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A Dynamic Model for Spatial Planning in Metropolitan Areas[1]

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Abstract

The fast pace of development in metropolitan areas does not allow them to forecast their own growth and development. The high rate of population growth that becomes a typical characteristic of metropolitan area has caused planning efforts always to lag behind realities. This work is an attempt to provide urban planners and policy makers in Indonesia with a "micro-world" in which they can experiment with their policy options, prior to adoption. This helps them test their mental models regarding the solutions they see for the problems associated with rapid urban growth.

The application to Semarang City as one of the emerging metropolitan cities in Indonesia is a case study, and a part of a larger project aiming at building a generic model for spatial planning for metropolitan areas in Indonesia. The model is focused to accommodate the proposed policy of the city's government, to develop the industrial sector in Semarang. An experiment with a set of policy options is conducted to find the best result. In this particular case, we found that the original idea of investing in the industrial sector, shifting the industry from upstream to downstream, and making more inner-city land available for industrial purposes turns out NOT to be the best strategy for improving the quality of life and solving urban problems in Semarang City.

I. Metropolitan Problems and Spatial Planning in Indonesia

The term *metropolitan area* describes a geographical area with a large population center, with neighboring communities which have a high degree of economic and social interaction with that center (Hess et. al, 1988). One cause of fast paced population growth in metropolitan areas is urbanization, is an outcome of shifting main resources in agricultural sectors in rural areas toward industries and services developed in urban areas. Williams (1999: 172) described this concept as a phenomenon of rapid expansion of urban areas beyond established municipal boundaries. Urbanization and decentralization trigger expansion, and combined with increasing demands for upgraded infrastructure, overwhelm the capacity of established local governments to service and manage such growth.

A *metropolitan city* is defined as more than one million inhabitants inside its boundary. A *metropolitan area* is a system of urbanized areas that are based around a big city and its

[1] The paper is developed from our study conducted to the Ministry of Human Settlements and Regional Infrastructures Development.

[2] I would like to express my special thanks to Aldo Zagonel for stimulating me and my co-authors to write and send this paper to ISDC 2003. His continued support, critics, comments, editing are very helpful to improve this paper. I can't repay the time invested by him in commenting this paper, except to hope, he is glad to see how many of his suggestions has been incorporated into this paper.

outskirts. The city could expand the existing boundary and the total population in the area could be more than one million inhabitants. A *Metropolitan region* is a system of adjacent cities with total population of more than one million inhabitants arranged by a relationship, and forming a single region of urbanized area.

The pattern of metropolitan development can be seen in the following aspects: urbanization and economic growth, distribution of urban population, distribution of urban workers, pattern of location and transportation, land price, housing area and working location and basic infrastructure and services (Ingram, 1998). These aspects have produced problems, namely: limited job opportunities, development of slum areas, traffic congestion, etc.

As in other developing countries, Indonesia has had a high rate of urban growth in the last two decades. The population in urban areas increased at approximately 5.5% per year. In the year 2000, the population of urban areas was 87 million inhabitants, or about 39% of the total population of the country. There are about 26 million inhabitants, or 30% of the total urban population, located in nine main metropolitan cities.

In line with the high growth rate of Indonesian urban population, the number of metropolitan cities has increased (see Figure 1). In the 1950's there was only one metropolis in Indonesia, namely Jakarta. But within 20 years (1950-1970) two other metropolitan cities appeared, Bandung and Surabaya. Nowadays, there are five additional metropolitan areas besides the three cities mentioned above. They are Medan, Semarang, Palembang, Bogor and Ujung Pandang.

By and large, problems result from the fact that most Indonesian metropolitan areas, particularly Jakarta, cannot forecast accurately their own growth and development. The population growth rate is so high that planning efforts always seem to lag behind; indeed, economic, financial and managerial initiatives are always lower than what is needed for these cities to sustain their increasing populations.

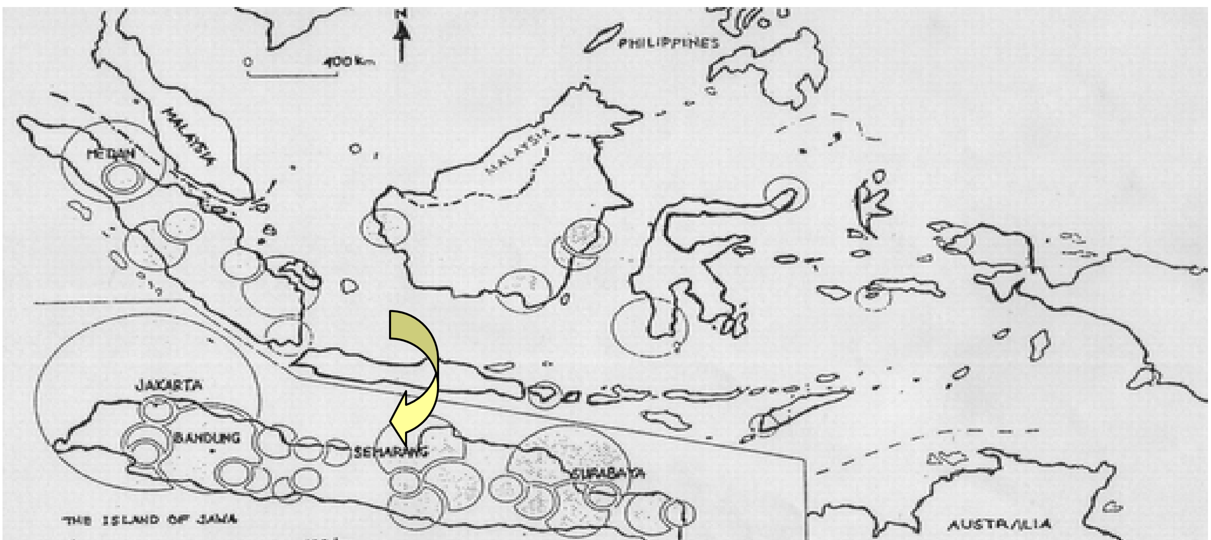

Figure 1. Map of Indonesia

Soejarto (1989) mentioned some persistent problems in most Indonesian metropolitan areas:

- These areas are growing very rapidly. In general the population rate of growth is higher than the average national increase, due to immigration from small towns and rural villages.

- The economic base to support such population increases in cities is low.

- Inadequate programs to provide housing, water, drainage systems, sanitation systems, sewage, electricity, and employment opportunities, create an inconvenient atmosphere.

- The standard of living in metropolitan cities is relatively better than in rural areas and small towns. Most investments, domestic as well as multinational, are made in or nearby metropolitan cities resulting in a continuous inflow of rural inhabitants to these cities to improve their standard of living.

This brings a new challenge for the decision makers facing population problems in urban areas: how to provide facilities and infrastructure, such as housing, transportation, water, sanitation, drainage, electricity, and other social facilities? The anticipation of population growth and how to develop the city infrastructures are essential to solve these problems.

Based on the background described above, this paper is concerned with the relationship between metropolitan growth, spatial planning and its impact on various essential urban components. Thus far the principles of implementing spatial planning have been regulated by "Spatial Planning Law" No. 24, of 1992. However, policies and regulations are not yet available in Indonesia that specifically treat metropolitan space; hence, metropolitan space is still handled like common urban areas. This presents a problem because the urban complexity in metropolitan areas differs from those of other urban spaces.

Before elaborating the spatial planning model, the paper will view an outline of the approach in spatial planning activities that is commonly used in Indonesia:

1. To calculate a trend in the population growth and to make a population projection based on low, medium or high growth rate scenarios, the usual technique being a simple linear projection.
2. To analyze the physical resources and land capacity.
3. To analyze the potential sources of economic growth, and identifying the economic sectors that have the highest growth.
4. To analyze the space required based on the population growth scenarios, and projection of facilities, infrastructures and utilities required in that space.
5. To derive the indication of medium term development program.

Currently, spatial planning presents two disconnected sectors, taking neither the linkage among sectors nor the interwoven relationship among the urban components into consideration. The planning is unable to simulate the policy chosen by the urban decision-makers in order to observe its impact on space. The objective of the modeling effort is to develop a generic model of spatial planning, based upon metropolitan areas case in Indonesia. It is expected that the model can be useful for planners as well as decision makers to give an early warning regarding the city's alteration and as an instrument:
1. for linking various urban components and metropolitan growth.
2. for exploring the impact of planning decision on the development of metropolitan areas and for examining and anticipating the results of alternative development policies.

To observe whether the generic model is able to reach the goal, the model is applied to the case of Semarang City, as a one of the emerging metropolitan cities in Indonesia. What is presented in this paper is only a small experiment regarding the application of the model.

