.039	0.165	0.057	0.067	0.157
difference	0.006	0.001	0.008	0.004	0.001	-0.012

Using a new distribution of immobile activity (Table 4.13), the initial distribution of mobile activity is calculated by running the simulation. This simulation gives a result of the final distribution of mobile activity that is finally used in the base simulation (see Table 4.14).

Table 4.14 Initial distribution of mobile activity (final)

location	1	2	3	4	5	6
initial distribution **mobile** activity	0.0825	0.0994	0.1021	0.0931	0.1086	0.0797
location	7	8	9	10	11	12
initial distribution **mobile** activity	0.0544	0.0627	0.0705	0.0848	0.0879	0.0741

4.4 Share on income spent in manufactures (δ)

By using the same data (as presented in Table 4.11), the share of income spent in manufacture (δ) can be calculated by using equation 4.3, hence give a result that is equal to 0.9. This value will be used in the simulation as the upper bond value of parameter δ. This value contains some errors due to the difficulties of grouping the data (GRDP) as pure mobile and immobile, and thus has to be adjusted. In order to overcome this problem, the initial simulation will first run with the value of delta equals to 0.6. Later on, this value will be increased and decreased, and the result will be compared to come to conclusion.

$$\delta = \frac{\sum_{n=1}^{12} M\_GRDP_n}{\sum_{n=1}^{12} M\_GRDP_n + \sum_{n=1}^{12} I\_GRDP} \qquad (4.3)$$

4.5 Other Parameters: Transport cost (*T*), Congestion (τ), and Elasticity of substitution (ε)

The values of other parameters (transport cost, congestion, and elasticity of substitution) are determined by making a guess for these parameters. The following section will discuss the reasoning behind the selection of the parameters value.

Transport cost T

Transport cost is used in the geographic economics model to represent a fraction of manufactured goods that do not arrive at the destination when goods are delivered between regions. In other words, it represents the number of goods that have to be shipped; to ensure that one unit of manufactured goods per unit of distances arrives.[27] Transport cost terminology can also be used to describe different types of trading obstacles between locations, as for example tariffs and language barriers.[28] Considering the fact that the regions in this research are located close to each other, in the same country, transport cost for delivering goods from one region to the others is assumed to be low. In the Jakarta Metropolitan Area, it is estimated that 1.2 goods need to be shipped to ensure that 1 unit of goods arrives in another region (T is equal to 1.2). This value, later on in this research, will be increased and decreased in order to see the impact of changing the transport cost value.

Congestion cost τ

As it is previously stated in Chapter 2, urban agglomeration may cause external diseconomies of scale that act as spreading forces to people and mobile economic activities. This happens because the agglomeration of human activity within an urban area may increase some problems related to the increase of commuting cost, land rent, environmental pollution, traffic jam, and other disadvantages that rise because of crowdedness. All of these diseconomies of scale, categorized as congestion (τ), can provide an incentive for firms and mobile workforce to move away from the congested area in the centre to the urban fringe. Given that fact, congestion cost is not only the function of industry, but a function of the size of the city as a whole.

Congestion can be calculated by looking at the size and the economy of the city as a whole. Unfortunately, with the limitation of available data, it is difficult to calculate the value of congestion in the Jakarta Metropolitan Area. The value of congestion in this research is drawn by making a guess based on the size and the population of the study area. Finally, congestion cost is estimated to be equal to 0.3. This value, later on in this research, will be increased and decreased in order to see the impact of changing the congestion cost value.

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27 See Brakman, Garretsen, and Van Marrewijk (2001), p.80

28 See Brakman, Garretsen, and Van Marrewijk (2001), p.105

Elasticity of substitution ε

Elasticity of substitution represents the difficulties to substitute one variety of manufactured goods for another variety. There are several different econometric methods that can be used to calculate the value of this parameter. Nevertheless, these methods are very complex and most of them demand very detailed data. According to Brakman, Garretsen and Van Marrewijk (2001), the elasticity of substitution is also used to measure the economies of scale, by dividing the average cost by the marginal costs. If the marginal costs are lower than the average costs, an increase in production will reduce the cost per unit of goods.

The relationship between the elasticity of substitution and the share of income spent in manufacture is strong. It implies that the larger the fraction of income spent in manufacture, the higher is the elasticity of substitution.[29] The value of substitution is drawn by comparing the value of this parameter in the Germany case study done by Brakman, Garretsen and Van Marrewijk (2001)[30] and the value of the share of income in this research. In the Germany case study, the value of the share of income spent on manufacture is between 0.68 and 0.82, and thus yielding to the value of elasticity of substitution that is equal to 4. In this study, the portion of income spend in manufactured is equal to 0.6. Given that, it is assumed that the initial value of elasticity of substitution is equal to 5. However, later on, this value will be increased and decreased in order to see the impact of changing the elasticity of substitution value.

[29] See Brakman, Garretsen, and Van Marrewijk (2001), Chapter 4

[30] See Brakman, Garretsen, and Van Marrewijk (2001), Chapter 5
This case study applies the geographical economics model in Germany after the unification

Chapter 5 Simulations on BRT Lane Development on the Spatial Distribution of Economic Activity within the Jakarta Metropolitan Area

5.1 Introduction

The objective of this chapter is applying some simulations on the BRT lane project in order to see the impact of the project development to the spatial distribution of economic activity within the Jakarta Metropolitan Area, and understanding the importance of hysteresis in this project. To do so, there are several simulations that will be done in this research. The first simulation is a simulation before the development of any corridors to verify and justify the selection of the value of several parameters and the initial distribution of mobile and immobile activity. The second one is simulating the development of the project if the first three corridors are developed together. The third one is simulating the development of the project according to the Jakarta Transportation Master Plan, where the 1st corridor is developed earlier than the 2nd and 3rd corridors. The fourth one is simulating the development of the project if the 2nd and the 3rd corridors are developed together, earlier than the 1st corridor. The result of the second, third, and fourth simulation are compared in order to understand the importance of hysteresis in the project. Figure 5.1 gives a visual description of these simulations. [31]

The last simulations are simulating the long run equilibrium when the entire project has been completed. It can be done through three different simulations as follows:

- The fifth one is simulating the long run equilibrium from the final distribution of the base (from the first simulation) directly to all 15 corridors
- The sixth one is simulating the long run equilibrium from the final distribution of the third simulation (1st, 2nd and 3rd corridors) to all 15 lanes
- The seventh one is simulating the long run equilibrium from the final distribution of the fourth simulation (2nd, 3rd, and 1st corridors) to all 15 lanes

After doing the simulations, it is important to see the impact of changing the value of congestion, transport cost, elasticity of substitution, and share of income spent in manufacture parameters. The result of these simulations will be compared to the result of the initial simulations.

[31] Reminder: all of these simulations will run using δ =0.6, ε =5, τ =0.3, and T=1,2

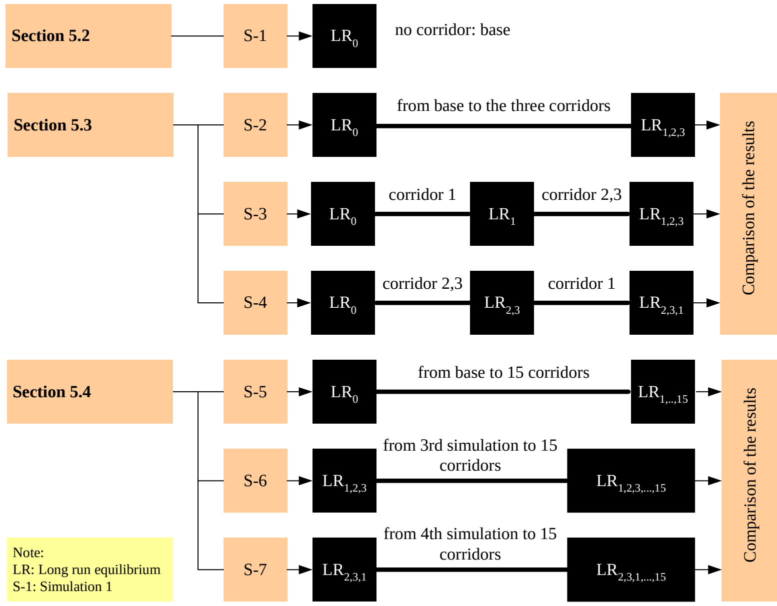


Figure 5.1 The simulation in the research

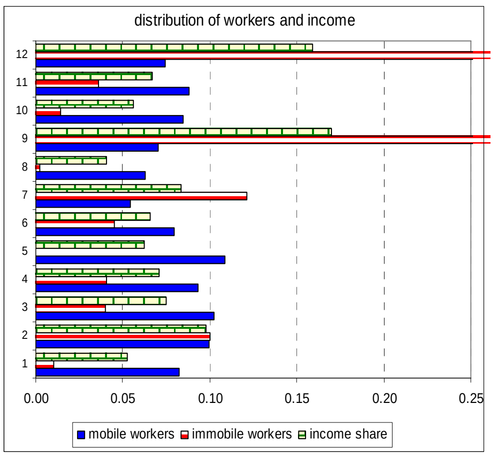
5.2 Simulation 1: no BRT lane development as the base of simulation

Using the value of parameters that are already described in Chapter 4, the final distribution of mobile activity and the final income share in the long run equilibrium are calculated (see Table 5.1 and Figure 5.2). The result of this simulation will be used as the base (benchmark) and all future simulations will be evaluated relative to the impact they have on this benchmark. This result represents a reasonable long run distribution of the current situation in the Jakarta Metropolitan Area (given the fact that the actual geography of Jakarta is entered in the simulation) yielding to a fairly good indication of the impact of the bus lanes development relative to this benchmark (and hence a fortiori relative to reality).

From Table 5.1 and Figure 5.2, it can be seen that almost half of the mobile activity in the Jakarta Metropolitan Area is located in Jakarta (Region 1 to 5), and most of the immobile activity is located outside Jakarta. The highest concentration of the immobile activity is located in Region 9 and 12 (58.9 %). This is understandable regarding the high agricultural, forestry, and mining activities, that are immobile, and high concentration of people in these regions. The final income share of all regions in Jakarta is equal to 35.8 % of the whole area. The highest share of income is in Region 9 (17 %) and Region 12 (15.9 %). The following simulations will show the impact of the project development on the final distribution of mobile activity and the final income share over the twelve regions.

Table 5.1 Distribution of immobile and mobile activity when there is no corridor's development[32]

location	1	2	3	4	5	6	7	8	9	10	11	12
distribution **immobile** activity	0.0100	0.1001	0.0400	0.0408	0.0007	0.0453	0.1214	0.0023	0.3073	0.0142	0.0361	0.2816
initial distribution **mobile** activity	0.0825	0.0994	0.1021	0.0931	0.1086	0.0797	0.0544	0.0627	0.0705	0.0848	0.0879	0.0741
final distribution mobile activity	0.0825	0.0994	0.1021	0.0931	0.1086	0.0797	0.0544	0.0627	0.0705	0.0848	0.0879	0.0741
final income share	0.0526	0.0976	0.0750	0.0708	0.0622	0.0658	0.0836	0.0404	0.1697	0.0560	0.0669	0.1593
differences initial-final mobile activity	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000



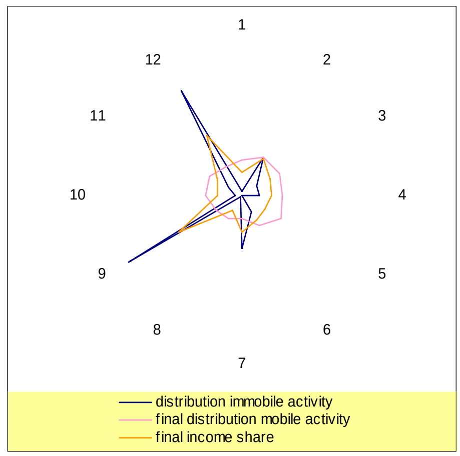


Figure 5.2 Distribution of workers and income

5.3 Long run equilibrium for the first three corridors

Long run equilibrium for the first three corridors can be reached through three ways, as it can be seen in Figure 5.3. The result of these simulations will be compared in order to see the relation of the project development sequences and the final distribution of mobile activity and final income share of each region.

32 See again the explanation of this table in Section 4.3.
The final distribution of mobile activity in the base simulation shows the same value as the initial distribution of this activity. It implies that long run equilibrium is achieved in this stage.
Note that the initial distribution of immobile activity does not change in all simulations because it represents the current long run equilibrium in the Jakarta Metropolitan Area.

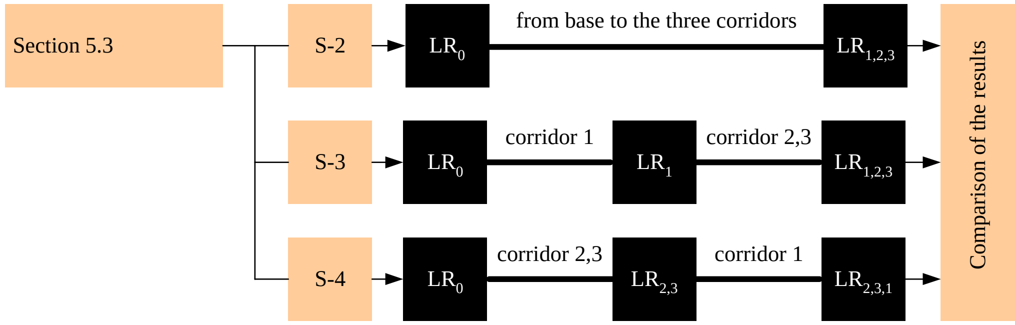


Figure 5.3 The simulation for the first three corridors

5.3.1 Second simulation: from the base to the first three corridors

The second simulation is done by using the final distribution of mobile activity in simulation 1 as the input for the initial distribution of mobile activity.

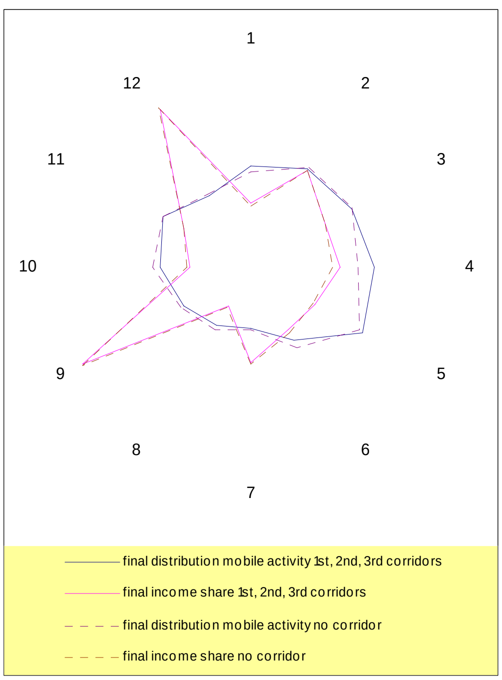


Figure 5.4 Final distribution of mobile activity and income share (simulation 2)

When comparing the result of the second simulation with the first simulation (see Figure 5.4), it can be seen that the development of the first three corridors in Jakarta (connecting Region 1 to Region 3 and Region 4 to Region 2) increases the final distribution of mobile activity in most of the regions inside Jakarta, except mobile activity in regions 2 and 3 that is slightly decreased by 0.1% point change. On the other hand, the development of these corridors decreases the final distribution of mobile activity in most of the regions outside Jakarta, except mobile activity in Region 11 that is increased by 0.2% point change.