An outline of the modeling process developed in this study, is shown in Figure 2:

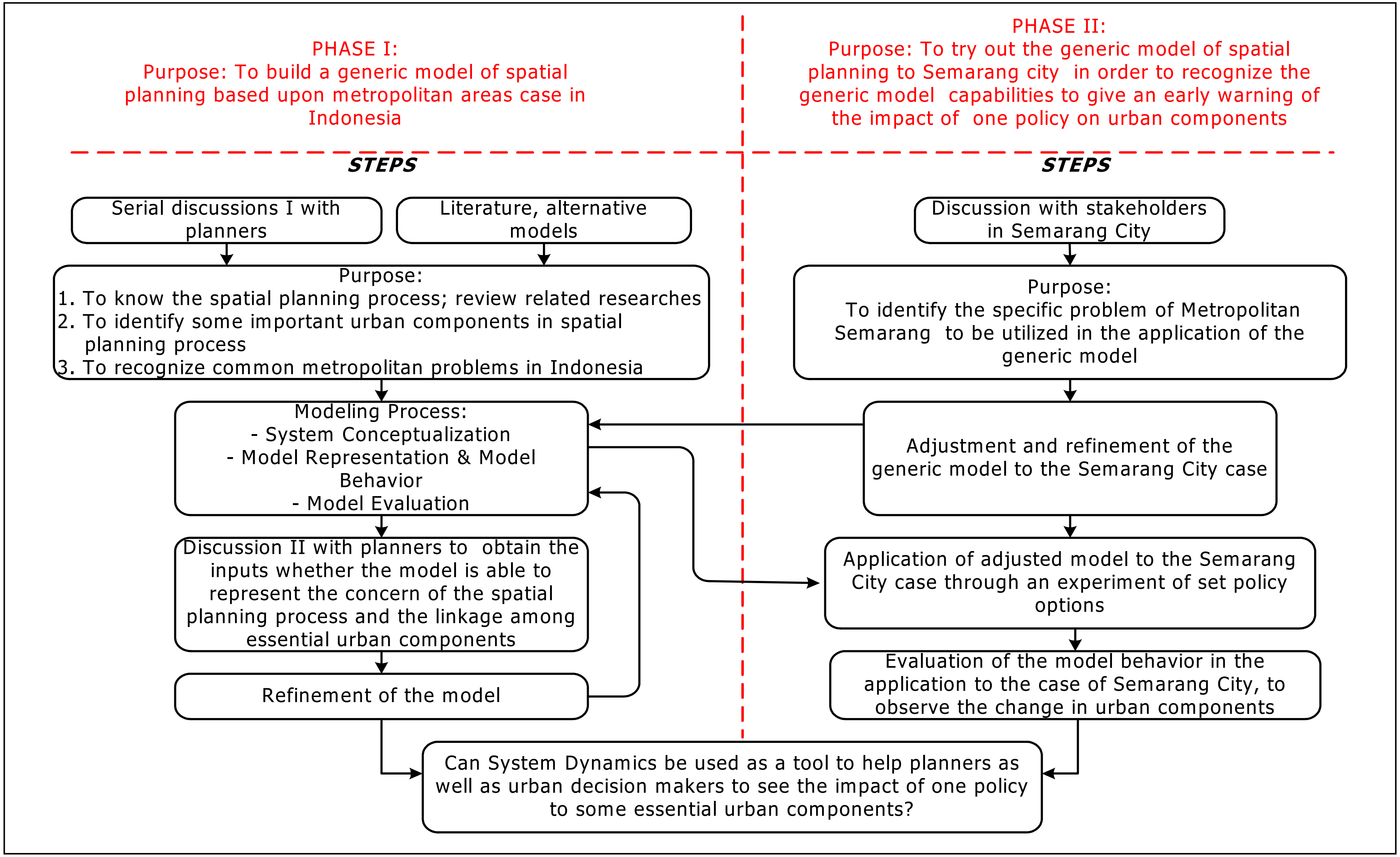

Figure 2. Modeling process

II. General Features of the Spatial Planning Model

The model comprises four interrelated components in spatial planning of an urban area, as shown in Figure 2.

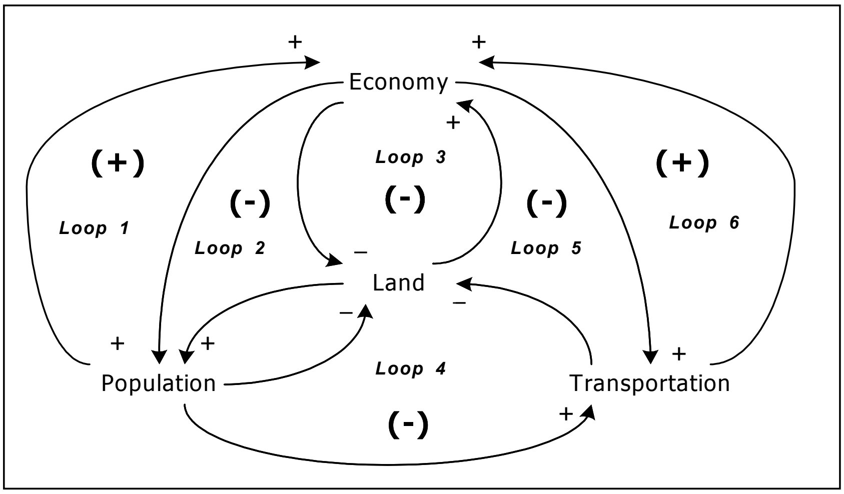

Figure 3. A macro-view of the model

As depicted in the above causal-loops, *the model links population, land, economy and transportation*. The economic sector is divided further into service, trade-hotels-restaurants, agriculture and mining subsectors. These are the result of aggregation of 13 components common in Indonesian economy. Meanwhile the land sector includes land for several types of infrastructure and use, including transportation (roads, terminals, airports, etc.), service and trade, agriculture, housing, mining and conservation.

The interaction among the four sectors produces six feedback loops: two positive loops (loops 1 & 6) and four negative loops (loops 2, 3, 4 and 5). *Loop 1* connects the population and economic sectors. If the size of the population increases, then the economic activities would also be influenced. The population sector contributes to the economic sector especially with the provision of labor. On contrary, the economic activities would attract people further for entering the city. *Loop 2* links the economic, land and population sectors. The inflow population produces higher demand for land (mainly for housing) and, in turn, it reduces land available. This negative loop would control the growth of economic activities and reduce the attractiveness for migrating.

Loop 3 connects *the land* and *economic sectors* and creates a negative relationship. The more intensive urban economic activities, the higher the need for space. As a consequence, this would reduce the land available, and control further the economic growth. *Loop 4* also forms a negative loop. Although the connections between *the land* and *population* as well as *population* and *transportation* are positive, the raise in the need of land for transportation will reduce the land available. Through this mechanism, further growth in population number would be restrained.

Loop 5 links the land, the transportation and the economic sectors. It also creates a negative feedback loop. A positive relationship between the economy and the transportation means that the higher the growth in urban economic activities, the higher is the transportation activities (trips generated by people and goods). This increases *demand capacity ratio* (DCR) as an indicator of the traffic congestion level. On one hand, good transportation system and infrastructures (no congestion, adequacy in number of roads, etc) would push economic activities further, as shown in *loop 6*. On the other hand, through the negative relationship with the land available, the economic activities will indirectly decrease when more spacious land for these are required, while the rapid reduction in land available is taking place.

A description of each of these four sectors mentioned above is introduced here:

A. *Population sector*

Naturally, the size of the population and how it changes over time is significant in spatial planning, because the reason for planning is to accommodate the needs of the population and their activities to a limited land area. This sector is concerned about factors that alter the population in the city (such as fecundity, mortality and migration). In spatial planning procedures, the projection of the pattern of population change is the first task that is carried out to predict land requirement in order to accommodate the estimated population growth in the next few years. The sector contains multipliers which portray the impact of factors of urban attraction that influence migration, such as *land availability* and *land price*, *job opportunities* and *income levels*.

Besides showing the pattern of population growth (Figure 4), this sector is also developed to reflect labor conditions, such as the pattern in the *unemployment rate*. The feedback loops of the labor subsector are illustrated in Figure 5. This subsector serves as a link between the population and economic sectors.

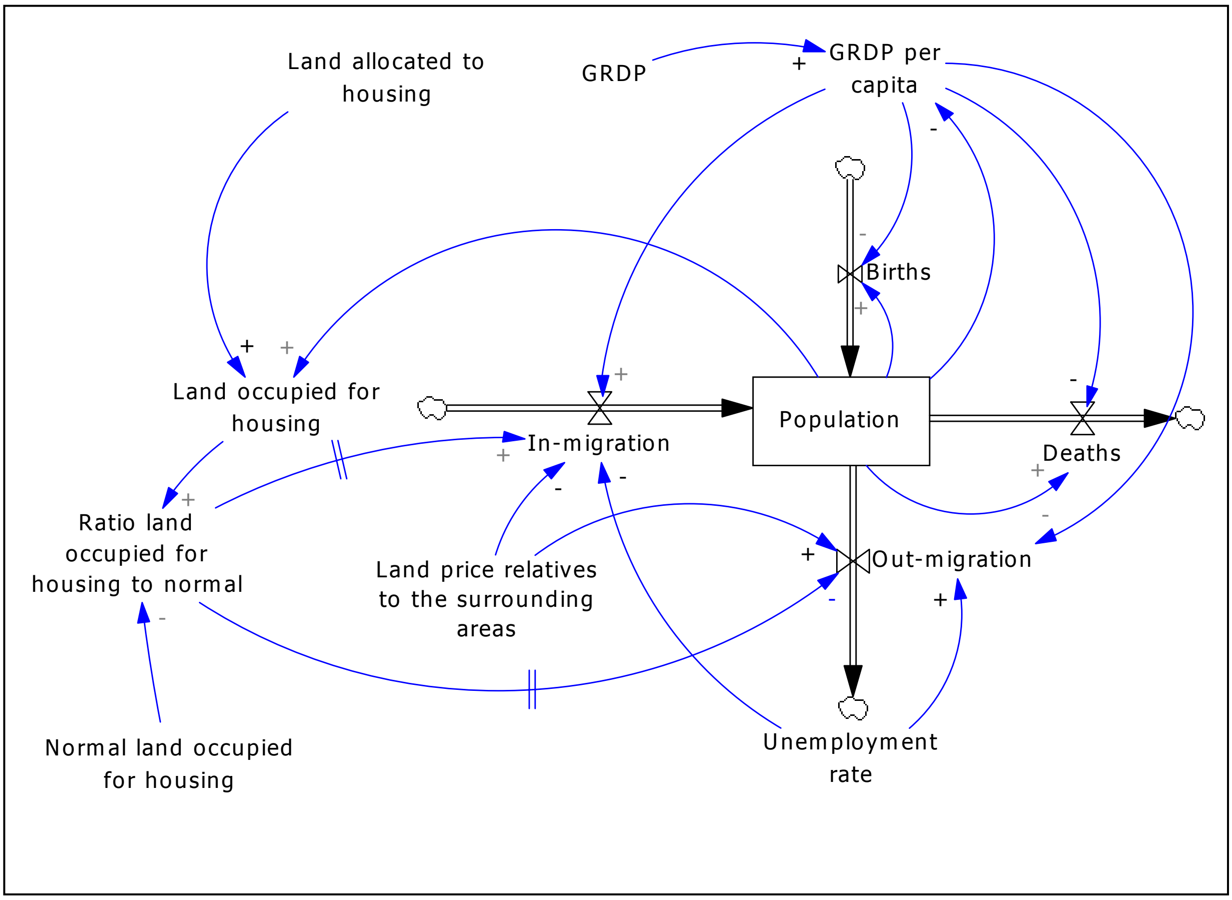

Figure 4. Population sector

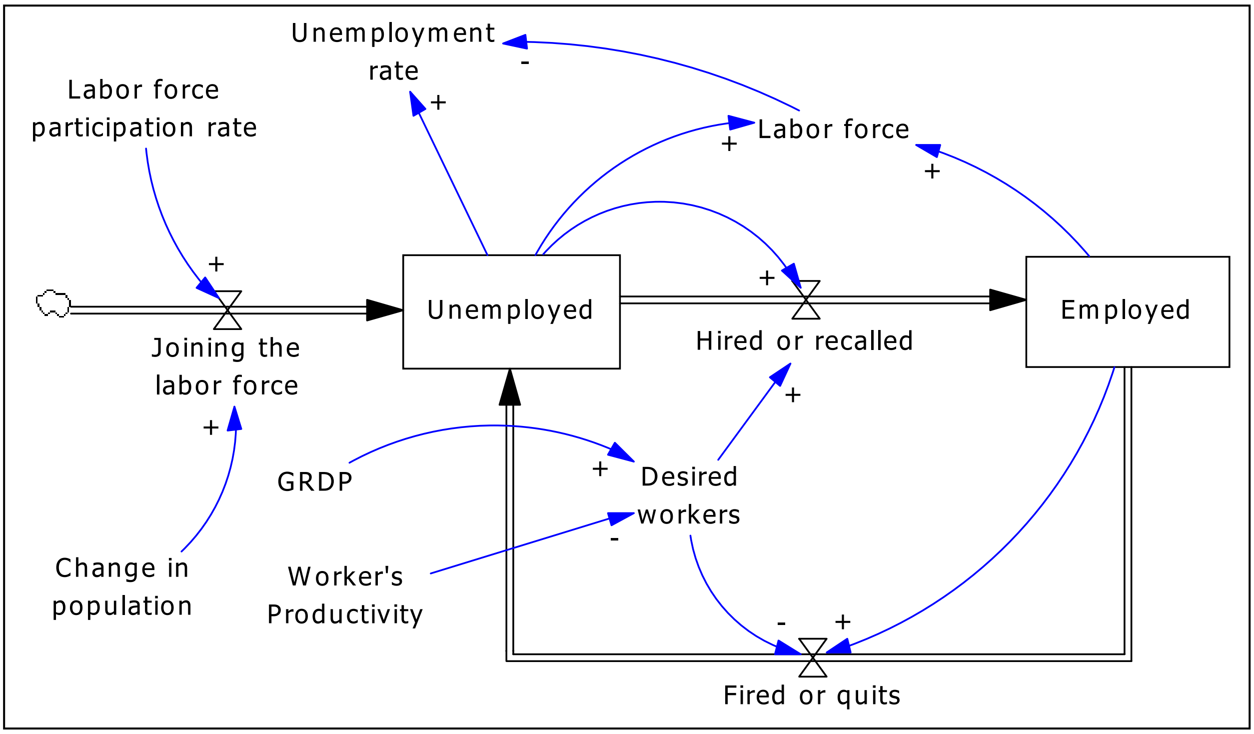

Figure 5. Labor subsector

There are four important variables in the labor subsector: *employed, unemployed, labor force* and *unemployment rate*. The labor force contains both the employed and the unemployed. The rates of flow of workers who are hired and recalled for jobs, or that leave or lose jobs affect the stock of the employed population. The same factors determine the unemployed condition, in addition to changes in numbers of *working-age population*. The last variable, the *unemployment rate*, is determined as the ratio of the *unemployed population* to the *labor force*, and it has an important effect on migration flows in the population sector.

B. *Economic sector*

To represent the economic sector in the model, *GRDP* (Gross Regional Domestic Product) computation is applied. There are 13 economic subsectors contributed to the urban economy, and subdivided into two major sectors:

1. Agriculture subsector (becomes a separated sub model, since its GRDP value is determined by the availability of the land for agriculture and its productivity).
2. Non-Agriculture subsectors, consist of industry, service, trade, hotel and restaurant sectors (GRDP in these subsectors is estimated using the productivity of capital in each sector).

Generally, urban/regional development is affected by the development of the economic sector and linkage among subsectors. In the line with the attempt to improve the linkage among economic subsectors within the model, the *Input-Output modeling (I-O)* as well as KOR (Capital-Output Ratio) concept are applied. To estimate the GRDP, steps of computation are conducted to find following values:

1. *the change in final demand*
2. *the change in output*
3. *the capital and investment rate*
4. *the output*
5. *the Gross Regional Domestic Product (GRDP)*

The GRDP estimation method in non-agriculture subsectors is as follow:

- I-O concept is applied to figure up *the output, the change in output, the final demand* and *the change in final demand*, using following formulation:

$$X = [I - A]^{-1} F \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (1)$$

$$\dot{X} = [I - A]^{-1} \dot{F} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (2)$$

Where X = output, F = the final demand, $\dot{X}$ = the change in output, $\dot{F}$ = the change in final demand, [I- A] = determinant coefficient, and $[I - A]^{-1}$ = *Leontief inverse coefficients*.

- KOR (*Capital-Output Ratio*) concept is applied to calculate *the change in capital* ($\frac{dK}{dt}$) which can be formulated as follows:

$$X = \frac{K}{KOR} \text{ or } \frac{dX}{dt} = \frac{dK/dt}{KOR} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (3)$$

$$\frac{dK}{dt} = KOR * \frac{dX}{dt} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (4)$$

- *Desired investment* (I_{des}) and *actual investment* are formulated as follows:

$$I_{des} = \frac{dK}{dt} + Depr \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (5)$$

Actual Investment:

$$I_{Actual} = I_{des} * \text{effects of land} * \text{traffic congestion } (\leq 1) \qquad \ldots\ldots \qquad (6)$$

The calculation of GRDP of the non-agriculture subsectors which take the abovementioned concepts into consideration, can be represented in following causal loop:

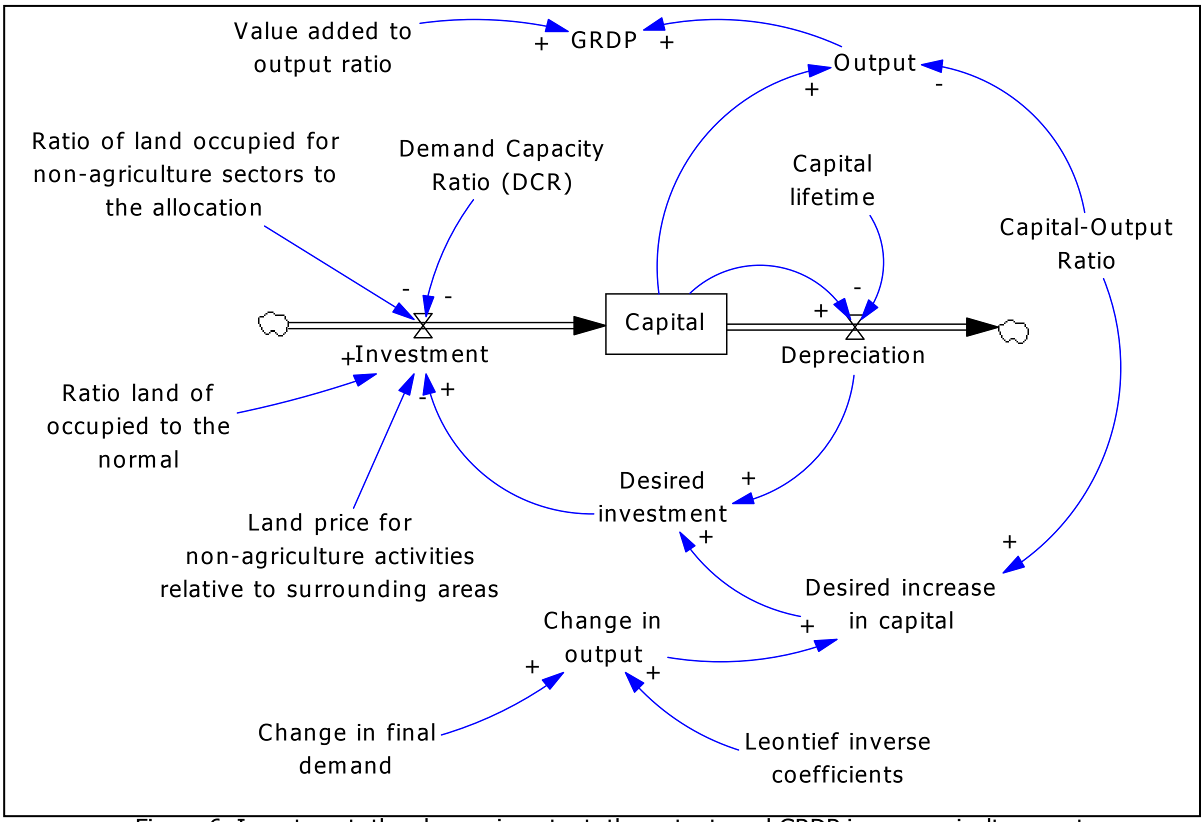

Figure 6. Investment, the change in output, the output, and GRDP in non-agriculture sectors

With reference to the *GRDP* in agriculture subsector, there is little difference between the estimation of *GRDP* in agriculture subsector and other economic subsectors under non-agriculture group, namely:

- Change in agriculture subsector is affected by *the change in land for agriculture* and *land productivity.* Meanwhile the former variable is determined by *the change of non-agriculture land*.
- Similar to non-agriculture subsectors, *the change in output of agriculture subsector* will further influence *the change in capital* and *investment* rate. GRDP in agriculture sector is also determined by *output* and *value added ratio to the output*. However, the agriculture sector differs from other modeled economic sectors in determining *the output*. In the latter sectors, output is calculated by the division of *the capital* and KOR (Capital Output Ratio), while in the former sector it is estimated from multiplication between *availability of land for agriculture* with *productivity of land for agriculture*. KOR is applied to determine *the change in capital* of agriculture sector.