Regions with high final income share also have high final mobile activity. This happens because mobile workers tend to move to regions with higher income level and thus increase mobile activity in the regions.

Table 5.2 Distribution of mobile activity and income share when the 1st, 2nd, and 3rd corridors are developed simultaneously[33]

location	1	2	3	4	5	6	7	8	9	10	11	12
final distribution mobile activity	0.0884	0.0982	0.1012	0.1069	0.1127	0.0743	0.0529	0.0585	0.0669	0.0795	0.0882	0.0721
final income share	0.0559	0.0972	0.0745	0.0778	0.0645	0.0630	0.0826	0.0382	0.1679	0.0534	0.0669	0.1580
Differences (point change)												
final distribution mobile activity	0.006	-0.001	-0.001	0.014	0.004	-0.005	-0.002	-0.004	-0.004	-0.005	0.000	-0.002
final income share	0.003	0.000	0.000	0.007	0.002	-0.003	-0.001	-0.002	-0.002	-0.003	0.000	-0.001

5.3.2 Third simulation: 1st corridor→2nd and 3rd corridors

The third simulation is done by finding the long run equilibrium after the development of the 1st corridor and using the result of this simulation as an input in the initial distribution of mobile activity when running the simulation for the 2nd and the 3rd corridors. The result of these simulations can be seen in the following figure and tables.

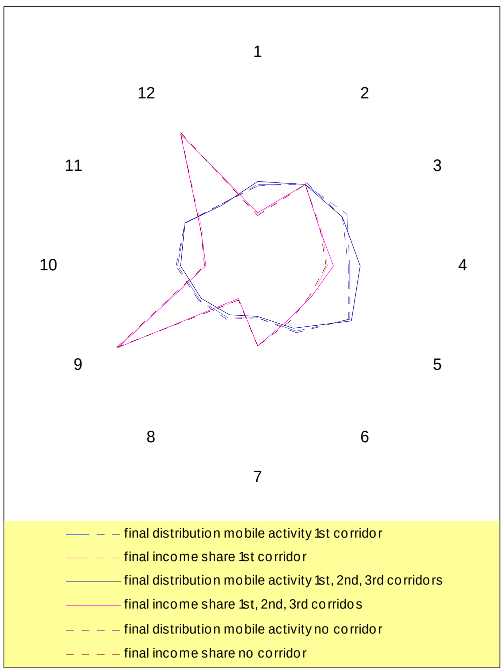


Figure 5.5 Final distribution of mobile activity and income share (simulation 3)

From Figure 5.5, it can generally be seen that the development of the 1st corridor, connecting Region 1 to Region 3, increases the final distribution of mobile activity in all regions in Jakarta, except mobile activity in Region 2 that is slightly decreased by 0.2% point change. On the other hand, it decreases final distribution of mobile activity in all regions outside Jakarta.

The completion of the first three corridors after the development of the 1st corridor increases the final distribution of mobile activity in most of the regions in Jakarta, except mobile activity in Region 3 that is decreased by 0.5% point change. Conversely, it decreases the final distribution of mobile activity in most of the regions outside Jakarta, except mobile activity in Region 11 that is increased by 0.1% point change.

33 This simulation runs using the final distribution of mobile activity in the base simulation (see Table 5.1).
The differences in each region are calculated by subtracting the final distribution and final income share of this simulation (Simulation 2) from the base simulation (Simulation 1).

From this simulation, it can be concluded that the completion of the first three corridors attracts more economic activity into Jakarta. This happens due to the growth of the final income share in Jakarta (from the base).

Table 5.3 Distribution of immobile and mobile activity when only the 1st corridor is developed[34]

location	1	2	3	4	5	6	7	8	9	10	11	12
final distribution mobile activity	0.0850	0.0978	0.1058	0.0953	0.1100	0.0781	0.0534	0.0613	0.0696	0.0831	0.0872	0.0733
final income share	0.0539	0.0969	0.0767	0.0719	0.0630	0.0650	0.0831	0.0397	0.1692	0.0552	0.0666	0.1589
Differences (point change)												
final distribution mobile activity	0.002	-0.002	0.004	0.002	0.001	-0.002	-0.001	-0.001	-0.001	-0.002	-0.001	-0.001
final income share	0.006	-0.001	-0.001	0.014	0.004	-0.005	-0.002	-0.004	-0.004	-0.005	0.000	-0.002

Table 5.4 Distribution of mobile activity and income share when the 1st, 2nd, and 3rd corridors are developed[35]

location	1	2	3	4	5	6	7	8	9	10	11	12
final distribution mobile activity	0.0884	0.0982	0.1012	0.1069	0.1127	0.0743	0.0529	0.0585	0.0669	0.0795	0.0882	0.0721
final income share	0.0559	0.0972	0.0745	0.0778	0.0645	0.0630	0.0826	0.0382	0.1679	0.0534	0.0669	0.1580
Differences (point change)												
final distribution mobile activity	0.006	-0.001	-0.001	0.014	0.004	-0.005	-0.002	-0.004	-0.004	-0.005	0.000	-0.002
final income share	0.003	0.000	0.000	0.007	0.002	-0.003	-0.001	-0.002	-0.002	-0.003	0.000	-0.001

5.3.3 Fourth simulation: 2nd and 3rd corridors→1st corridor

The fourth simulation is done by changing the sequence of BRT lanes development. In this simulation, it is assumed that the 2nd and the 3rd corridors are developed before the 1st corridor. Long run equilibrium after the development of the 2nd and the 3rd corridors is used as the initial distribution of mobile activity when running the simulation for the 1st corridor. The result of these simulations can be seen in the following figure and tables.

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34 This simulation runs using the final distribution of mobile activity in the base simulation (see Table 5.1)
The differences in each region are calculated by subtracting the final distribution and final income share of this simulation (Simulation 3a) from the base simulation (Simulation 1).

35 This simulation runs using the final distribution of mobile activity in Table 5.3 as the initial distribution of mobile activity when the 1st, 2nd, and 3rd corridors are developed.
The differences in each region are calculated by subtracting the final distribution and final income share of this simulation (Simulation 3b) from the base simulation (Simulation 1).

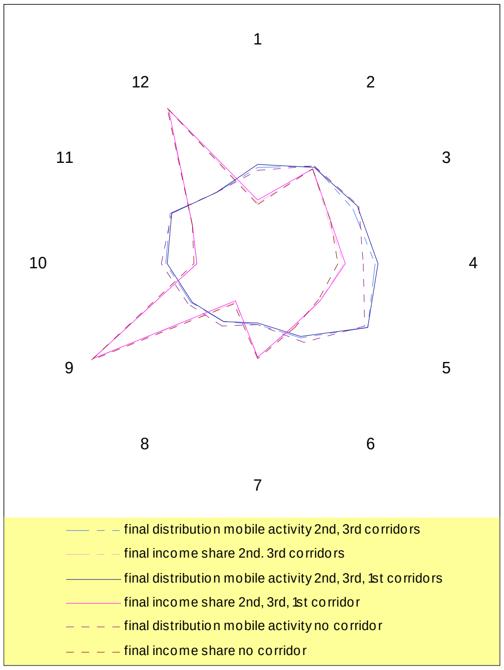


Figure 5.6 Final distribution of mobile activity and income share (simulation 4)

From Figure 5.6, it can generally be seen that the development of the 2nd and the 3rd corridors increases the final distribution of mobile activity in most of the region in Jakarta, except mobile activity in Region 3 that is decreased by 0.5% point change. Inversely, it decreases final distribution of mobile activity in most of the regions outside Jakarta, except mobile activity in Region 7 that is remained constant and in Region 11 that is increased by 0.1% point change.

The development of the 1st corridor connecting Region 1 to Region 3 after the development of the 2nd and the 3rd corridors increases the final distribution of mobile activity in most of the region in Jakarta, except Region 2 that is slightly decreased by 0.1% point change. Conversely, it decreases the final distribution of mobile activity in all regions outside Jakarta.

From this simulation, it can be concluded that the completion of the first three corridors attracts more economic activity into Jakarta. This happens due to the growth of the final income share in Jakarta (from the base).

Table 5.5 Final distribution of mobile activity and income share when only the 2nd and 3rd corridors are developed[36]

location	1	2	3	4	5	6	7	8	9	10	11	12
final distribution mobile activity	0.0858	0.0996	0.0976	0.1042	0.1114	0.0759	0.0540	0.0598	0.0680	0.0811	0.0893	0.0733
final income share	0.0545	0.0979	0.0727	0.0765	0.0638	0.0638	0.0832	0.0389	0.1685	0.0542	0.0675	0.1586
Differences (point change)												
final distribution mobile activity	0.003	0.000	-0.005	0.011	0.003	-0.004	0.000	-0.003	-0.002	-0.004	0.001	-0.001
final income share	0.002	0.000	-0.002	0.006	0.002	-0.002	0.000	-0.002	-0.001	-0.002	0.001	-0.001

[36] This simulation runs using the final distribution of mobile activity in the base simulation (see Table 5.1).
The differences in each region are calculated by subtracting the final distribution and final income share of this simulation (Simulation 4a) from the base simulation (Simulation 1).

Table 5.6 Distribution of mobile activity and income share when there is no corridor's development when the 2nd, 3rd, and 1st corridors are developed[37]

location	1	2	3	4	5	6	7	8	9	10	11	12
final distribution mobile activity	0.0884	0.0982	0.1012	0.1069	0.1127	0.0743	0.0529	0.0585	0.0669	0.0795	0.0882	0.0722
final income share	0.0559	0.0972	0.0745	0.0778	0.0645	0.0630	0.0826	0.0382	0.1679	0.0534	0.0669	0.1580
Differences (point change)												
final distribution mobile activity	0.006	-0.001	-0.001	0.014	0.004	-0.005	-0.002	-0.004	-0.004	-0.005	0.000	-0.002
final income share	0.003	0.000	0.000	0.007	0.002	-0.003	-0.001	-0.002	-0.002	-0.003	0.000	-0.001

5.3.4 Comparing the result of the second, the third and the fourth simulation

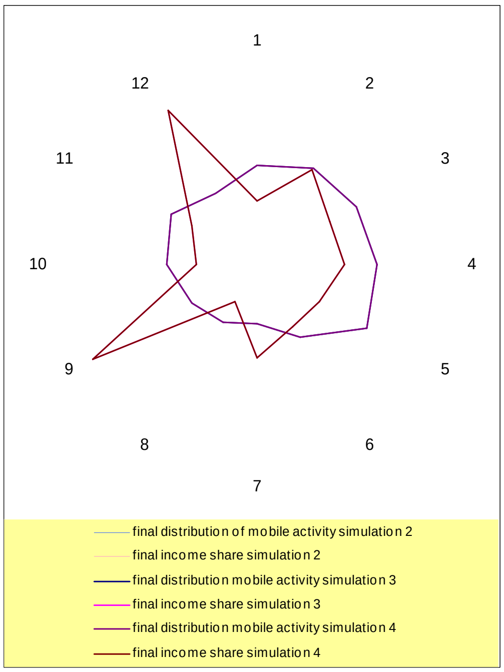


Figure 5.7 Comparison of simulation 2, 3, and 4

When comparing the results of simulation 2, 3 and 4 (see Figure 5.7 and Table 5.7), it can be seen that the sequence of development of the first three BRT corridors does not play an important role in determining the final distribution of mobile activity and the final income share in the Jakarta Metropolitan Area. Implying that it does not matter whether these three corridors are developed simultaneously or whether it develops in stages, starting with the 1st corridor and ending up with the 2nd and 3rd corridors or vice verse. From Figure 5.5 and 5.6, it also can be seen that the development of both 2nd and 3rd corridors gives more influence in determining the final distribution of mobile activity in the Jakarta Metropolitan Area rather than the development of the 1st corridor only.

From Figure 5.8 and Figure 5.9, it is clear that the development of the first three corridors connecting East to West Jakarta (Region 1 to 3) and North to South Jakarta (Region 2 to 4) creates better interaction between these regions and thus attract more mobile economic activity to North, West, and Centre Jakarta (Region 1, 4, and 5).

[37] This simulation runs using the final distribution of mobile activity in Table 5.5 as the initial distribution of mobile activity when the 2nd, 3rd, and 1st corridors are developed.
The differences in each region are calculated by subtracting the final distribution and final income share of this simulation (Simulation 4b) from the base simulation (Simulation 1).

This happens because the rise of income share attracts more mobile activity into these regions. On the other hand, the increase of the mobile activity in the north part of Jakarta reduces the mobile activity income share in its surrounding regions and accordingly reduces the mobile activity in most of the regions outside North, West, and Centre Jakarta.