C. Land sector

Commonly adopted categories of land use in spatial planning are agriculture, conservation, housing, industry, transportation, and trade and services. Basically, the total land area remains unchanged, in so far as there is no expansion of the city limits. More likely, land use is converted as illustrated in Figure 7. In other words, the expansion of residential area, for example, means that land use has been converted from other economic and social activities (in Indonesia, this conversion would most likely come at the expense of agricultural land). This sector takes into account the dynamics of possible land conversions.

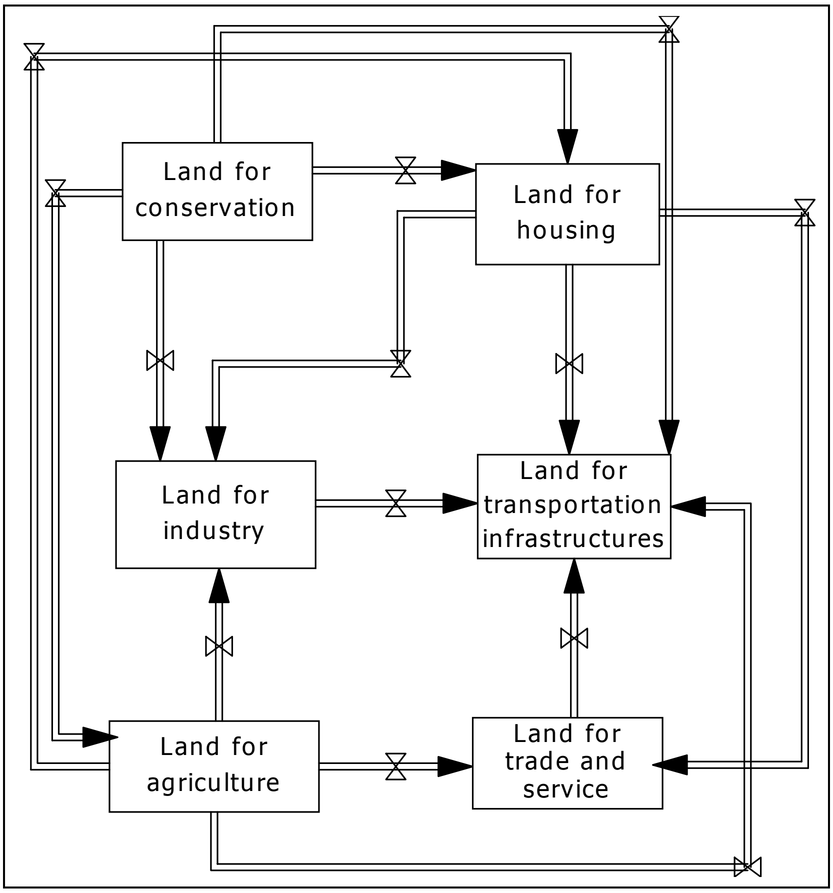

Figure 7. Land conversions in urban area

1. Land for Conservation

This includes forests, catchment areas, areas surrounding dams, lakes and springs, critical land, areas which have slopes of more than forty percent, and areas stipulated in Presidential Decree No. 32, of 1990. The land sector of the model portrays only an outflow from land for conservation, since historically the conversion from other land uses to conservation has not occurred. *Land for conservation* has been converted to other uses due to, for example, loose guidelines for housing expansion. For instance, there is the huge alteration of catchment area in the northern part of Bandung, where luxurious residential areas have been developed. Also, deforestation results in conversion to either agriculture or new settlements. The model takes these conversions into account, as well as the policies that regulate this phenomenon.

2. ***Land for Agriculture***

Land for agriculture is most frequently offered to fulfill the strong demand for land for developing typical urban activities (such as trade and services), or as an outcome of the pressure from speedy growth of the population requiring more space for housing. Agricultural land steadily becomes smaller. Even though the possibility of its enlargement theoretically exists (for example, from the conversion of non-productive land), this type of land use has not resisted the pressures of conversion to other uses.

3. Land for Housing

Expansion in *land for housing* is most likely to come about due to rapid growth rate of the urban population, particularly in metropolitan areas. The (negative) feedback loop that controls this growth is triggered by the unavailability of land for housing, as the *land occupied* approaches *the allocated ratio for housing*. The model disregards environmental limits, and other issues that can also limit further growth of new settlements. This subsector and the industry, service-trade subsectors as well, do not take the physical structures, or aging of structures into consideration.

4. Land for Industry, Trade and Services

This subsector accounts for the provision of an important resource in terms of the thriving dynamics of an urban area. Industry, trade and services are typical economic activities in metropolitan areas, and are continuously in demand of land. The use of allocated land is indicated from *the land-occupied to allocation (planned land) ratio*. The higher its value, the smaller the remaining land available becomes. This ratio, in turn, has an effect in land allocation for industry, heightening the probability of land conversion from other functions.

5. Land for Transportation Infrastructures

Land for transportation covers every transportation infrastructure that needs space. In contrast with *land for agriculture* that is always declining, *land for transportation infrastructures* is always expanding due to development of new housing, trade, services, and industrial activities. This will be further explained in the transportation sector of the model.

6. Land Price

In addition to the previously discussed subsectors, the land sector of the model also contains the *land price* subsector. A price index is used, comparing land price in the city to surrounding areas, in the form of a ratio. The value is one in the beginning of the simulation, and it rises as inner-city land becomes more costly. Inflation rate and the amount of land occupied affect the growth rate of inner city landprice (the higher is the *land occupied*, the higher is *the land price growth rate*). The prices are computed separately for housing as opposed to industry, trade and services. These relative prices have effects upon the attractiveness for people entering the city, in terms of housing, and for investment decisions regarding the location of new businesses.

D. ***Transportation sector***

Transportation also has an important influence in the dynamics of urban life. Economic development is closely connected to the movements of goods and people, requiring adequate transportation infrastructures (such as roads, terminals, airports, and seaports). Increasing demand without support of greater transportation capacity generates constraints. This is one of the main problems to be solved in planning for metropolitan areas.

This sector of the model is adapted from the transportation model developed by Drew (1991). It accounts for two aspects of the transportation system, as illustrated in Figure 8. The demand side is accounted for in terms of *peak-hour traffic demand*, while the supply side captures *highway capacity*. The interaction of demand and supply is indicated by the *demand capacity ratio*. The need to adjust highway capacity to serve increases in demand requires land conversion from other uses, such as business and housing (as previously established in Figure 7).

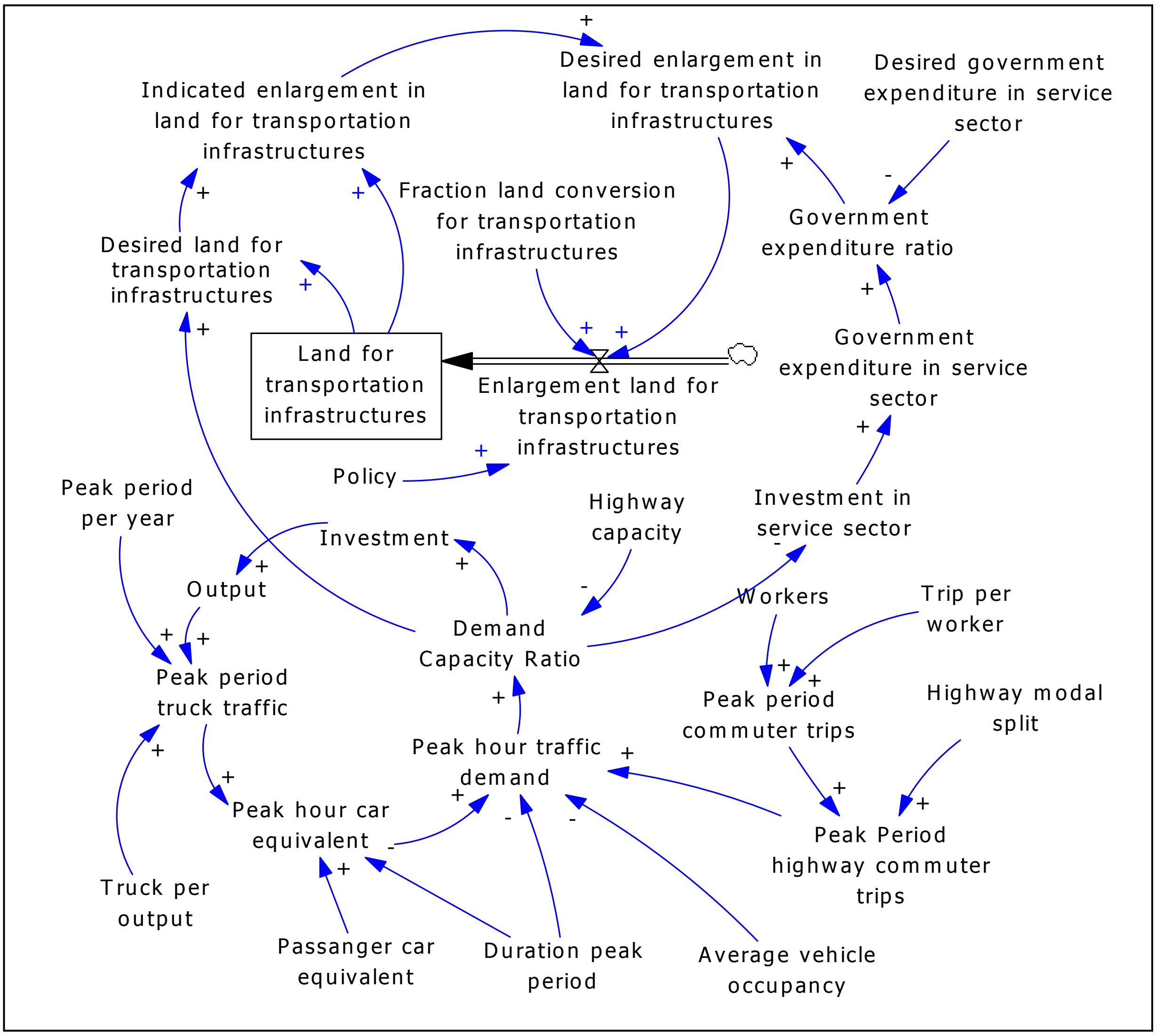

Figure 8. Causal loop of transportation sector

Although there are other types of trips, *peak hour traffic demand* is estimated from a combination of only two sources of transportation usage, transportation of goods in trucks and transportation of people commuting to and from work. Transportation of goods in trucks is denoted as *output* movement, and is represented by *peak-hour truck traffic*. It is converted into *peak-hour car equivalents*. Transportation of people is represented by *peak-period commuter trips*.