Table 5.7 Comparison of the differences (point change) of the final distribution of mobile activity and final income share[38]

location	1	2	3	4	5	6	7	8	9	10	11	12
Simulation 2												
final distribution mobile activity	0.006	-0.001	-0.001	0.014	0.004	-0.005	-0.002	-0.004	-0.004	-0.005	0.000	-0.002
final income share	0.003	0.000	0.000	0.007	0.002	-0.003	-0.001	-0.002	-0.002	-0.003	0.000	-0.001
Simulation 3												
final distribution mobile activity	0.006	-0.001	-0.001	0.014	0.004	-0.005	-0.002	-0.004	-0.004	-0.005	0.000	-0.002
final income share	0.003	0.000	0.000	0.007	0.002	-0.003	-0.001	-0.002	-0.002	-0.003	0.000	-0.001
Simulation 4												
final distribution mobile activity	0.006	-0.001	-0.001	0.014	0.004	-0.005	-0.002	-0.004	-0.004	-0.005	0.000	-0.002
final income share	0.003	0.000	0.000	0.007	0.002	-0.003	-0.001	-0.002	-0.002	-0.003	0.000	-0.001

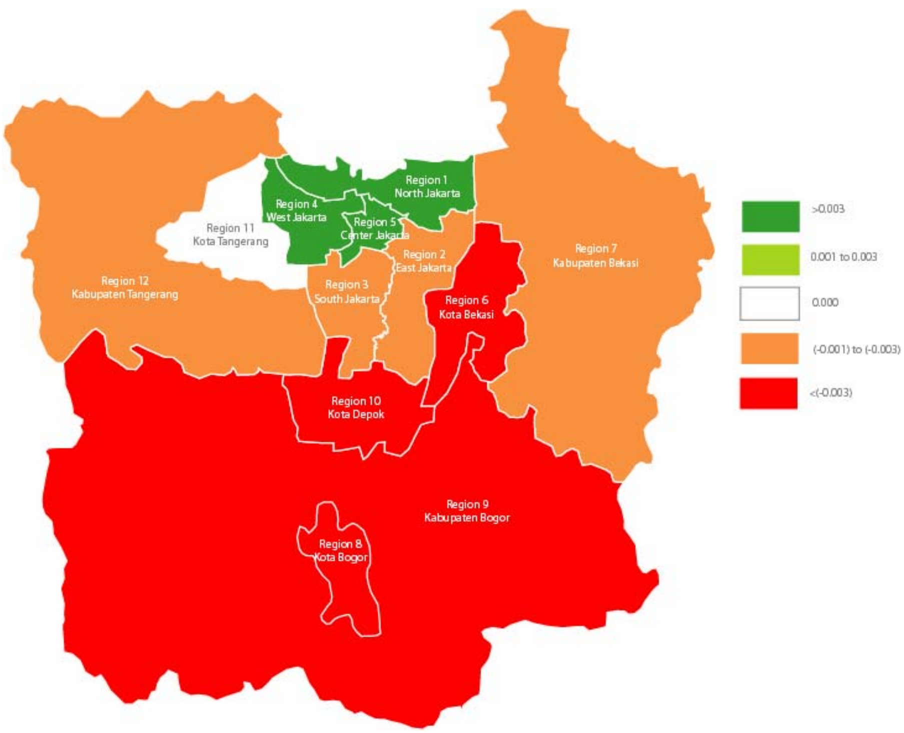


Figure 5.8 The differences (point change) of the final distribution of mobile activity before and after the development of the three corridors

[38] The differences in each region are calculated by subtracting the final distribution and final income share of each simulation from the base simulation (Simulation 1)

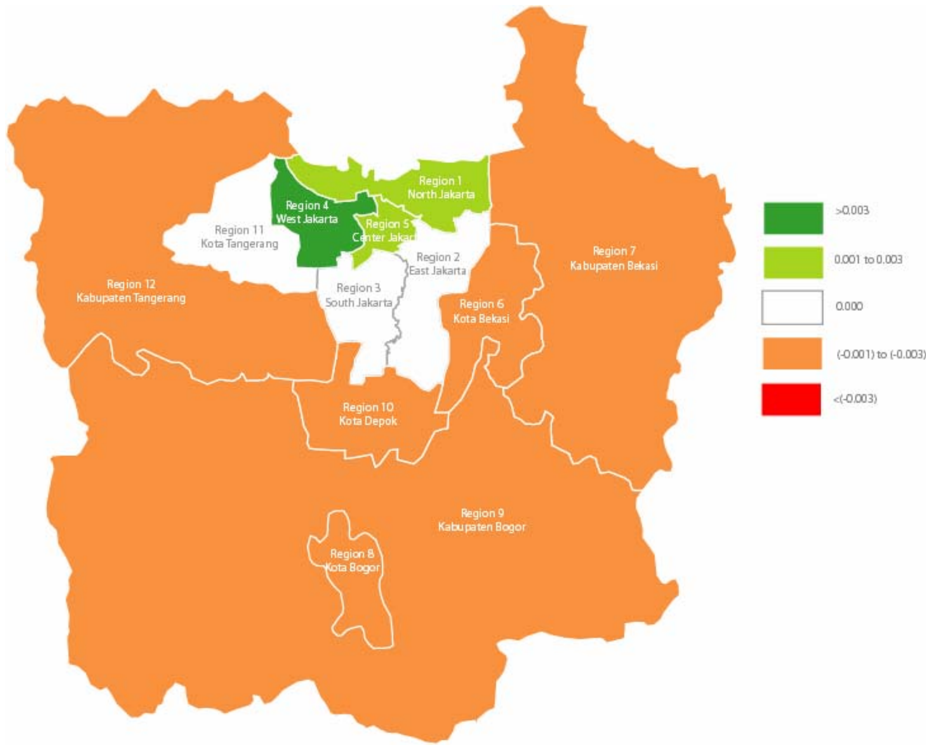


Figure 5.9 The differences (point change) of the final income share before and after the development of the three corridors

5.4 Long run equilibrium for the entire project

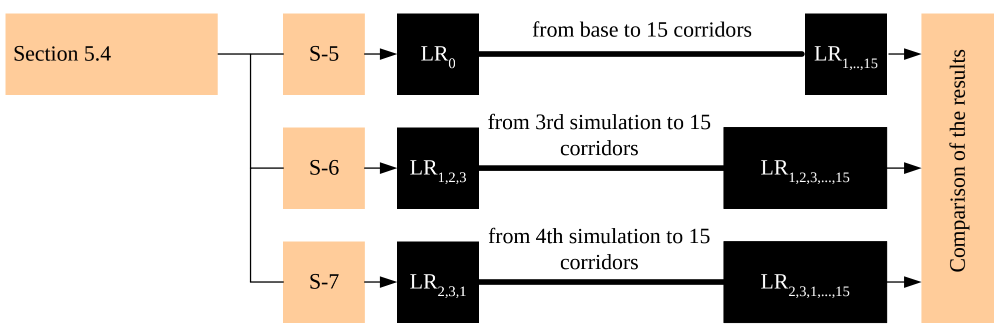


Figure 5.10 The simulation for fifteen corridors

Long run equilibrium for the fifteen corridors can be reached through three different approaches, as it can be seen in Figure 5.8. The result of these simulations will be compared in order to see the relation of the project development sequences to the final distribution of mobile activity and the final income share in each region and to see whether the result shows the similar indication to the previous simulations.

5.4.1 Fifth simulation: from the base to the fifteen corridors

The fifth simulation is done by using the final distribution of mobile activity in simulation 1 as the input for the initial distribution of mobile activity.

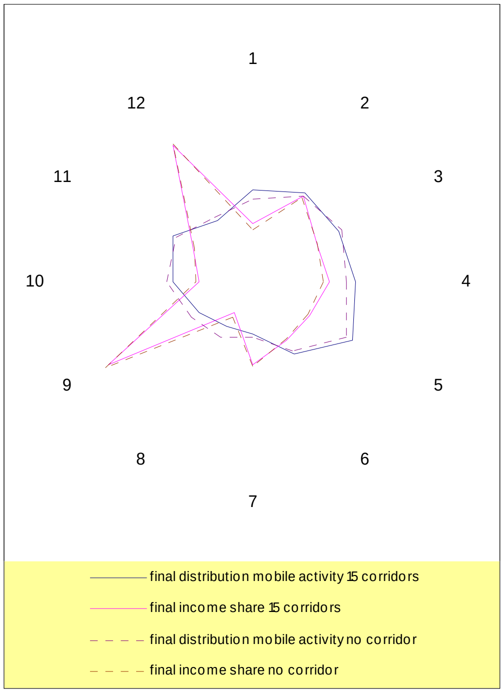


Figure 5.11 Final distribution of mobile activity and income share (simulation 5)

When comparing the result of the fifth simulation with the first simulation (see Figure 5.11 and Table 5.8), it can be seen that the development of the entire project increases the final distribution of mobile activity in most of the regions inside Jakarta, except mobile activity in Region 3 that is slightly decreased by 0.3% point change. On the other hand, the development of this project decreases the final distribution of mobile activity in most of the regions outside Jakarta, except mobile activity in Region 6 that is increased by 0.3% point change.

Regions with high final income share also have high final mobile activity. This happens because mobile workers tend to move to regions with higher income level and thus increase mobile activity in these regions until it is stable in the long run equilibrium.

Table 5.8 Distribution of mobile activity and income share when the entire project is completed (from the first simulation)[39]

location	1	2	3	4	5	6	7	8	9	10	11	12
final distribution mobile activity	0.0918	0.1015	0.0995	0.1029	0.1137	0.0824	0.0527	0.0526	0.0617	0.0801	0.0912	0.0698
final income share	0.0578	0.0990	0.0739	0.0760	0.0653	0.0673	0.0824	0.0349	0.1646	0.0538	0.0685	0.1565
Differences (point change)												
final distribution mobile activity	0.009	0.002	-0.003	0.010	0.005	0.003	-0.002	-0.010	-0.009	-0.005	0.003	-0.004
final income share	0.002	0.002	-0.001	-0.002	0.001	0.004	0.000	-0.003	-0.003	0.000	0.002	-0.001

[39] This simulation run using the final distribution of mobile activity in the base simulation (see Table 5.1)
The differences in each region are calculated by subtracting the final distribution and final income share of this simulation (Simulation 5) from the base simulation (Simulation 1)

5.4.2 Sixth simulation: from the third simulation to the fifteen corridors

The sixth simulation is done by using the final distribution of mobile activity in the third simulation as the input for the initial distribution of mobile activity.

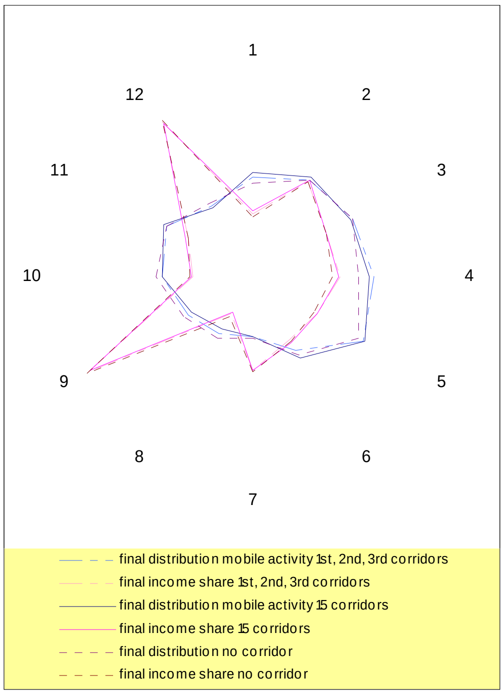


Figure 5.12 Final distribution of mobile activity and income share (simulation 6)

From Figure 5.12 and Table 5.9, it can generally be seen that the completion of the project through the existing 1st, 2nd and 3rd corridors, increases the final distribution of mobile activity in most of the regions in Jakarta, except mobile activity in Region 3 that is slightly decreased by 0.3% point change. On the other hand, it decreases the final distribution of mobile activity in most of the regions outside Jakarta, except mobile activity in Region 6 and 11 that is increased by 0.3% point change.

From the same figure and table, it is clear that the increase of the final distribution of mobile activity in most of the regions in Jakarta and its hinterland area happens because of the increase of the income share in these regions. Higher income share in some regions attracts more mobile activity to move to these regions until it is stable in the long run equilibrium.

Table 5.9 Distribution of mobile activity and income share activity when the entire project is completed (from the second simulation)[40]

location	1	2	3	4	5	6	7	8	9	10	11	12
final distribution mobile activity	0.0918	0.1015	0.0995	0.1029	0.1137	0.0824	0.0527	0.0526	0.0617	0.0801	0.0912	0.0698
final income share	0.0578	0.0990	0.0739	0.0760	0.0653	0.0673	0.0824	0.0349	0.1646	0.0538	0.0685	0.1565
Differences (point change)												
final distribution mobile activity	0.009	0.002	-0.003	0.010	0.005	0.003	-0.002	-0.010	-0.009	-0.005	0.003	-0.004
final income share	0.002	0.002	-0.001	-0.002	0.001	0.004	0.000	-0.003	-0.003	0.000	0.002	-0.001

40 This simulation run using the final distribution of mobile activity in Simulation 3 (Table 5.4) as the initial distribution of mobile activity when the entire project is completed
The differences in each region are calculated by subtracting the final distribution and final income share of this simulation (Simulation 6) from the base simulation (Simulation 1)

5.4.3 Seventh simulation: from the fourth simulation to the fifteen corridors

The seventh simulation is done by using the final distribution of mobile activity in the fourth simulation as the input for the initial distribution of mobile activity.

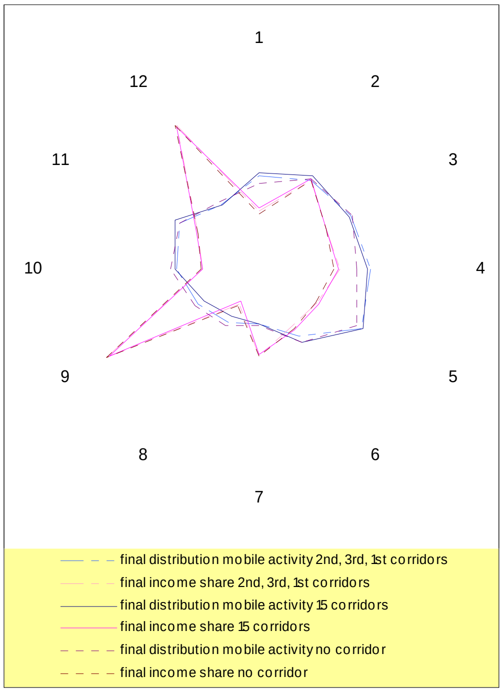


Figure 5.13 Final distribution of mobile activity and income share (simulation 7)

From Figure 5.13 and Table 5.10, it can generally be seen that the completion of the project through the existing 2nd, 3rd, and 1st corridors, gives the same impact as the development through 1st, 2nd, and 3rd corridors. It increases the final distribution of mobile activity in most of the regions in Jakarta, except mobile activity in Region 3 that is slightly decreased by 0.3% point change. On the other hand, it decreases the final distribution of mobile activity in most of the regions outside Jakarta, except mobile activity in Region 6 and 11 that is increased by 0.3% point change.