Normally, *highway capacity* is influenced by several factors, namely: number of lanes, side friction, width of road shoulder, and city size. In the model, we consider simply the amount of land required to fulfill the demand on roads, and other infrastructures that have spatial consequences. However, the submodel also accommodates the possibility of increasing *highway capacity* from the supply side, for example, by regulating *the average vehicle occupancy*.

The *demand capacity ratio* compares *peak hour traffic demand* with *highway capacity.* It serves as an indicator of the level of traffic congestion. Increases in this indicator denote pressure for conversion of land from other uses to transportation, in order to allow for expansion of the existing infrastructures. Also, it has an adverse effect upon the attractiveness of the area for business investments.

III. An Application of the Model

1. The Problem of Semarang City

This part of the paper will present the small experiment in applying the generic model of spatial planning described above to the specific problem of Semarang City.

Thus far, Semarang is the smallest of the Indonesian metropolitan areas, with a population of 1.6 million. Its growth rate is also the smallest, at two percent per year. However, if precautionary measures are not taken, it has the potential to develop in similar ways, expanding to the size of Medan (at 3.5 million), Surabaya (at 4.6 million), Bandung (at 6.72 million), or even Jakarta (at 11.8 million). This modeling effort, attempts to find ways to prevent such uncontrolled growth and its unintended impacts, by equipping urban planners and decision-makers with tools to examine and anticipate the results of alternative development policies.

The City of Semarang, the Capital of Central Java Province, is located on the north coast of the Java Sea. The northern part of the city lies on the coastal plain, and the southern part is on the hill sides, from the Candi Baru Area upward to the Town of Ungaran. Semarang is a busy administrative and trading city; most of the offices, business centers, and industrial estates are concentrated in the low land, whereas the hill sides holds the residential area. What is called the Semarang Metropolitan Area is known as the "Kedung Sepur" Area, covering Kendal, Demak, Ungaran, Semarang City and Purwodadi.

Semarang City is experiencing the typical problems faced by the other (bigger) metropolitan areas. Some problems include: traffic congestion is a problem on account of inadequate road capacity, aggravated due to the development of the peripheral area of the city. Spreading slum areas and limited availability of land for housing. Inappropriate land use in general and flooding caused by conversion of catchment areas in the hill sides. The provision of adequate basic infrastructures, such as drainage systems, allocation of land to appropriate use, and the pattern of development of the city in general, are key issues important to urban planners. Fortunately, the problems in Semarang are not yet as complicated as what has taken place in Bandung and Jakarta.

In specific, with respect to this modeling effort, and based on discussions with stakeholders in Semarang City, they are concerned with the improvement of their industrial sector, namely: how to attract investors to make use of Semarang industrial estates and the desire to change their industrial structures. With reference to the first issue, local decision-makers have provided some industrial estates in Semarang City, however, few investors have taken this opportunity to invest in the inner city because in the surrounding area the price of land for industry is considerably lower. Therefore, unproductive land in the urban center, and industrial expansion in the outskirts of the city, have become important problems to be solved from the perspective of spatial planning.

The development of the industrial sector in the city is said to have several advantages, such as increasing the tax base and employment opportunities, thus stimulating the urban economy, as reflected in the gross regional domestic product (GRDP). In addition, Semarang City wants to switch its existing industrial structures from "upstream" to "downstream industry." In other words, from the processing of "intermediate" goods to "final" goods. It is assumed that this shift will result in higher value added in goods produced and sold. *This paper describes some simulation experiments used to explore this developmental approach, based upon industrial expansion*. First is a look at model behavior in terms of a base-run that will later be used for comparison purposes against policy runs.

2. Model Behavior

This part will examine the model behavior of some important variables while using the magnitude of some existing paramaters in Semarang City. It is assumed that during simulation in the base run all urban aspects in the model will grow as they are based on available Semarang historical data. In simulating population sub-model, with existing population growth rate (and other economic magnitudes) and without adding any sources of attractiveness, the population inflow to the city will always increase. In not even 15 years, the number of inhibitants of Semarang City would approximately double and would steadily go up until the end of simulation time although its rate would become slower. And, from the base run simulation result in Figure 9, it is recognized that the source that has the highest contribution to the Semarang population growth originates from inflow population. But, the most important thing that could be learned from this result is that from the amount of population side, Semarang has the potential to equal other metropolitan areas.

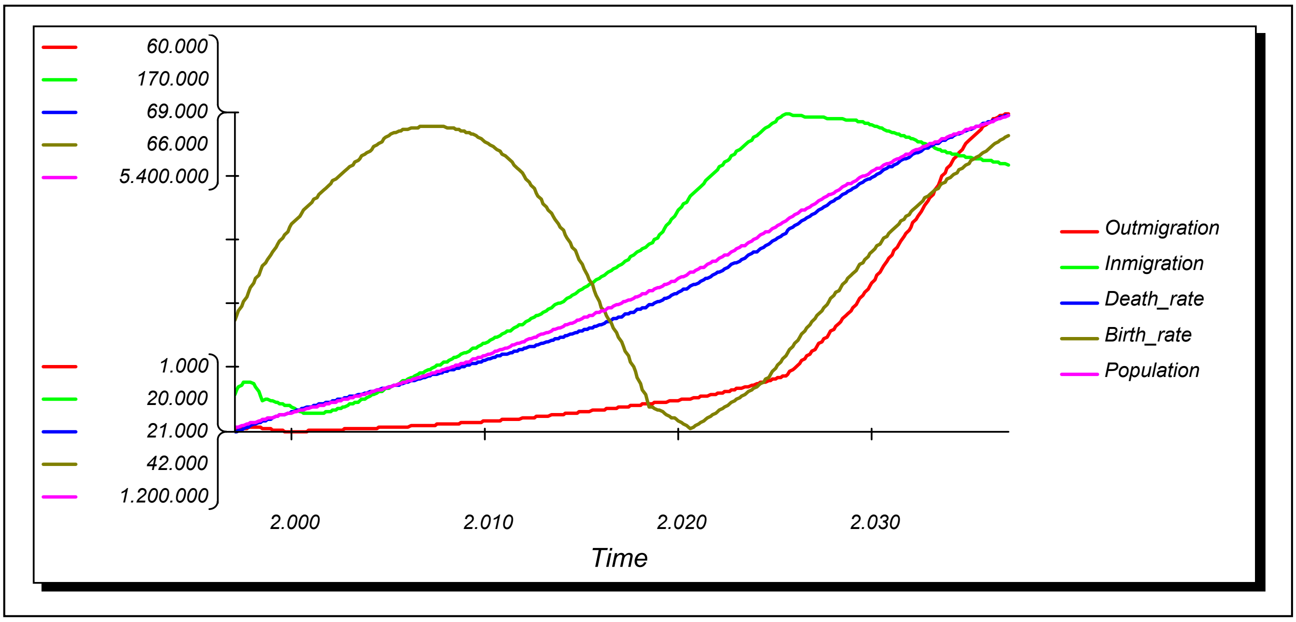

Figure 9 Model behavior of population change

Simulation in the economic sector (Figure 10 and 11) shows that the Hotels-Trade and Restaurant sector has the highest GRDP contribution to Semarang City (Figure 10) and achieves the highest growth rate in excess of other sectors (the picture doesn't show the agriculture sector because, from the simulation result, its contribution to total GDRP is very small, always declining and has a negative growth rate). Though lower than the former sector, GRDP in service sector tends to grow and has the potential to improve.

In general, a slow-down process in the growth rate of the economic sectors can be seen (Figure 11). Although originally, GRDP growth rate in industry (2) as well as hotels-restaurants sectors (4) are above total GRDP growth rate (1), in the long run, sharp declines come about particularly in the industrial sector while others can still maintain above average growth.

With respect to the concerns of urban decision makers: i.e., the development of industrial sector, the base run shows that the existing patterns will yield stagnation of growth in the long term. We can relate is phenomenon with the decline in interest to invest in the industrial sector in Semarang city (see Figure 12) and the inclination to select cheaper land for their industrial locations. This condition would certainly put a ceiling in the development of land occupied for the industrial sector (see Figure 14) though as a matter of a fact available industrial land still exists. The consequence is a decline for desired growth of industrial workers (see Figure 13).