Table 5.10 Distribution of mobile activity and income share activity when the entire project is completed (from the third simulation)[41]

location	1	2	3	4	5	6	7	8	9	10	11	12
final distribution mobile activity	0.0918	0.1015	0.0995	0.1029	0.1137	0.0824	0.0527	0.0526	0.0617	0.0801	0.0912	0.0698
final income share	0.0578	0.0990	0.0739	0.0760	0.0653	0.0673	0.0824	0.0349	0.1646	0.0538	0.0685	0.1565
Differences (point change)												
final distribution mobile activity	0.009	0.002	-0.003	0.010	0.005	0.003	-0.002	-0.010	-0.009	-0.005	0.003	-0.004
final income share	0.002	0.002	-0.001	-0.002	0.001	0.004	0.000	-0.003	-0.003	0.000	0.002	-0.001

41 This simulation run using the final distribution of mobile activity in Simulation 4 (Table 5.6) as the initial distribution of mobile activity when the entire project is completed
The differences in each region are calculated by subtracting the final distribution and final income share of this simulation (Simulation 4b) from the base simulation (Simulation 1)

5.4.4 Comparing the result of fifth, sixth, and seventh simulation

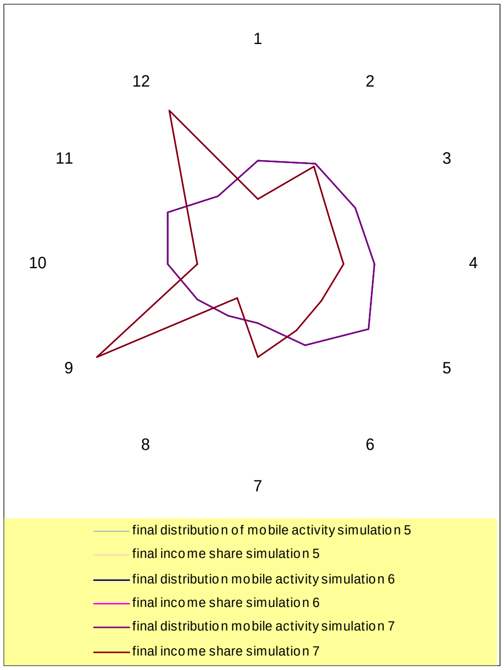


Figure 5.14 Comparison of simulation 5, 6, and 7

When comparing the results of simulation 5, 6 and 7 (see Figure 5.14 and Table 5.11), it can be seen that the sequence of development of the entire BRT project does not play an important role in determining the final distribution of mobile activity and the final income share in the Jakarta Metropolitan Area. Implying that it does not matter whether the entire corridors are developed simultaneously or whether they are developed in stages, starting with the 1st, 2nd and 3rd corridors or 2nd, 3rd, and 1st corridors and ending up with the entire corridors.

Table 5.11 Comparison of the differences (point change) of the final distribution of mobile activity and final income share in simulation 5, 6, and 7

location	1	2	3	4	5	6	7	8	9	10	11	12
Simulation 5												
final distribution mobile activity	0.009	0.002	-0.003	0.010	0.005	0.003	-0.002	-0.010	-0.009	-0.005	0.003	-0.004
final income share	0.002	0.002	-0.001	-0.002	0.001	0.004	0.000	-0.003	-0.003	0.000	0.002	-0.001
Simulation 6												
final distribution mobile activity	0.009	0.002	-0.003	0.010	0.005	0.003	-0.002	-0.010	-0.009	-0.005	0.003	-0.004
final income share	0.002	0.002	-0.001	-0.002	0.001	0.004	0.000	-0.003	-0.003	0.000	0.002	-0.001
Simulation 7												
final distribution mobile activity	0.009	0.002	-0.003	0.010	0.005	0.003	-0.002	-0.010	-0.009	-0.005	0.003	-0.004
final income share	0.002	0.002	-0.001	-0.002	0.001	0.004	0.000	-0.003	-0.003	0.000	0.002	-0.001

From Figure 5.15 and Figure 5.16, it is clear that the development of the entire BRT project connecting all regions in Jakarta creates better interaction between these regions and thus attracts more mobile economic activity to Jakarta city and some cities that are located in the fringe of Jakarta (Tangerang and Bekasi city). This happens because the rise of income share attracts more mobile activity into these regions. On the other hand, the increase of the mobile activity in Jakarta and its surrounding cities reduces the income share in some regions that are located in the outskirt of the study area, and therefore reduces the mobile activity in these regions.

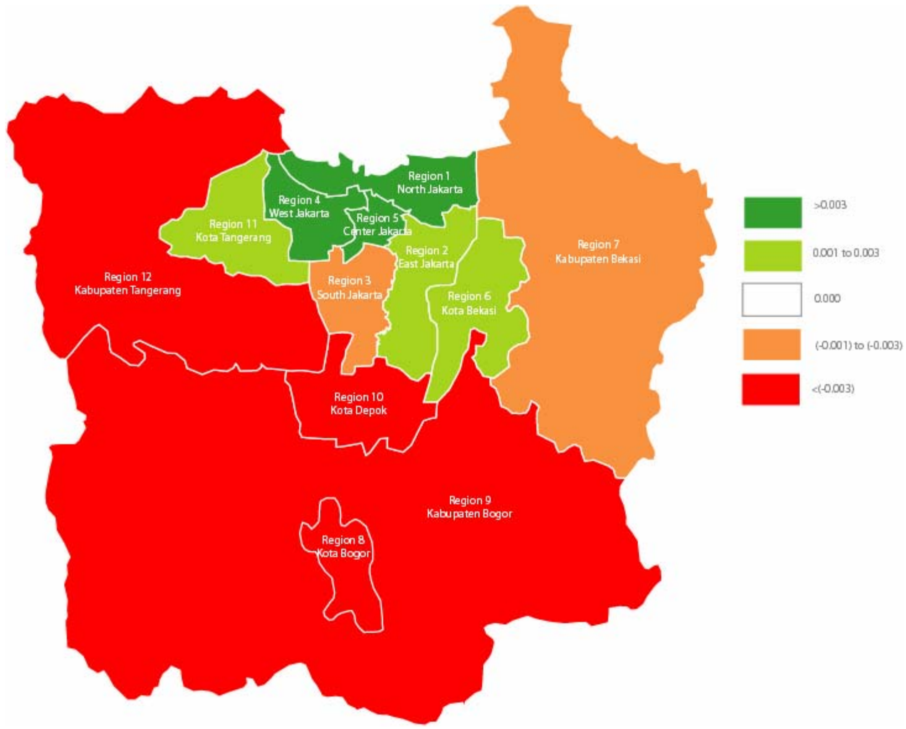


Figure 5.15 The differences (point change) of the final distribution of mobile activity before and after the development of the entire project

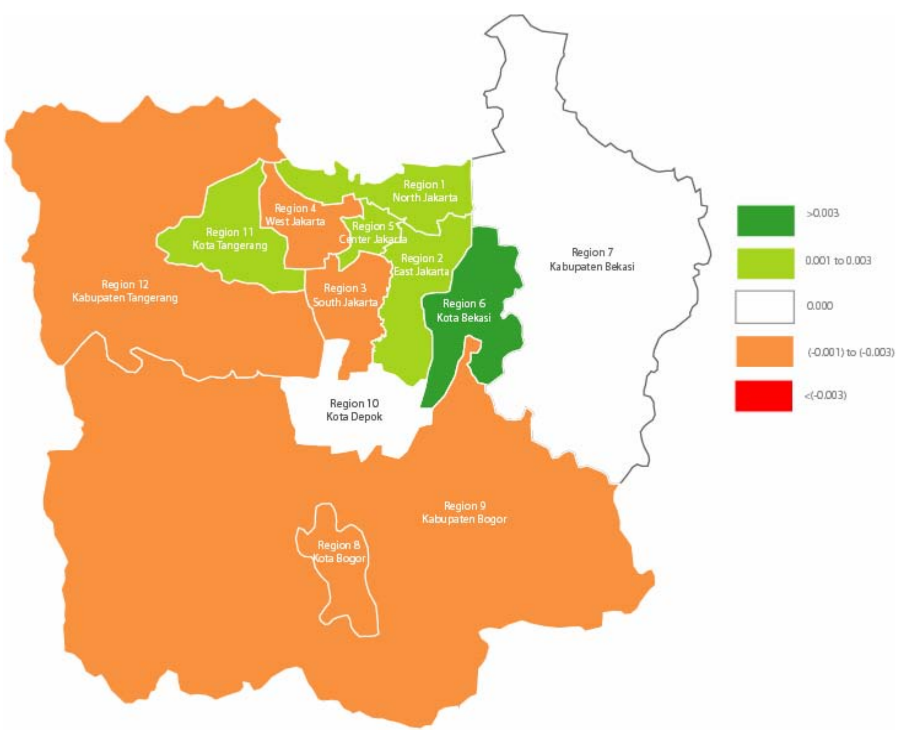


Figure 5.16 The differences (point change) of the final income share before and after the development of the entire project

5.5 Changing the value of congestion parameter (τ)

The aim of this section is to see the importance of congestion parameter in determining the final distribution of mobile activity and the final income share in the Jakarta Metropolitan Area. It is done by increasing and decreasing the value of this parameter. Considering the fact that hysteresis does not play an important role in this project, only the first, second and fifth simulations will be observed.

5.5.1 Decreasing the value of congestion parameter to 0.2

Keeping the other parameters constant, as in the initial simulations (δ=0.6, ε=5, T=1.2), the difference of the final distribution of mobile activity together with the final income share before and after decreasing tau and the comparison of the results can be seen in the following figure.

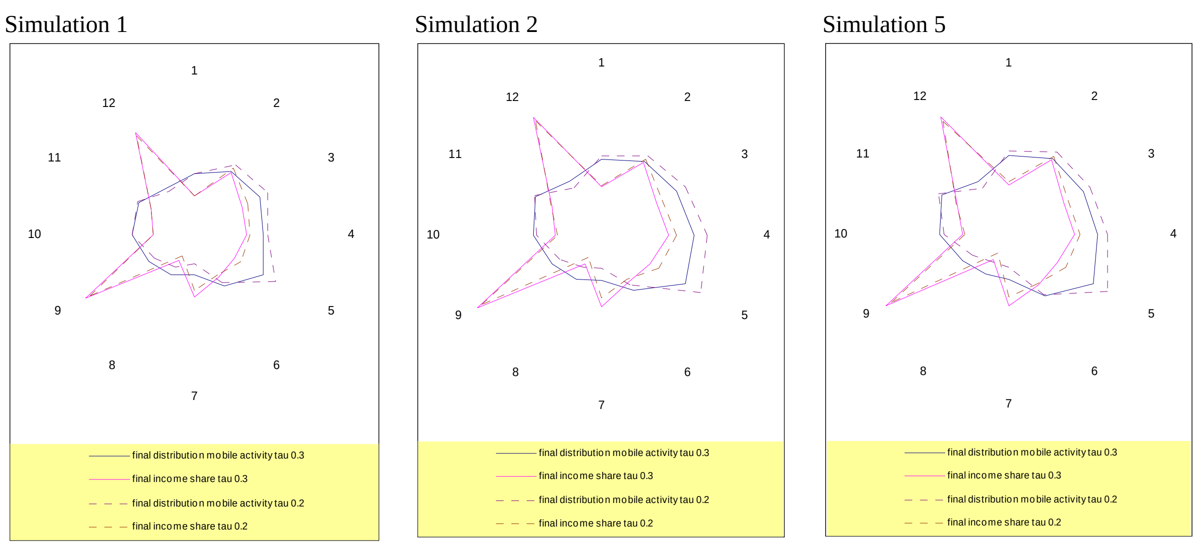


Figure 5.17 Decreasing the value of congestion parameter

From Figure 5.17 and Table 5.12, it can be observed the long run equilibrium when congestion is equal to 0.2. The results of the first, second and fifth simulations show that the reduction in congestion parameter value increases the final income share in Jakarta (Region 1 to 5) and thus brings mobile activity back to this area. Besides, it also increases the final mobile activity in Region 11 that is located in the fringe of Jakarta region. This simulation shows that the development of BRT project improves the interaction within regions in Jakarta and Tangerang city and accordingly increases the attractiveness of these cities. It can be concluded from this simulation that the decrease in congestion cost to 0.2 causes the agglomeration of economic activities in Jakarta.

Table 5.12 The differences (point change) of the final distribution mobile activity and income share after decreasing tau

location	1	2	3	4	5	6	7	8	9	10	11	12
Simulation 1												
final distribution mobile activity	0.0001	0.0099	0.0125	0.0061	0.0176	-0.0039	-0.0147	-0.0128	-0.0090	-0.0004	0.0014	-0.0069
final income share	0.0002	0.0058	0.0073	0.0036	0.0100	-0.0020	-0.0090	-0.0075	-0.0053	0.0000	0.0010	-0.0041
Simulation 2												
final distribution mobile activity	0.0035	0.0078	0.0115	0.0157	0.0200	-0.0076	-0.0151	-0.0147	-0.0108	-0.0043	0.0019	-0.0078
final income share	0.0021	0.0048	0.0068	0.0091	0.0115	-0.0042	-0.0092	-0.0088	-0.0064	-0.0022	0.0012	-0.0047
Simulation 5												
final distribution mobile activity	0.0047	0.0100	0.0090	0.0116	0.0194	-0.0023	-0.0147	-0.0157	-0.0125	-0.0042	0.0033	-0.0087
final income share	0.0029	0.0061	0.0055	0.0069	0.0113	-0.0011	-0.0091	-0.0096	-0.0077	-0.0021	0.0022	-0.0052

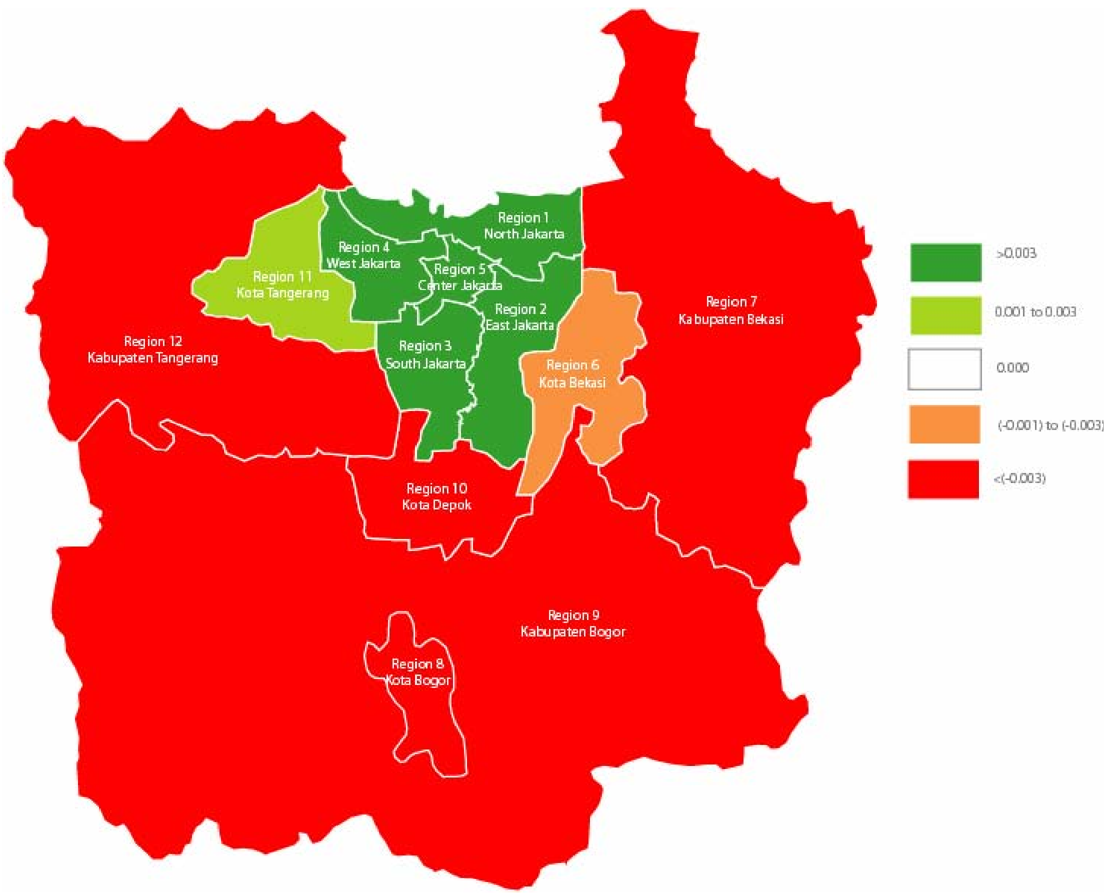


Figure 5.18 The differences (point change) after decreasing the value of congestion cost in simulation 5

5.5.2 Increasing the value of congestion parameter to 0.4

Keeping the other parameters constant, as in the initial simulations (δ=0.6, ε=5, T=1.2), the difference of the final distribution of mobile activity together with the final income share before and after increasing tau and the comparison of the results can be seen in the following figure.