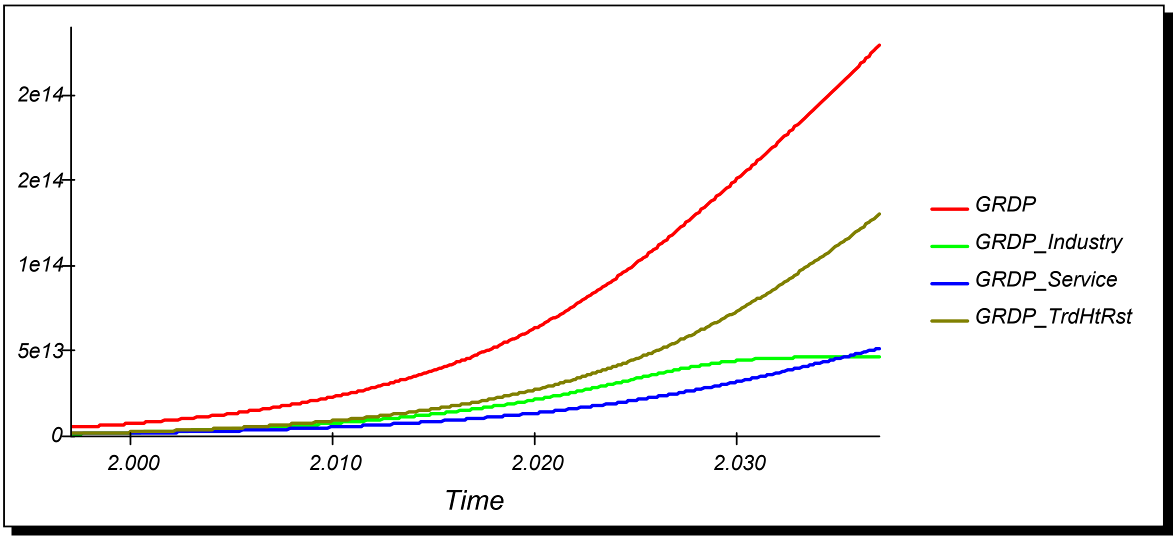

Figure 10. Model behavior of Gross Regional Domestic Product

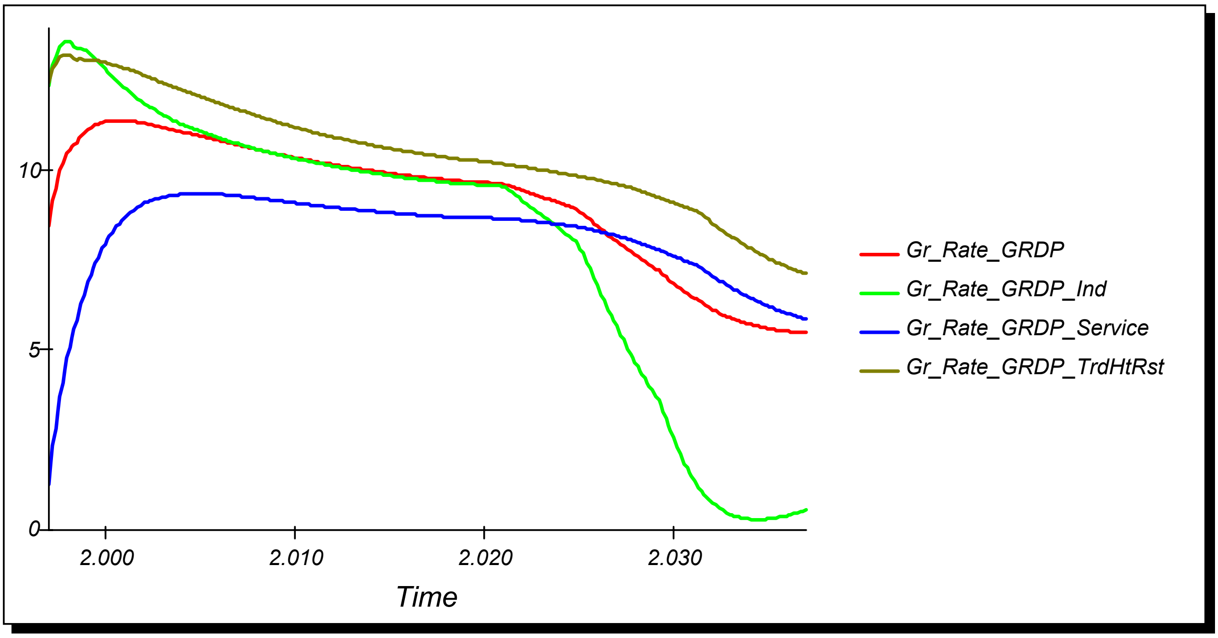

Figure 11. Model behavior of GRDP growth rate

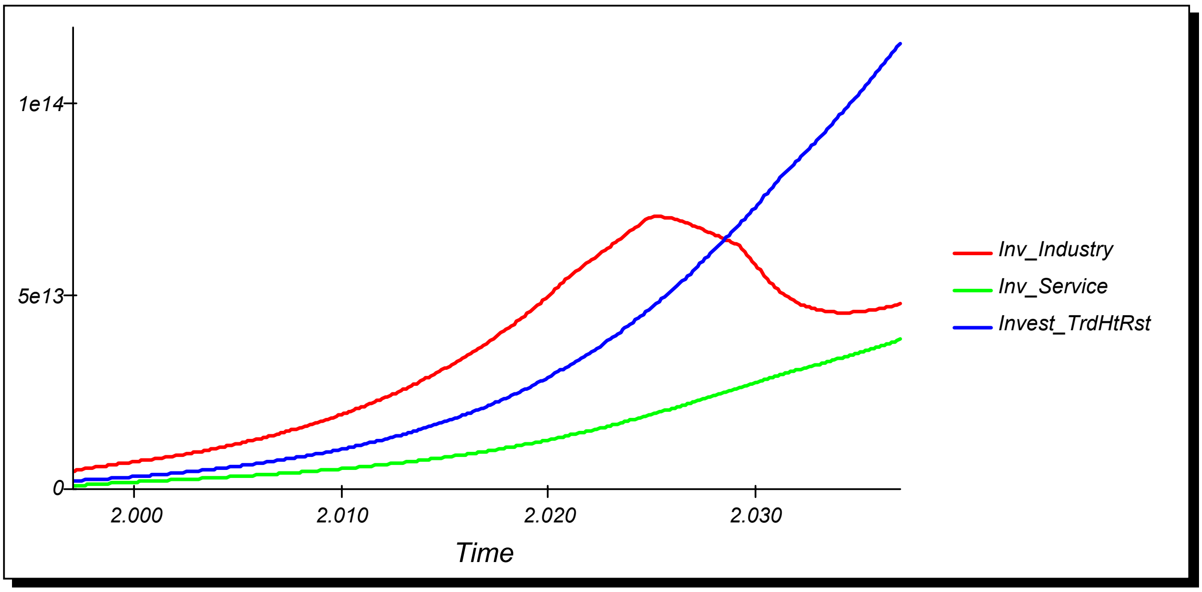

Figure 12. Model behavior of investment

How do these situations influence the unemployment rate? The simulation resut in Figure 13 indicate that the the development in the economy (that might happen) in the short and medium term will reduce the unemployment rate (5). However, in the long run, unemployment rate would maintain its rate roughly above 15% per year.