Simulation 1 Simulation 2 Simulation 5

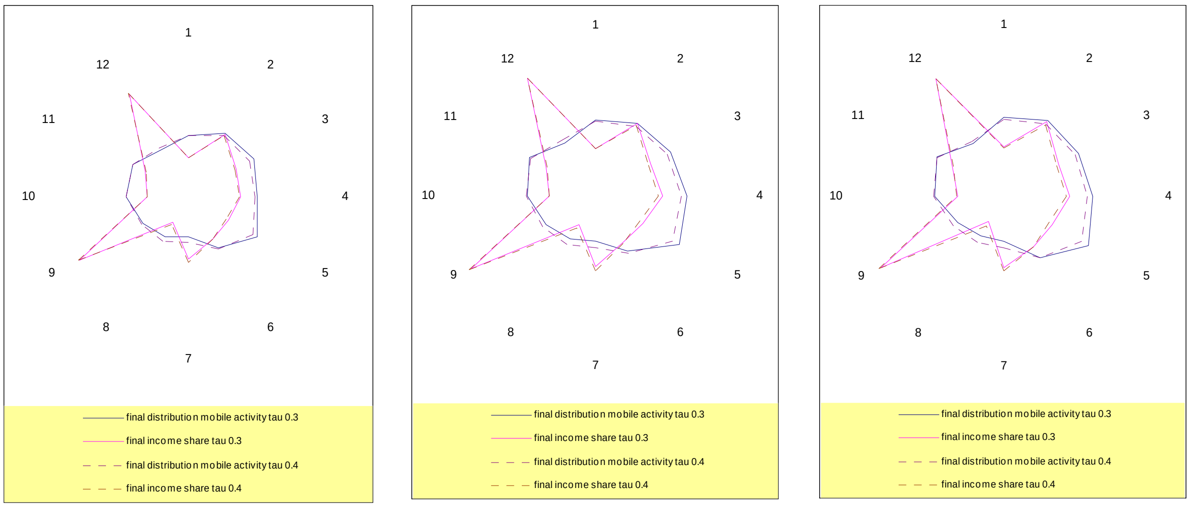


Figure 5.19 Increasing the value of congestion parameter

From Figure 5.18 and Table 5.13, it can be observed the long run equilibrium when congestion is equal to 0.4. The results of the first, second and fifth simulations show that increasing the congestion cost has the inverse result than decreasing it. Changing congestion cost to 0.4 decreases the final income share in Jakarta and Tangerang city and accordingly brings mobile activity away from this area.

Table 5.13 The differences (point change) of final distribution mobile activity and income share after increasing tau

location	1	2	3	4	5	6	7	8	9	10	11	12
Simulation 1												
final distribution mobile activity	0.0001	-0.0045	-0.0054	-0.0028	-0.0074	0.0013	0.0075	0.0058	0.0038	-0.0002	-0.0010	0.0028
final income share	0.0000	-0.0026	-0.0031	-0.0016	-0.0042	0.0007	0.0045	0.0034	0.0022	-0.0002	-0.0007	0.0017
Simulation 2												
final distribution mobile activity	-0.0015	-0.0039	-0.0051	-0.0068	-0.0086	0.0029	0.0078	0.0069	0.0048	0.0014	-0.0012	0.0033
final income share	-0.0009	-0.0024	-0.0030	-0.0039	-0.0049	0.0016	0.0047	0.0041	0.0028	0.0007	-0.0007	0.0020
Simulation 5												
final distribution mobile activity	-0.0023	-0.0049	-0.0044	-0.0054	-0.0087	0.0006	0.0078	0.0081	0.0060	0.0013	-0.0019	0.0039
final income share	-0.0014	-0.0029	-0.0026	-0.0032	-0.0050	0.0002	0.0047	0.0048	0.0036	0.0006	-0.0012	0.0023

5.6 Changing the value of transportation cost parameter (*T*)

The aim of this section is to see the importance of transportation cost in determining the final distribution of mobile activity and the final income share in the Jakarta Metropolitan Area by increasing and decreasing the value of this parameter. Considering the fact that hysteresis does not play an important role in this project, only the first, second and fifth simulations will be observed.

5.6.1 Decreasing the value of transportation cost parameter to 1.1

Keeping the other parameters constant, as in the initial simulations (δ=0.6, ε=5, τ=0.3), the difference of the final distribution of mobile activity together with the final income share before and after decreasing transportation cost and the comparison of the results can be seen in the following table and figure.

Table 5.14 The differences (point change) of final distribution mobile activity and income share after decreasing transport cost

location	1	2	3	4	5	6	7	8	9	10	11	12
Simulation 1												
final distribution mobile activity	0.0031	-0.0040	-0.0041	-0.0022	-0.0081	0.0042	0.0073	0.0082	-0.0048	0.0029	-0.0009	-0.0017
final income share	0.0023	-0.0015	-0.0015	-0.0007	-0.0033	0.0025	0.0037	0.0042	-0.0052	0.0018	-0.0004	-0.0019
Simulation 2												
final distribution mobile activity	0.0006	-0.0031	-0.0044	-0.0082	-0.0102	0.0062	0.0084	0.0096	-0.0030	0.0049	-0.0009	0.0001
final income share	0.0009	-0.0012	-0.0017	-0.0037	-0.0045	0.0035	0.0043	0.0049	-0.0042	0.0028	-0.0003	-0.0007
Simulation 5												
final distribution mobile activity	-0.0014	-0.0057	-0.0045	-0.0068	-0.0119	0.0031	0.0102	0.0112	0.0000	0.0045	-0.0017	0.0029
final income share	-0.0003	-0.0026	-0.0019	-0.0031	-0.0056	0.0018	0.0054	0.0059	-0.0023	0.0026	-0.0008	0.0009

From Table 5.14 and Figure 5.19, the difference of the first, second and fifth simulations when transport cost is equal to 1.1 can be observed. In the first simulation, decreasing transport cost decreases the final distribution of mobile activity and the final income share in most of the regions in Jakarta (except in Region 1) and some regions outside it (Region 9, 11, and 12). In the second simulation, the reduction of transport cost decreases the final distribution of mobile activity together with the final income share in most of the regions in Jakarta (except in Region 1) and some regions outside it (Region 9, and 11). In addition, the fifth simulation shows that the decline in transport cost reduces the final distribution of mobile activity along with the final income share in all regions in Jakarta and one region outside it (Region 11). From these simulations, it can be concluded that the decline in transport cost to 1.1, reduces the importance of the BRT project, and thus decreases the mobile economic activity in Jakarta.

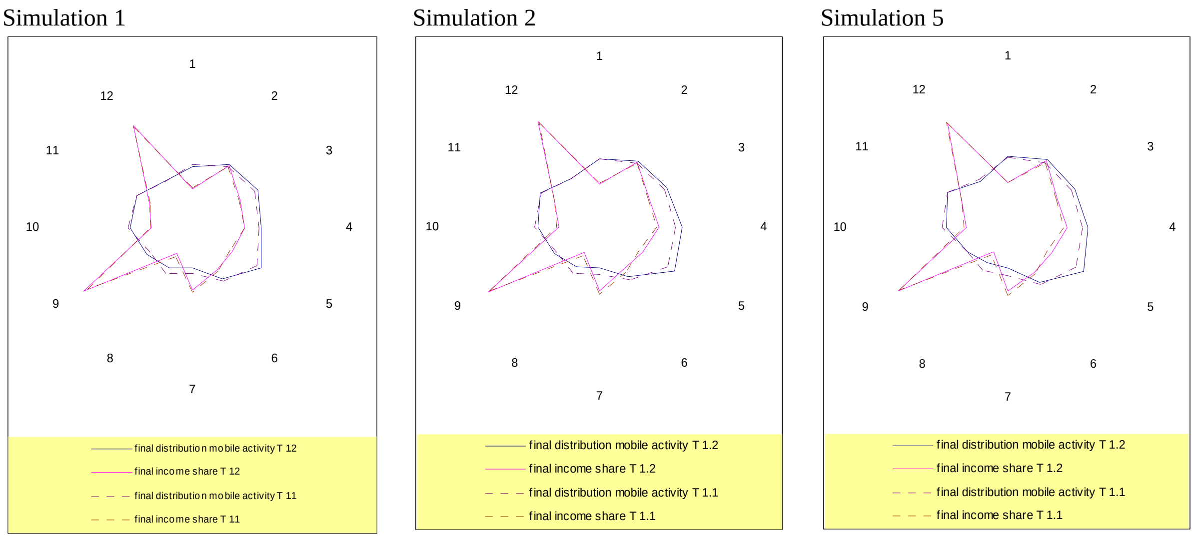


Figure 5.20 Decreasing the value of transport cost parameter

5.6.2 Increasing the value of transportation cost parameter to 1.3

Keeping the other parameters constant, as in the initial simulations (δ=0.6, ε=5, τ=0.3), the difference of final distribution mobile activity together with income share before and after increasing transportation cost and the comparison of the results can be seen in the following Table 5.15 and Figure 5.20.

Table 5.15 The differences (point change) of final distribution mobile activity and income share after increasing transport cost

location	1	2	3	4	5	6	7	8	9	10	11	12
					Simulation 1							
final distribution mobile activity	-0.0059	-0.0015	-0.0030	-0.0019	0.0003	-0.0054	0.0015	-0.0032	0.0168	-0.0057	-0.0004	0.0083
final income share	-0.0041	-0.0017	-0.0025	-0.0018	-0.0011	-0.0034	0.0014	-0.0016	0.0133	-0.0036	-0.0005	0.0057
					Simulation 2							
final distribution mobile activity	-0.0043	-0.0022	-0.0016	0.0021	0.0025	-0.0061	0.0000	-0.0036	0.0151	-0.0063	-0.0011	0.0056
final income share	-0.0032	-0.0019	-0.0018	0.0001	0.0001	-0.0037	0.0005	-0.0017	0.0125	-0.0038	-0.0010	0.0039
					Simulation 5							
final distribution mobile activity	-0.0023	0.0008	-0.0004	0.0020	0.0058	-0.0050	-0.0028	-0.0046	0.0116	-0.0062	-0.0012	0.0023
final income share	-0.0019	-0.0003	-0.0010	0.0003	0.0020	-0.0031	-0.0012	-0.0023	0.0102	-0.0037	-0.0010	0.0020

From the Table 5.15 and Figure 5.20, it can be observed the difference of the first, second and fifth simulations when transport cost is equal to 1.3. In the first simulation, increasing transport cost decreases the final distribution of mobile activity in most of the regions in Jakarta (except in Region 5) and some regions outside it (Region 7, 9, and 12). In the second simulation, the rise of transport cost decreases the final distribution of mobile activity in most of the region in Jakarta (except in Region 4 and 5) and some regions outside it (Region 7, 9, and 12). In addition, the fifth simulation shows that the growth of transport cost reduces the final distribution of mobile activity in some regions in Jakarta (except in Region 2, 4, and 5) and most of the regions outside it except (Region 9 and 12). From these simulations, it can be concluded that the rise of transport cost to 1.3, reduces the interaction between some regions and thus decreases the mobile economic activity in these regions.

Simulation 1 Simulation 2 Simulation 5

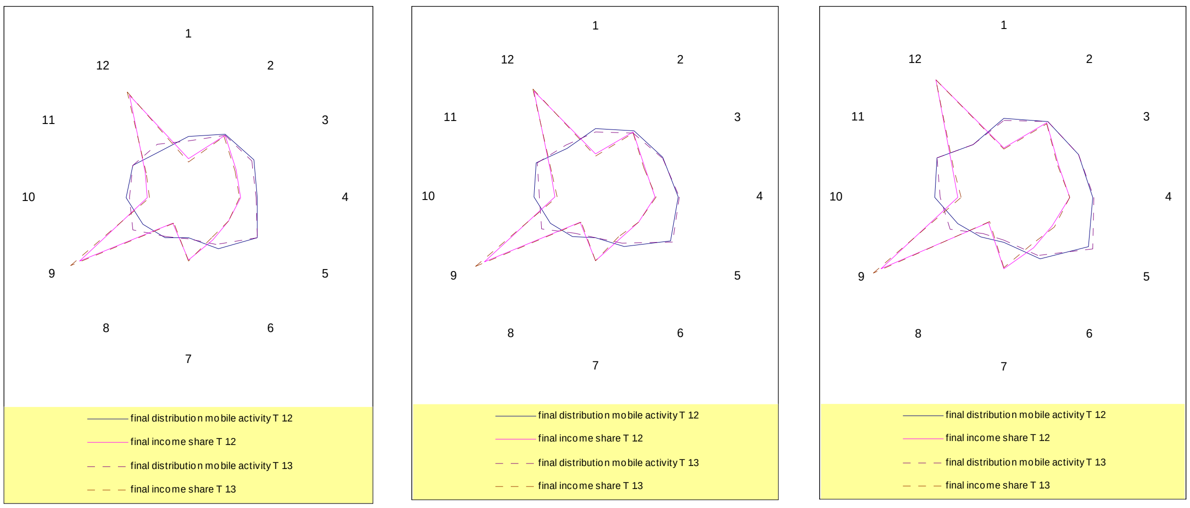


Figure 5.21 Increasing the value of elasticity of substitution

5.7 Changing the value of share of income spent in manufacture (δ)

The aim of this section is to see the importance of income spent in manufacture parameter in determining the final distribution of mobile activity and the final income share in the Jakarta Metropolitan Area by increasing and decreasing the value of this parameter. Considering the fact that hysteresis does not play an important role in this project, only the first, second and fifth simulations will be observed.

5.7.1 Decreasing the value of share of income spent in manufacture parameter to 0.5

Keeping the other parameters constant, as in the initial simulations (T=1.2, ε=5, τ=0.3), the difference of the final distribution of mobile activity together with the final income share before and after decreasing the value of income spent in manufacture and the comparison of the results can be seen in the following tables and figure.

Simulation 1 Simulation 2 Simulation 5

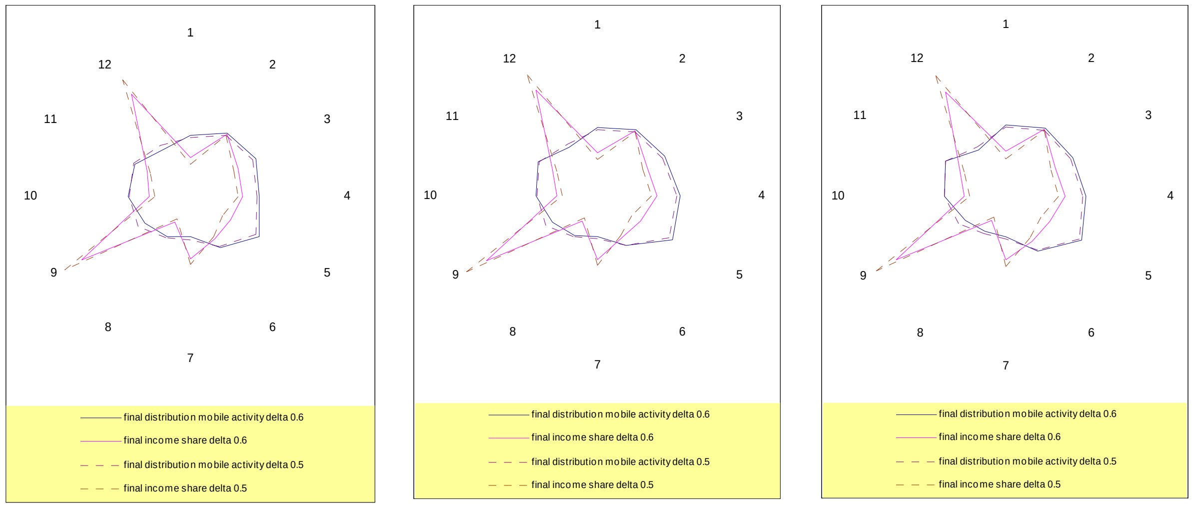


Figure 5.22 Decreasing the value of share of income spent on manufacture

From Figure 5.21 and Table 5.16, it can be observed that decreasing the value of share of income spent on manufacture to 0.5 (from 0.6) decreases the final income share in all regions in Jakarta and thus brings mobile activity away from this area. Besides, it also decreases the final distribution of mobile activity in the regions that are located in the fringe of Jakarta (Region 6, 10, and 11). From these simulations, it can be concluded that the decline of the share of income spent on manufacture to 0.5 decreases the importance of mobile activity and thus reduces agglomeration in Jakarta and the attractiveness of the BRT project.

Table 5.16 The differences (point change) of final distribution mobile activity and income share after decreasing delta

location	1	2	3	4	5	6	7	8	9	10	11	12
Simulation 1												
final distribution mobile activity	-0.0033	-0.0036	-0.0040	-0.0026	-0.0057	-0.0010	0.0037	0.0025	0.0100	-0.0017	0.0001	0.0056
final income share	-0.0087	-0.0011	-0.0075	-0.0062	-0.0126	-0.0040	0.0079	-0.0054	0.0276	-0.0078	-0.0051	0.0229
Simulation 2												
final distribution mobile activity	-0.0031	-0.0030	-0.0042	-0.0041	-0.0054	-0.0004	0.0035	0.0029	0.0101	-0.0010	-0.0004	0.0052
final income share	-0.0091	-0.0008	-0.0076	-0.0079	-0.0128	-0.0033	0.0079	-0.0048	0.0280	-0.0071	-0.0053	0.0229
Simulation 5												
final distribution mobile activity	-0.0029	-0.0031	-0.0034	-0.0033	-0.0049	-0.0011	0.0031	0.0030	0.0096	-0.0008	-0.0008	0.0046
final income share	-0.0093	-0.0011	-0.0071	-0.0073	-0.0128	-0.0043	0.0077	-0.0042	0.0283	-0.0071	-0.0058	0.0229

5.7.2 Increasing the value of income spent in manufacture parameter to 0.7

Keeping the other parameters constant, as in the initial simulations (T=1.2, ε=5, τ=0.3), the difference of the final distribution of mobile activity and the final income share before and after increasing the value of income spent in manufacture and the comparison of the results can be seen in the following figure.

Simulation 1 Simulation 2 Simulation 5

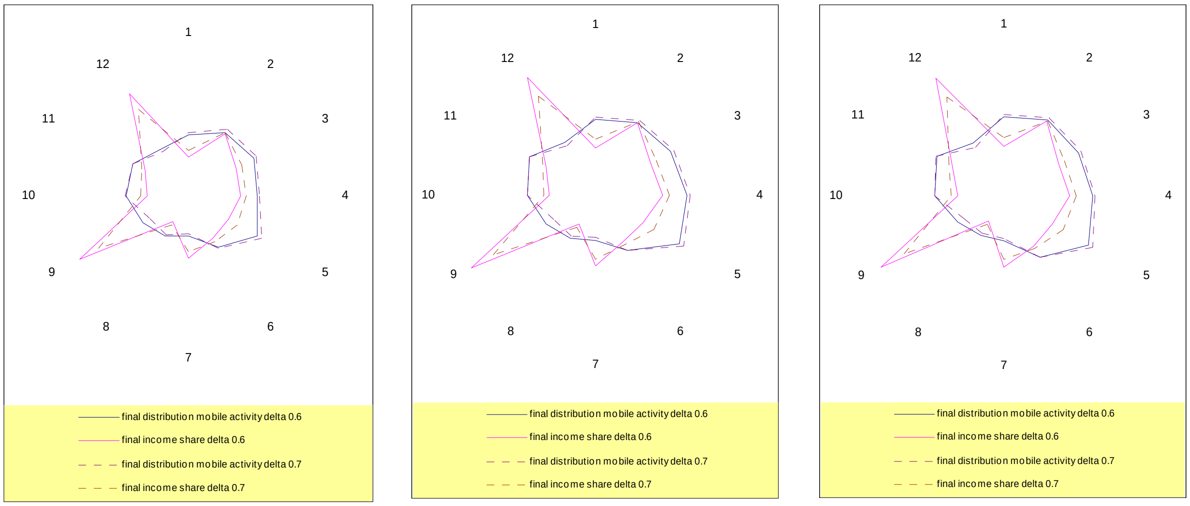


Figure 5.23 Increasing the value of share of income spent on manufacture

Table 5.17 The differences (point change) of final distribution mobile activity and income share after increasing delta

location	1	2	3	4	5	6	7	8	9	10	11	12
						Simulation 1						
final distribution mobile activity	0.0034	0.0037	0.0041	0.0027	0.0060	0.0009	-0.0038	-0.0028	-0.0099	0.0015	-0.0002	-0.0057
final income share	0.0094	0.0019	0.0083	0.0067	0.0138	0.0042	-0.0086	0.0048	-0.0297	0.0081	0.0051	-0.0240
						Simulation 2						
final distribution mobile activity	0.0032	0.0030	0.0044	0.0043	0.0056	0.0003	-0.0035	-0.0033	-0.0099	0.0008	0.0003	-0.0051
final income share	0.0098	0.0014	0.0084	0.0087	0.0139	0.0034	-0.0085	0.0041	-0.0300	0.0072	0.0054	-0.0239
						Simulation 5						
final distribution mobile activity	0.0030	0.0031	0.0034	0.0034	0.0051	0.0010	-0.0031	-0.0033	-0.0094	0.0006	0.0008	-0.0046
final income share	0.0099	0.0017	0.0078	0.0079	0.0137	0.0045	-0.0083	0.0036	-0.0302	0.0072	0.0059	-0.0237

From Figure 5.22 and Table 5.17, it can be observed the long run equilibrium when the income spent on manufacture is equal to 0.7. The results of the first, second and fifth simulations show that increasing the share of income spent on manufacture has the inverse result than decreasing it. Increasing the value of this parameter to 0.7

increases the attractiveness of the BRT project and thus brings mobile activity into Jakarta and cities around it (Bekasi, Depok and Tangerang cities).

5.8 Changing the value of elasticity of substitution (ε)

The aim of this section is to see the importance of elasticity of substitution parameter in determining the final distribution of mobile activity and the final income share in the Jakarta Metropolitan Area by increasing and decreasing the value of this parameter. Considering the fact that hysteresis does not play an important role in this project, only the first, second and fifth simulations will be observed.

5.8.1 Decreasing the value of elasticity of substitution parameter to 4

Keeping the other parameters constant, as in the initial simulations (*T*=1.2, δ=0.6, τ=0.3), the difference of the final distribution of mobile activity together with the final income share before and after decreasing the value of elasticity of substitution to 4 and the comparison of the results can be seen in the following figure.

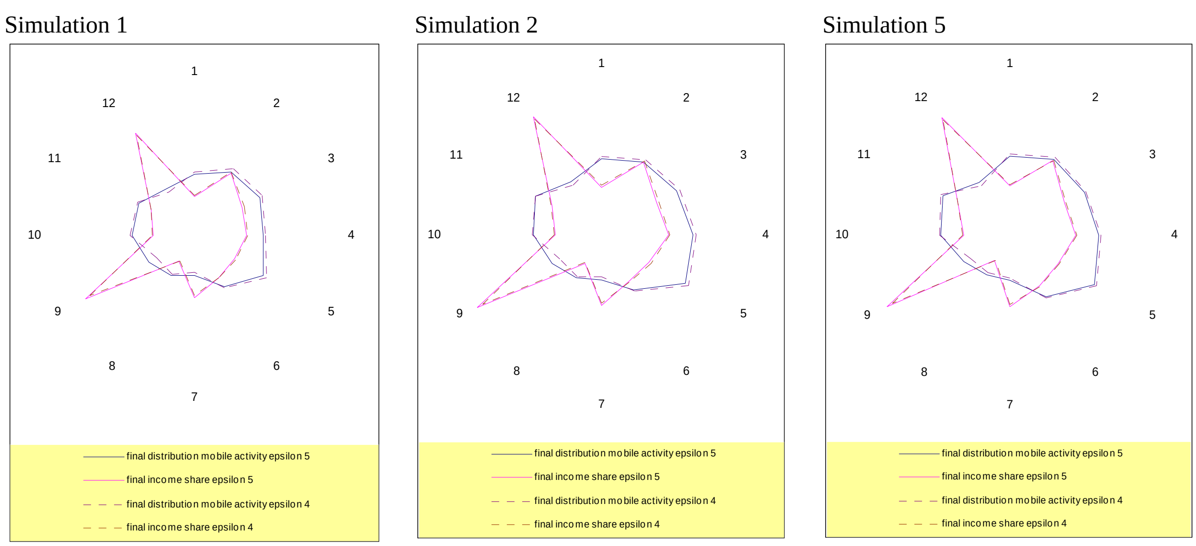


Figure 5.24 Increasing the value of elasticity of substitution parameter

From Tables 5.18 and Figure 5.23, it can be observed that decreasing the value of elasticity of substitution to 4 increases the final income share in all regions in Jakarta and the cities that are located in the fringe of it (Region 6, 10, and 11). This happens because the decrease in elasticity of substitution increases the impact of building the BRT project, encourages more agglomeration of the economic activity, and enlarge mobile activity in Jakarta (the area where the project is occurring) and its surrounding cities (Bekasi, Tangerang, and Depok city).

Table 5.18 The differences (point change) of final distribution mobile activity and income share after decreasing epsilon

location	1	2	3	4	5	6	7	8	9	10	11	12
Simulation 1												
final distribution mobile activity	0.0030	0.0037	0.0051	0.0026	0.0048	0.0017	-0.0051	-0.0021	-0.0112	0.0029	0.0007	-0.0062
final income share	0.0018	0.0021	0.0028	0.0016	0.0027	0.0011	-0.0028	-0.0010	-0.0070	0.0017	0.0005	-0.0035
Simulation 2												
final distribution mobile activity	0.0031	0.0036	0.0042	0.0034	0.0045	0.0010	-0.0045	-0.0025	-0.0109	0.0021	0.0010	-0.0051
final income share	0.0019	0.0020	0.0024	0.0019	0.0025	0.0008	-0.0025	-0.0013	-0.0069	0.0013	0.0007	-0.0029
Simulation 5												
final distribution mobile activity	0.0025	0.0027	0.0029	0.0025	0.0030	0.0018	-0.0029	-0.0026	-0.0097	0.0019	0.0015	-0.0036
final income share	0.0015	0.0015	0.0017	0.0014	0.0017	0.0012	-0.0016	-0.0013	-0.0062	0.0012	0.0009	-0.0020

5.8.2 Increasing the value of elasticity of substitution parameter to 6

Keeping other parameters constant as in the initial simulations (T=1.2, δ=0.6, τ=0.3), the difference of the final distribution of mobile activity and the final income share before and after increasing the value of elasticity of substitution and the comparison of the results can be seen in the following figure.