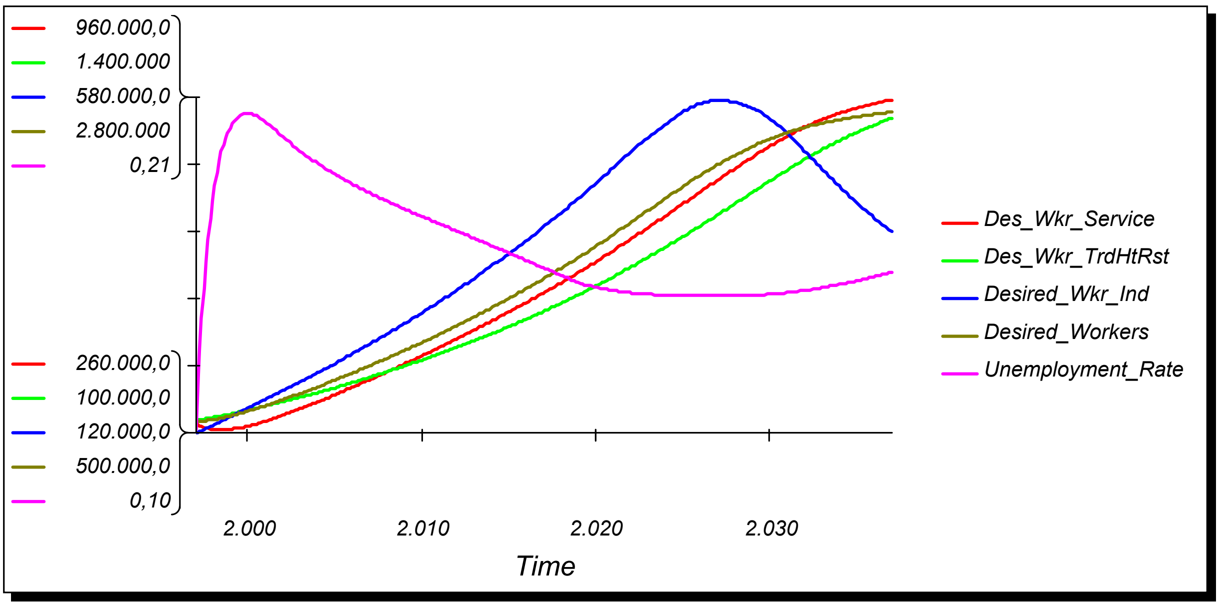

Figure 13 Model behavior of desired workers and unemployment rate

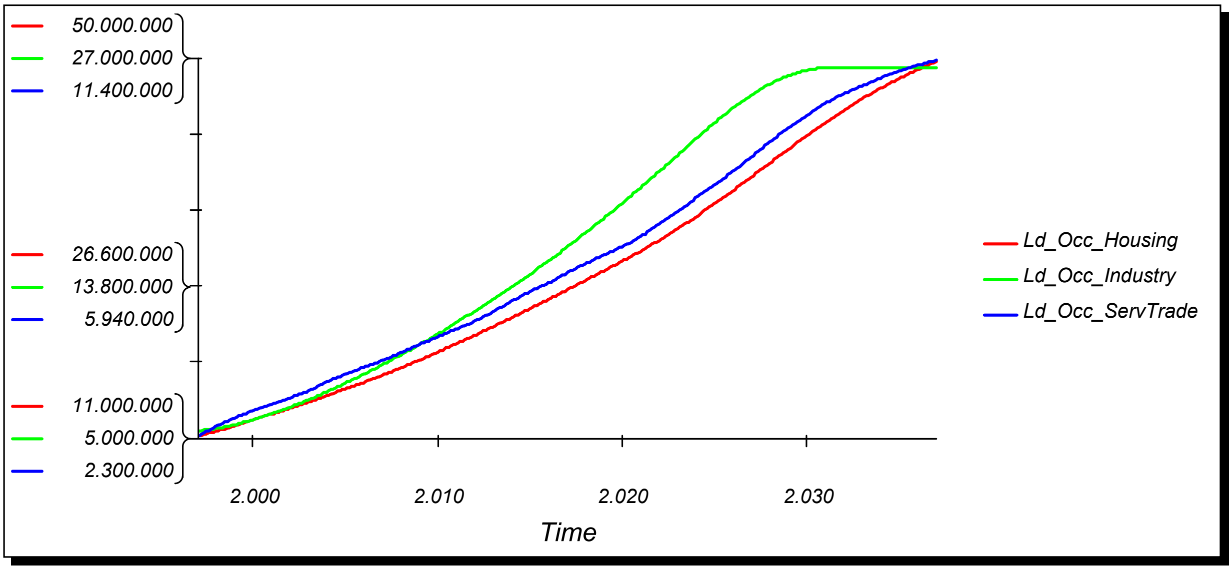

Figure 14. Model behavior of land occupied

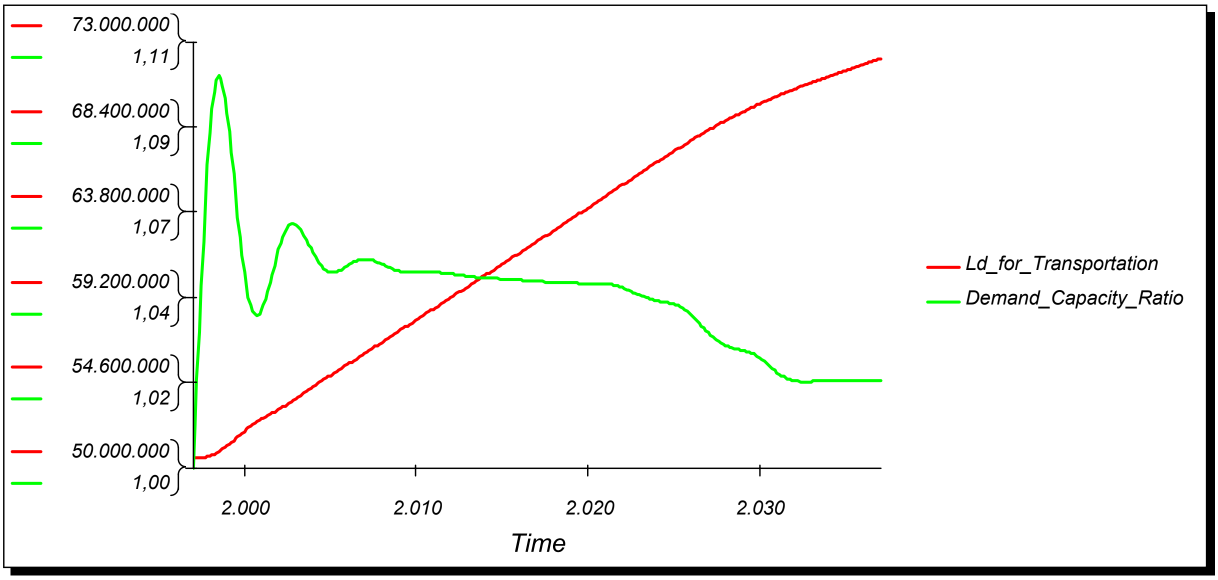

Figure 15. Model behavior of demand capacity ratio and land for transportation

It has been mentioned above that the model also incorporates the transportation sub model because it plays a major role in determining the economic development of the city. Something that can affect the increase or decline of the economic sector is the level of congestion, denoted by *Demand Capacity Ratio (DCR)*, which divides *peak period commuter trips* with *highway capacity*. If the ratio value is above one, it means that the congestion level rises. From the simulation result shown in Figure 15, looking at the beginning of the simulation year, Semarang City has begun to have a more complicated traffic problems caused by traffic congestion. Because of the congestion, the ratio will always be above 1, if there is no intervention to overcome the situation.

Considering the traffic congestion problems and the interest in investing in Semarang, how far are these factors able to be a negative feed-back to the economic development? In the investment simulation we saw, with the exception of industrial sector, that stagnation in GRDP growth doesn't occur in two other sectors. In conclusion, the congestion level of traffic is not the dominant factor that affects the limited long run of urban economic growth compared with the effect of land price.

One explanation for such behavior in transportation sector is that the model assumes, adjusment measurement is always undertaken for providing transportation infrastructure, so that very little changes in other sectors, don't yet affect long run traffic congestion level very much.

The main question which we address using this model is the consequences of choosing to develop the industrial sector and to change the industry to emphasize more of final goods. Will this development strategy yield the desired outcomes in term of urban land use and quality of life? The next section attemps to address this question through a set of simulations of six policy alternatives.

3. A Search for an Appropriate Strategy: A Policy Analysis

In using the model in attempt to search an appropriate strategy for a case of Semarang, we experiment with the following set of policy options:

(1) Policy 1: *Base run*; a point to compare with the simulation results from other various policies.
(2) Policy 2: *Transformation in industrial structures from upstream industry to downstream industry*. The intervention is executed by changing following parameters:

- To reduce the land per worker standard for industry with assumption that its requirement for downstream industry would also decline
- To reduce value capital output ratio from 5 to 4 with the assumption that in the downstream industry, output yielded has higher value added, or ratio between input to output becomes smaller
- To increase the labor productivity value in industrial sector from 5% (historical data) per annum to 7% per annum

This changes are commons to policy 3.
(3) In policy 3, land price growth rate of surrounding area is lower than in the city. This change is common to policies 4 and 5 as well.
(4) Policy 4 depict the trasformation of industry through higher investment growth rate. This change is common to policy 5.
(5) Policy 5 adds a shift in land use in order to provide more spacious land for industry. Through market mechanism/ government intervention, it is expected that the inner city becomes cheaper.
(6) Policy 3: Besides restructuring the existing industry, this policy strives to shift the emphasis of Semarang's economic development by enhancing the investment in service sector rather than pushing the industrial sector. This policy is examined in contrast with the industrial development approach. It serves to explore the potential benefits of adapting, alternatively, a strategy focused upon service sector.

In brief, the alteration in some essential parameters for each policy can be summarized as follows:

Table 1.
Some essential parameters and the changes in each policy option

		Land/Worker	KOR	Workers productivity growth	Land price growth rate of surr area	Desired industrial investment growth rate	Land conversion for industrial area	Desired export growth rate in service sector	Desired service investment growth rate
		(m2/worker)	(Rp/Rp/year)	(%/year)	(%/year)	(%/year)		(%/year)	(%/year)
1	Base-run	50	5	5	7	10	Not allowed	7,8	7,8
2	Industrial structure	30	4	7	7	10	Not allowed	7,8	7,8
3	Land price of surrounding area	30	4	7	4	10	Not allowed	7,8	7,8
4	Increase industrial investment	30	4	7	4	15	Not allowed	7,8	7,8
5	Expand land for industry	30	4	7	4	15	Allowed	7,8	7,8
6	Increase service investment	30	4	7	7	10	Not allowed	10	10

The simulation result from above policies produce following results:

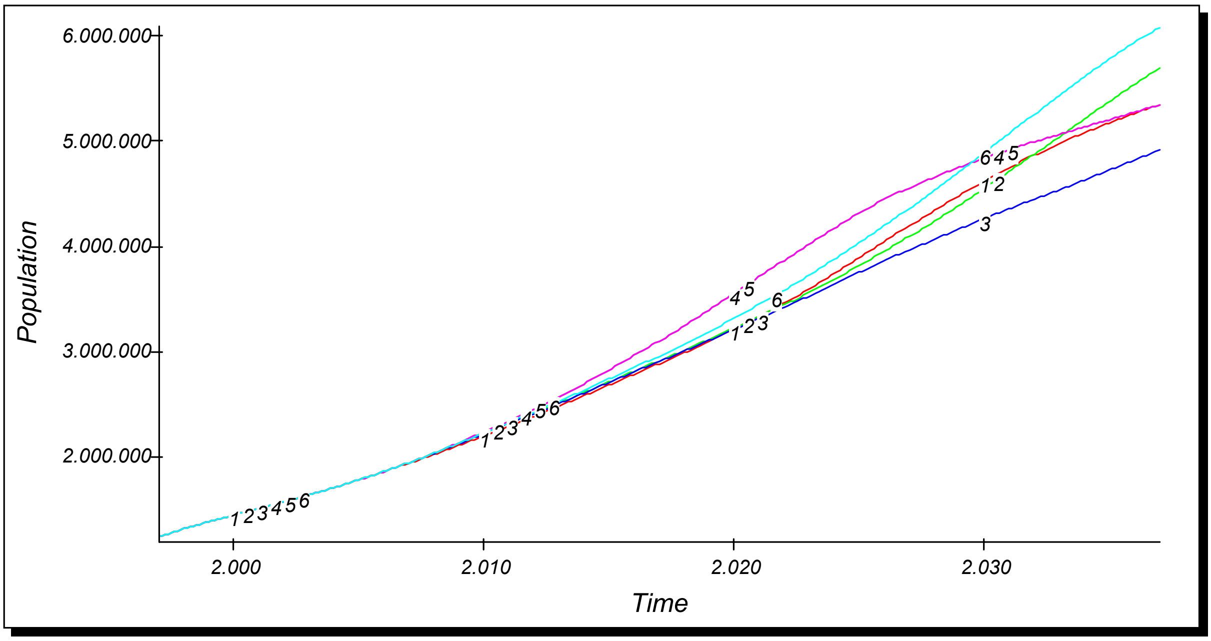

Figure 16. Simulation result of population variable

Population:

We start the analysis with the description of the adoption of two desired transformations of Semarang City: First transformation is, to emphasize more on *downstream industry* (policy 2). Second transformation is to spur on the investment in industrial sector (policy 4). The simulation results show that industrial restructuring with or without measurement to increase industrial investment are unable to restrain the population growth (Figure 16) and population inflow to the city. (Figure 17). By applying policy 2, the model produces an increase in population in almost the same as the base run. By applying policy 4 would population increases in the short run but, in the long run, population is almost the same as the base run.