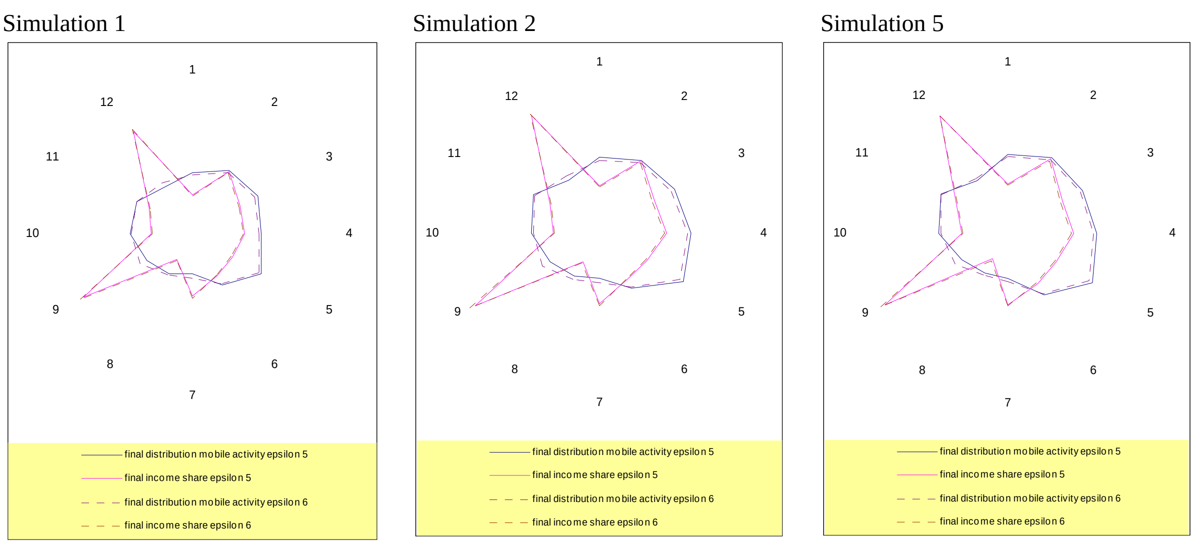


Figure 5.25 Increasing the value of congestion parameter

From Table 5.19 and Figure 5.24, it can be observed the long run equilibrium when the value of elasticity of substitution is equal to 6. The results of the first, second and fifth simulations show that increasing the elasticity of substitution has the inverse result than decreasing it. Increasing the value of this parameter to 6 decreases the impact of building the BRT project, and thus drive the economic activity away from

Jakarta (the area where the project is occurring) and its surrounding cities (Bekasi, Tangerang, and Depok city).

Table 5.19 The differences (point change) of final distribution mobile activity and income share after increasing epsilon

location	1	2	3	4	5	6	7	8	9	10	11	12
Simulation 1												
final distribution mobile activity	-0.0026	-0.0038	-0.0050	-0.0027	-0.0050	-0.0016	0.0056	0.0024	0.0105	-0.0027	-0.0009	0.0058
final income share	-0.0017	-0.0022	-0.0028	-0.0016	-0.0028	-0.0011	0.0031	0.0012	0.0067	-0.0016	-0.0006	0.0034
Simulation 2												
final distribution mobile activity	-0.0030	-0.0036	-0.0042	-0.0038	-0.0049	-0.0009	0.0051	0.0030	0.0105	-0.0018	-0.0012	0.0050
final income share	-0.0018	-0.0021	-0.0024	-0.0022	-0.0027	-0.0007	0.0028	0.0015	0.0067	-0.0012	-0.0008	0.0028
Simulation 5												
final distribution mobile activity	-0.0026	-0.0030	-0.0032	-0.0029	-0.0035	-0.0018	0.0037	0.0032	0.0097	-0.0019	-0.0017	0.0038
final income share	-0.0016	-0.0017	-0.0018	-0.0017	-0.0020	-0.0012	0.0020	0.0017	0.0062	-0.0012	-0.0011	0.0022

Chapter 6 Conclusion and recommendation

6.1 Conclusions

Ultimately, in order to answer the research questions, there are some conclusions that are drawn from the analysis. The first conclusion is about the impact of changing the sequence of the BRT lanes development on the spatial distribution of economic activity within the Jakarta Metropolitan Area. The second conclusion is related to the impact of the project development on the distribution of economic activity and the welfare level of each region. The last conclusion explains the impact of changing the value of parameters on the spatial distribution of economic activity in the area.

6.1.1 Hysteresis on the BRT project

One of the objectives of this research is to understand the impact of changing the sequences of the BRT lanes development, also known as hysteresis, on the spatial distribution of economic activity in the whole Jakarta Metropolitan Area. Based on the analysis, it can be concluded that hysteresis does not play an important role in determining the final distribution of mobile activity after the development of the first three corridors and the completion of the entire project.

6.1.2 Simulation of BRT lanes development in the Jakarta Metropolitan Area

In order to analyze the impact of the BRT project on the final distribution of economic activity, it is important to calculate the long run equilibrium before and after the development of the corridors. In the first seven simulations (the base scenario together with simulation 2 to 7), the following parameter values are chosen: the share of income spent on manufacturing production δ is 0.6, the elasticity of substitution ε is 5, the transport cost parameter T is 1.2, and the congestion parameter τ is equal to 0.3. In the base simulation, it can be seen that there is an economic agglomeration in Jakarta before the development of the project. The development of the project has a moderate impact on the distribution of manufacturing production, and accordingly leads to more agglomeration of economic activity in the area (see Table 6.1 and Figure 6.1).

The development of BRT lanes in Jakarta gives an impact on reducing travel time between the regions. Accordingly, it reduces the total cost when interacting from one region to the other regions in the Jakarta Metropolitan Area. The reduction of transport cost, resulting from building the corridors, benefits Jakarta from allowing this city to attract a larger share of mobile activity. The basic underlying principal of this phenomenon is the equalization of the real wage for manufacture labour force in all the regions. This gives no incentives for workers to move to the other regions. If manufacturing activity is evenly distributed over the twelve regions, the workers in the regions where the project is taking place have the highest real wage as the result of the lowest transportation cost in their regions. Taken the fact that this project is occurred in Jakarta, it attracts manufacturing workers to move to this city and accordingly reinforces the process. In contrast, the agglomeration of economic activity in Jakarta leads to more congestion and thus increases the urgency to move to the hinterland of the area. All of these processes are finally balanced in the long run equilibrium.

Table 6.1 Distribution of mobile workers in the Jakarta Metropolitan (%)

Region	Simulation 1 (no BRT project)	Simulation 2 (the first three corridors)	Simulation 5 (the entire project)
Jakarta (Region 1-5)	48.57	50.75	50.96
Bodetabek (Region 6-12)	51.43	49.25	49.04

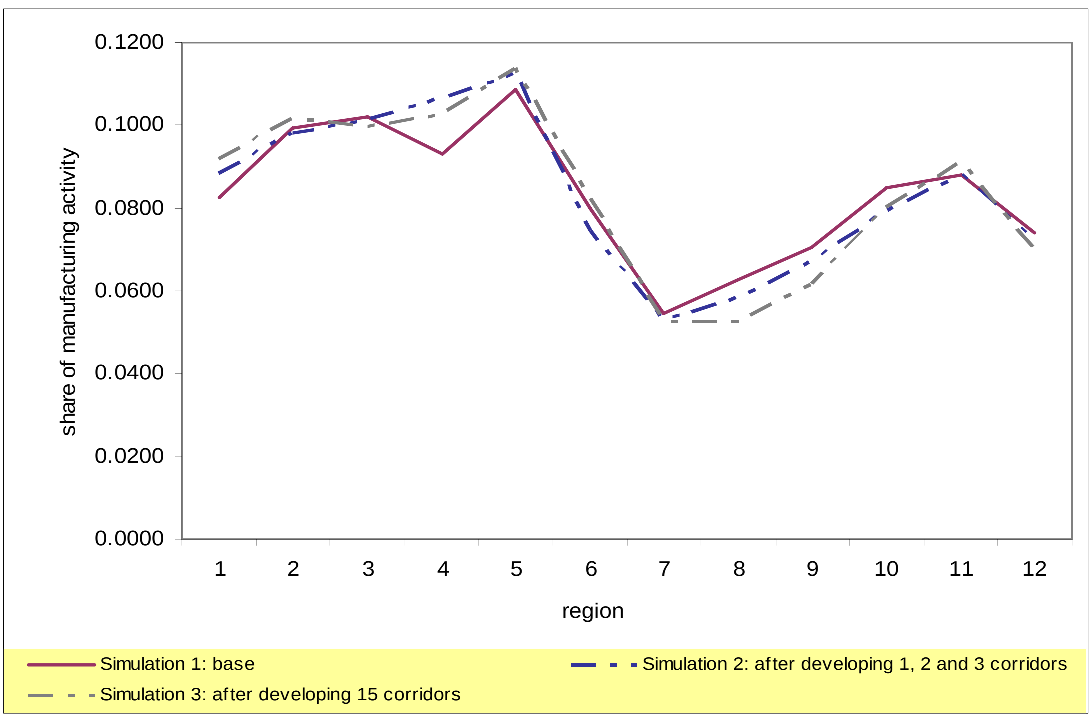


Figure 6.1 Impact of building the corridors on spatial distribution: base scenario, first three corridors, and the entire project

Even though the population growth rate in Jakarta has been declined, the congestion cost in the city is still very high due to the high number of people living in the area. This congestion cost works as spreading force and pushes the mobile activity to move to the hinterland of the area. Based on the simulations (simulation 1 to 7), the development of the BRT project will increase the attractiveness of Jakarta and therefore more people and mobile activity will move back to the city.

The question is: will mobile economic activity move back to Jakarta after the completion of the project in reality? In order to answer this question, it has to be bare in mind that the simulation does not take into account the population growth in the Jakarta Metropolitan Area. In other words, the simulation only indicates what will be happening relative to one point in time if there is no population growth. Besides, in reality, there are some forces that cause the decline of the economic activity in the centre of the area. The population growth is inevitable and this will increase congestion cost and cause the spreading of the economic activity. The development of the project will act as forces that counteract the decline of the economic activity due to the high congestion cost. In the future, there will still be the decline of economic activity in the centre of the Jakarta Metropolitan Area (Jakarta city), but this decline of economic activity will occur less rapidly than what it otherwise would have been done in a relative time. Basically the development of the project will counter balance the forces that are spreading people and mobile activity.

To complete the analysis of the BRT project, it is important to consider the impact that it has on the welfare level of people living on the area. There are thirteen different actors in this model, divided into twelve regions immobile workers that cannot move and mobile workers that are spreading in the area and can move to the area with the higher income share. In the long run equilibrium, the completion of this project will give a different welfare implication for each of the actors.

As it is previously stated, the basic effect of the BRT project development is to reduce the distances between regions. Welfare implications are calculated once the mobile workers are allowed to migrate in reaction of the project development. From Figure 6.2, it is clear that the development of this project increases the welfare level of both mobile and immobile workers in the twelve regions. The BRT project is an investment in infrastructure and thus increases the interaction between regions. The mobile workers gain from the reduction of the transport cost and the growth of interaction between regions. The immobile workers in the centre of the Jakarta Metropolitan Area (Jakarta) benefit because the increase of mobile economic activity in their regions reduces their import over some goods. The immobile workers in the outskirt of Jakarta hurt because now they have to import the goods needed. On the other hand, the goods that have to be imported from the centre, now, can be imported with the lower cost. In this simulation, the fact that immobile workers can import goods in a low cost gives more dominant effect than their loose over some mobile economic activity and therefore their welfare level increases.

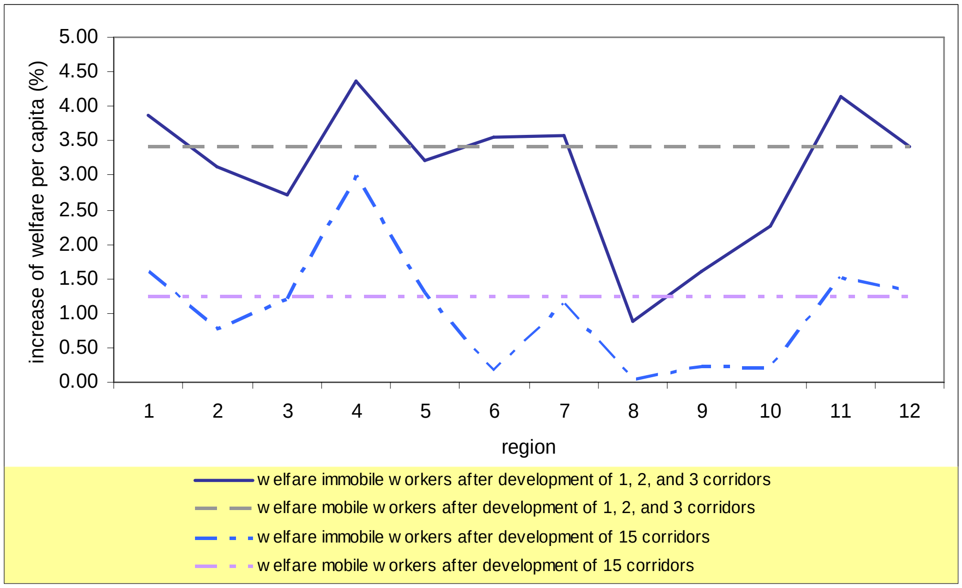


Figure 6.2 Increase in welfare per capita after building the first three corridors and the entire project (from the base)[42]

6.1.3 Effect of parameter changes on the BRT project

The effect of changing the value of parameters in the long run equilibrium is as follows:

Congestion cost, τ

Agglomeration of manufacturing activity becomes more attractive when τ decreases as a result of low congestion cost.[43] When the congestion cost decreases, building BRT project improves the transportation within regions in Jakarta and Tangerang city, located in the fringe of Jakarta, and increases the attractiveness of these cities (see Figure 6.3). Accordingly, it increases the economic agglomeration in Jakarta and Tangerang city. On the other hand, increasing the congestion cost decreases the magnetism of the project and therefore reduces manufacturing activity in Jakarta and Tangerang city.

[42] The welfare for immobile workers are calculated using the following equations:

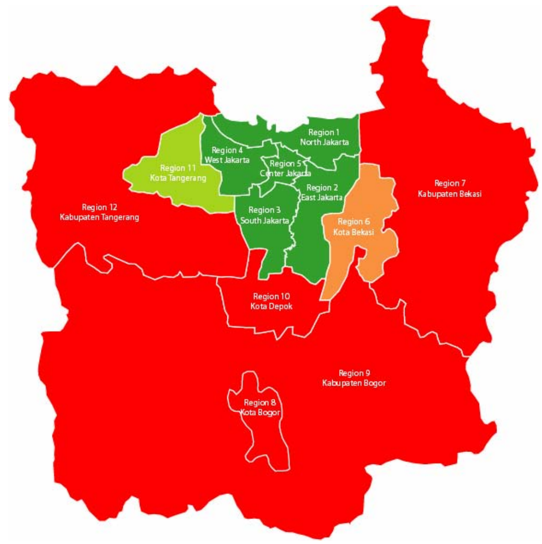
$$y_r \equiv Y_r I_r^{-\delta}$$

$$welfare = \sum_{r=1}^{R} y_r$$

Welfare for mobile workers is equal to the real wage (in the simulation)

[43] Brakman, Garretsen, and Van Marrewijk (2001) ch.11, p. 326

The distribution of mobile activity after the completion of the project



The distribution of mobile activity after decreasing congestion cost

Figure 6.3 The effect of the decrease in congestion cost on the final distribution of mobile activity after the completion of the project[44]

Transport cost, T

As it is stated in Brakman, Garretsen, and Van Marrewijk (2001):

"…the impact of transport cost on the resulting long-run equilibrium is non-monotonic." (Page 312)

For a very high, as well as low transport cost, the impact of building the project becomes minimal. The rational behind this is straightforward. When transport cost is very high, the cities become more autonomous, so the prosperity in each city will not be improved. When transport cost is very low, the cost of manufacture trading can be eliminated. It implies that the advantage from building BRT project becomes insignificant. From the analysis in Chapter 5, it can be seen that the decrease in transport cost to 1.1 reduces mobile activity in Jakarta and the increase of transport cost to 1.3 increases the mobile activity there.

Share of income spent on manufacture, δ

A decrease in δ means that mobile activity becomes less important than immobile activity and the inverse holds. Decreasing δ reduces agglomeration in Jakarta and decreases the attractiveness of the project. On the other hand, increasing δ raises the importance of mobile activity. Based on the analysis, it can generally be seen that the development of BRT project along with the increase of the share of income spent on

[44] See Figure 5.15 and 5.18

manufacture, enlarge mobile activity in Jakarta and its surrounding cities (Bekasi, Tangerang, and Depok city), and it holds to the contrary.

Elasticity of substitution, ε

A decrease in ε means that it is more difficult for the consumer to find the replacement of manufacturing goods because of lack of varieties. Basically, this increases the impact of building the project as also mentioned by Brakman, Garretsen, and Van Marrewijk (2001) and encourages more agglomeration of the economic activity in the area where the project is occurring. Based on the analysis, it can generally be seen that the development of BRT project along with the decrease of elasticity of substitution, enlarge mobile activity in Jakarta and its surrounding cities (Bekasi, Tangerang, and Depok city), and it holds to the contrary.

6.2 Recommendations

The development of urban project in Indonesia, in a lot of cases, is not really based on a deep planning and does not really take into account the impact of these developments in the future, especially in regards to the impact that they have to the urban form. Based on this research, it can be seen that the development of BRT project in Jakarta gives a high impact on the welfare level of people living in the regions. Some municipalities benefit more that the others. In this case study, building the project is a good investment for the whole metropolitan area. Even so, it is already the time for urban decision makers to adopt a broader perspective in planning the development of the city (Jakarta) and find the best solution to solve traffic congestion problems in Jakarta with more integrated analysis in order to get the best solutions for the whole Jakarta Metropolitan Area. Geographic economics model can be used by policy makers as one of the tools in their decision making process to analyse the impact of one urban project on the welfare level in the wider area.

Considering the importance of geographic economics, it is recommended for the future research to improve the method used to draw the value of parameters. It is realized that the value of parameters and the initial distribution of immobile activity have a very important role in determining the final distribution of mobile activity and income share in the simulation model. Taken that fact into consideration, the process of calibrating the value of immobile activity is very important in this research in order to get the most reliable value that can represent the real situation before the development of the project.

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Appendix

Appendix 1: Time travel from one region to the others if only corridor 1 is developed

Appendix 2: Time travel from one region to the others if only corridors 2 and 3 are developed

Appendix 3: Time travel from one region to the others when corridors 1, 2 and 3 are developed

Appendix 4: Time travel from one region to the others when the entire project has been completed

Appendix 1: Time travel from one region to the others if only corridor 1 is developed

Distances (minutes)		1	2	3	4	5	6	7	8	9	10	11	12
1	BRT lanes	0	0	26	6	0	0	0	0	13	0	6	6
	Normal lanes	0	119	65	93	58	188	295	322	338	183	161	234
	Total time	0	119	91	100	58	188	295	322	351	183	167	240
2	BRT lanes	0	0	0	4	0	0	0	0	0	0	4	4
	Normal lanes	119	0	89	130	69	82	194	254	319	129	197	270
	Total time	119	0	89	134	69	82	194	254	319	129	202	274
3	BRT lanes	26	0	0	20	16	0	0	0	0	0	0	0
	Normal lanes	65	89	0	77	32	159	271	216	278	92	129	224
	Total time	91	89	0	97	48	159	271	216	278	92	129	224
4	BRT lanes	6	4	20	0	4	4	4	8	5	8	0	0
	Normal lanes	93	130	77	0	61	199	311	302	365	177	81	154
	Total time	100	134	97	0	65	203	315	309	370	185	81	154
5	BRT lanes	0	0	16	4	0	0	0	0	8	0	4	4
	Normal lanes	58	69	32	61	0	138	254	258	304	133	128	201
	Total time	58	69	48	65	0	138	254	258	312	133	132	205
6	BRT lanes	0	0	0	4	0	0	0	0	0	0	0	0
	Normal lanes	188	82	159	199	138	0	152	232	337	177	243	339
	Total time	188	82	159	203	138	0	152	232	337	177	243	339
7	BRT lanes	0	0	0	4	0	0	0	0	0	0	0	0
	Normal lanes	295	194	271	311	254	152	0	343	415	313	355	451
	Total time	295	194	271	315	254	152	0	343	415	313	355	451
8	BRT lanes	0	0	0	8	0	0	0	0	0	0	0	0
	Normal lanes	322	254	216	302	258	232	343	0	163	129	289	372
	Total time	322	254	216	309	258	232	343	0	163	129	289	372
9	BRT lanes	13	0	0	5	8	0	0	0	0	0	0	0
	Normal lanes	338	319	278	365	304	337	415	163	0	221	355	445
	Total time	351	319	278	370	312	337	415	163	0	221	355	445
10	BRT lanes	0	0	0	8	0	0	0	0	0	0	0	0
	Normal lanes	183	129	92	177	133	177	313	129	221	0	221	317
	Total time	183	129	92	185	133	177	313	129	221	0	221	317
11	BRT lanes	6	4	0	0	4	0	0	0	0	0	0	0
	Normal lanes	161	197	129	81	128	243	355	289	355	221	0	96
	Total time	167	202	129	81	132	243	355	289	355	221	0	96
12	BRT lanes	6	4	0	0	4	0	0	0	0	0	0	0
	Normal lanes	234	270	224	154	201	339	451	372	445	317	96	0
	Total time	240	274	224	154	205	339	451	372	445	317	96	0

Appendix 2: Time travel from one region to the others if only corridors 2 and 3 are developed

Distances (minutes)		1	2	3	4	5	6	7	8	9	10	11	12
1	BRT lanes	0	0	0	19	3	3	22	3	1	3	32	32
	Normal lanes	0	119	127	62	52	182	243	316	366	177	100	172
	Total time	0	119	127	81	55	184	265	319	368	179	132	204
2	BRT lanes	0	0	0	27	0	0	0	0	0	0	32	32
	Normal lanes	119	0	89	75	69	82	194	254	319	129	132	205
	Total time	119	0	89	102	69	82	194	254	319	129	164	237
3	BRT lanes	0	0	0	19	0	0	0	0	0	0	0	0
	Normal lanes	127	89	0	80	69	159	271	216	278	92	129	224
	Total time	127	89	0	99	69	159	271	216	278	92	129	224
4	BRT lanes	19	27	19	0	19	19	47	19	18	19	13	13
	Normal lanes	62	75	80	0	25	164	211	275	335	150	51	124
	Total time	81	102	99	0	45	183	257	294	353	169	64	137
5	BRT lanes	3	0	0	19	0	0	45	0	0	0	19	19
	Normal lanes	52	69	69	25	0	138	147	258	323	133	93	166
	Total time	55	69	69	45	0	138	192	258	323	133	112	185
6	BRT lanes	3	0	0	19	0	0	0	0	0	0	0	0
	Normal lanes	182	82	159	164	138	0	152	232	337	177	243	339
	Total time	184	82	159	183	138	0	152	232	337	177	243	339
7	BRT lanes	22	0	0	47	45	0	0	0	0	0	0	0
	Normal lanes	243	194	271	211	147	152	0	343	415	313	355	451
	Total time	265	194	271	257	192	152	0	343	415	313	355	451
8	BRT lanes	3	0	0	19	0	0	0	0	0	0	0	0
	Normal lanes	316	254	216	275	258	232	343	0	163	129	289	372
	Total time	319	254	216	294	258	232	343	0	163	129	289	372
9	BRT lanes	1	0	0	18	0	0	0	0	0	0	0	0
	Normal lanes	366	319	278	335	323	337	415	163	0	221	355	445
	Total time	368	319	278	353	323	337	415	163	0	221	355	445
10	BRT lanes	3	0	0	19	0	0	0	0	0	0	0	0
	Normal lanes	177	129	92	150	133	177	313	129	221	0	221	317
	Total time	179	129	92	169	133	177	313	129	221	0	221	317
11	BRT lanes	32	32	0	13	19	0	0	0	0	0	0	0
	Normal lanes	100	132	129	51	93	243	355	289	355	221	0	96
	Total time	132	164	129	64	112	243	355	289	355	221	0	96
12	BRT lanes	32	32	0	13	19	0	0	0	0	0	0	0
	Normal lanes	172	205	224	124	166	339	451	372	445	317	96	0
	Total time	204	237	224	137	185	339	451	372	445	317	96	0

Appendix 3: Time travel from one region to the others when corridors 1, 2 and 3 are developed

Distances (minutes)		1	2	3	4	5	6	7	8	9	10	11	12
1	BRT lanes	0	0	26	25	3	3	22	3	14	3	38	38
	Normal lanes	0	119	65	48	52	182	243	316	335	177	85	158
	Total time	0	119	91	73	55	184	265	319	350	179	123	196
2	BRT lanes	0	0	0	32	0	0	0	0	0	0	36	36
	Normal lanes	119	0	89	65	69	82	194	254	319	129	122	194
	Total time	119	0	89	96	69	82	194	254	319	129	158	231
3	BRT lanes	26	0	0	39	16	0	0	0	0	0	0	0
	Normal lanes	65	89	0	32	32	159	271	216	278	92	129	224
	Total time	91	89	0	71	48	159	271	216	278	92	129	224
4	BRT lanes	25	32	39	0	24	24	51	27	23	27	13	13
	Normal lanes	48	65	32	0	15	153	200	256	322	132	51	124
	Total time	73	96	71	0	39	177	251	283	346	158	64	137
5	BRT lanes	3	0	16	24	0	0	45	0	8	0	24	24
	Normal lanes	52	69	32	15	0	138	147	258	304	133	82	155
	Total time	55	69	48	39	0	138	192	258	312	133	106	179
6	BRT lanes	3	0	0	24	0	0	0	0	0	0	0	0
	Normal lanes	182	82	159	153	138	0	152	232	337	177	243	339
	Total time	184	82	159	177	138	0	152	232	337	177	243	339
7	BRT lanes	22	0	0	51	45	0	0	0	0	0	0	0
	Normal lanes	243	194	271	200	147	152	0	343	415	313	355	451
	Total time	265	194	271	251	192	152	0	343	415	313	355	451
8	BRT lanes	3	0	0	27	0	0	0	0	0	0	0	0
	Normal lanes	316	254	216	256	258	232	343	0	163	129	289	372
	Total time	319	254	216	283	258	232	343	0	163	129	289	372
9	BRT lanes	14	0	0	23	8	0	0	0	0	0	0	0
	Normal lanes	335	319	278	322	304	337	415	163	0	221	355	445
	Total time	350	319	278	346	312	337	415	163	0	221	355	445
10	BRT lanes	3	0	0	27	0	0	0	0	0	0	0	0
	Normal lanes	177	129	92	132	133	177	313	129	221	0	221	317
	Total time	179	129	92	158	133	177	313	129	221	0	221	317
11	BRT lanes	38	36	0	13	24	0	0	0	0	0	0	0
	Normal lanes	85	122	129	51	82	243	355	289	355	221	0	96
	Total time	123	158	129	64	106	243	355	289	355	221	0	96
12	BRT lanes	38	36	0	13	24	0	0	0	0	0	0	0
	Normal lanes	158	194	224	124	155	339	451	372	445	317	96	0
	Total time	196	231	224	137	179	339	451	372	445	317	96	0

Appendix 4: Time travel from one region to the others when the entire project has been completed

Distances (minutes)		1	2	3	4	5	6	7	8	9	10	11	12
1	BRT lanes	0	31	33	32	14	51	55	43	46	38	50	50
	Normal lanes	0	47	50	32	25	66	164	220	260	93	57	130
	Total time	0	77	82	64	39	118	219	263	306	131	107	180
2	BRT lanes	31	0	19	47	20	11	19	16	26	17	65	65
	Normal lanes	47	0	43	28	21	57	149	216	256	89	53	126
	Total time	77	0	63	75	42	68	168	232	283	106	118	191
3	BRT lanes	33	19	0	40	19	40	49	0	0	0	28	28
	Normal lanes	50	43	0	31	24	63	155	216	278	92	62	158
	Total time	82	63	0	71	43	103	204	216	278	92	90	186
4	BRT lanes	32	47	40	0	27	68	76	51	51	51	18	18
	Normal lanes	32	28	31	0	7	48	140	199	256	74	39	111
	Total time	64	75	71	0	34	116	216	250	307	125	57	129
5	BRT lanes	14	20	19	27	0	41	49	27	31	27	45	45
	Normal lanes	25	21	24	7	0	41	139	193	249	68	32	104
	Total time	39	42	43	34	0	82	188	220	280	96	77	149
6	BRT lanes	51	11	40	68	41	0	0	0	29	0	68	68
	Normal lanes	66	57	63	48	41	0	152	232	269	177	81	177
	Total time	118	68	103	116	82	0	152	232	298	177	150	245
7	BRT lanes	55	19	49	76	49	0	0	0	0	45	77	77
	Normal lanes	164	149	155	140	139	152	0	343	415	205	174	269
	Total time	219	168	204	216	188	152	0	343	415	250	250	346
8	BRT lanes	43	16	0	51	27	0	0	0	0	0	0	0
	Normal lanes	220	216	216	199	193	232	343	0	163	129	289	372
	Total time	263	232	216	250	220	232	343	0	163	129	289	372
9	BRT lanes	46	26	0	51	31	29	0	0	0	0	30	30
	Normal lanes	260	256	278	256	249	269	415	163	0	221	283	373
	Total time	306	283	278	307	280	298	415	163	0	221	313	403
10	BRT lanes	38	17	0	51	27	0	45	0	0	0	47	45
	Normal lanes	93	89	92	74	68	177	205	129	221	0	108	210
	Total time	131	106	92	125	96	177	250	129	221	0	156	255
11	BRT lanes	50	65	28	18	45	68	77	0	30	47	0	0
	Normal lanes	57	53	62	39	32	81	174	289	283	108	0	96
	Total time	107	118	90	57	77	150	250	289	313	156	0	96
12	BRT lanes	50	65	28	18	45	68	77	0	30	45	0	0
	Normal lanes	130	126	158	111	104	177	269	372	373	210	96	0
	Total time	180	191	186	129	149	245	346	372	403	255	96	0