The simulation of all factors that affect the change in the population number in this analysis, only represented by in-migration since what we grasp from model behaviour in the base run, it has the highest contribution to increase the population number. Figure 17 demonstrates that policy 2 (transforming industrial structure) and policy 6 (pushing investment in service sector) would bring about the highest in-migration rate and number of population as well. In both policies, the population number would reach almost 6 million, at the end of the simulation time. While policy 4 and 5 affect the inflow temporarily until the middle of simulation time, then it falls down below the base run.

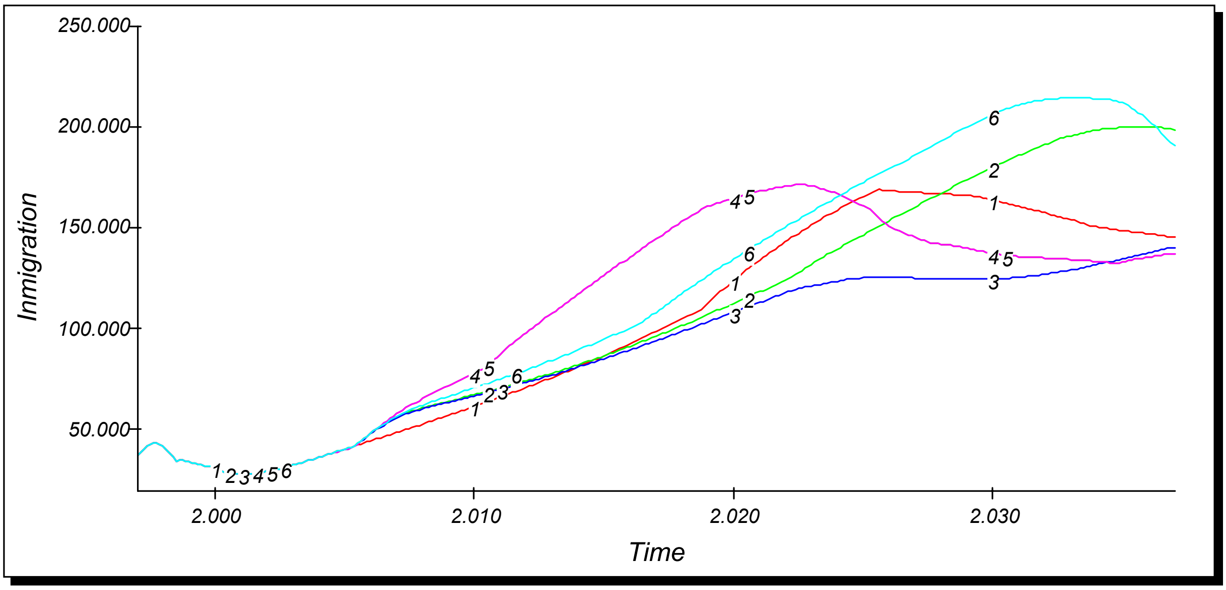

Figure 17. Simulation result of in-migration

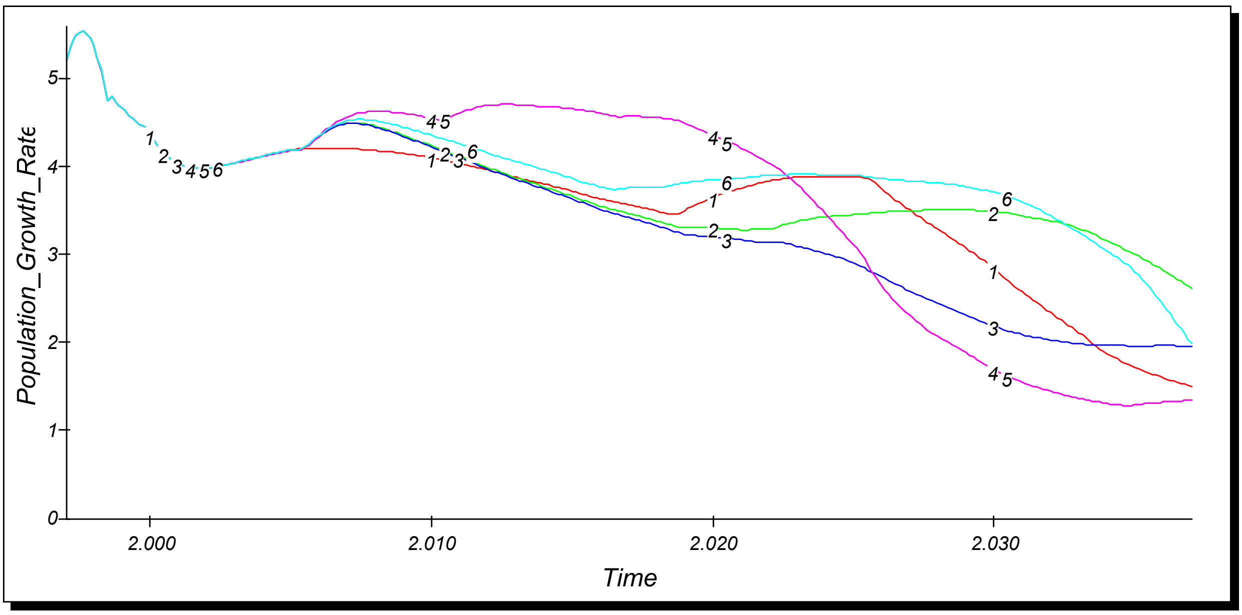

Figure 18 Simulation result of population growth rate

As a whole, we see that all policies can't restrain the speed up of population growth rate. However, the trend of slow down process would occur (Figure 18) in the long run. Population growth rate is still higher than average national population growth rate.

Policy 3 is common to policy 2 (restructuring the industrial sector), but we incorporate the pessimistic assumption that the land price growth rate of surrounding areas is lower than inner-city. The simulation result shows that the population growth is lower than all policies option. This condition will affect the effort to alleviate unemployment. It produces the highest unemployment rate (Figure 19), lowest GRDP total as well as the stagnation of GRDP in industrial sector. In respect to the high unemployment rate, we can relate this to the lowest GRDP resulting from policy 3 which also means the smaller number of workers needed. So far, policy 4 and 5 would give rise to more controlled population growth, in the long run.

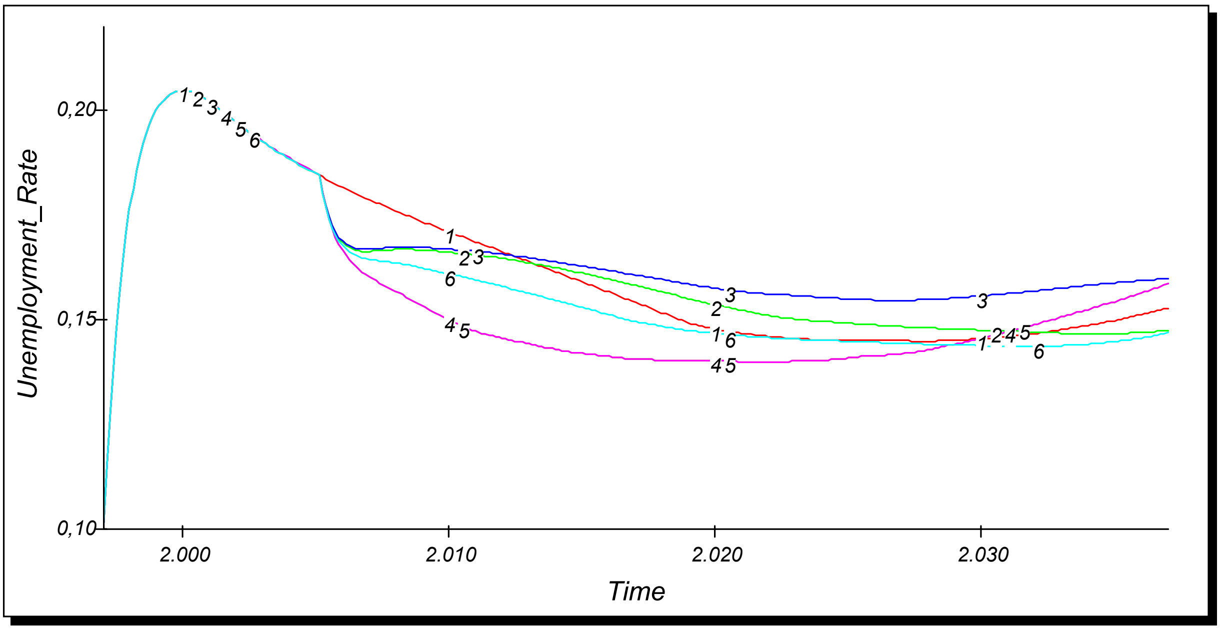

Figure 19 Simulation result of unemployment rate

Economic Sector

As previously stated, an apparent indicator of urban economic development is the increasing in the value of *GRDP*. It is achieved through policy 2 and 6 where in the long run its growth rate would surpass the base-run (Figure-20). However, the indication of the slow down in its growing process was apparent in all policies. It can be observed from Figure 20, where *GRDP growth rate* in both policies go up roughly 9-10% per year. Afterwards there is a downturn until around 5-6% per year, but it still transcends a trend in base-run growth rate.

With reference to the adoption of policy to shift existing industry toward higher value added industry, the simulation result signify that it able to trigger long-run GRDP growth rate in industrial sector (Figure-21), but have little impact on the improvement investment in other sector (in this paper, it is represented only by service sector in Figure-22) as well as total GRDP which is almost the same as the base-run. On the other side, it also creates more jobs in industrial sector (not shown in the picture) or total in all economic sectors in the long-run.

The pessimistic projection for the same policy is also applied (policy 3) a taking the uneven land price growth rate between Semarang and surrounding area into consideration. It brings about the worst result viewed from urban economic development standpoint (the lowest GRDP, the least in creates job opportunities, the highest unemployment rate, the smallest impact in triggering investment in other sector).

Most similar result is shown in policy 4 (striving to enhance the industrial sector) and policy 5 (possibility of land conversion into industrial area). The result demonstrates that GRDP total lower than the base run. GRDP in industrial sector increased temporarily but after that it fell and became lower than initial simulation. However, it produces the lowest unemployment rate and tends to flatten until the middle of simulation time, around 10% per year. But, in the long run, the figure is higher than the base run.

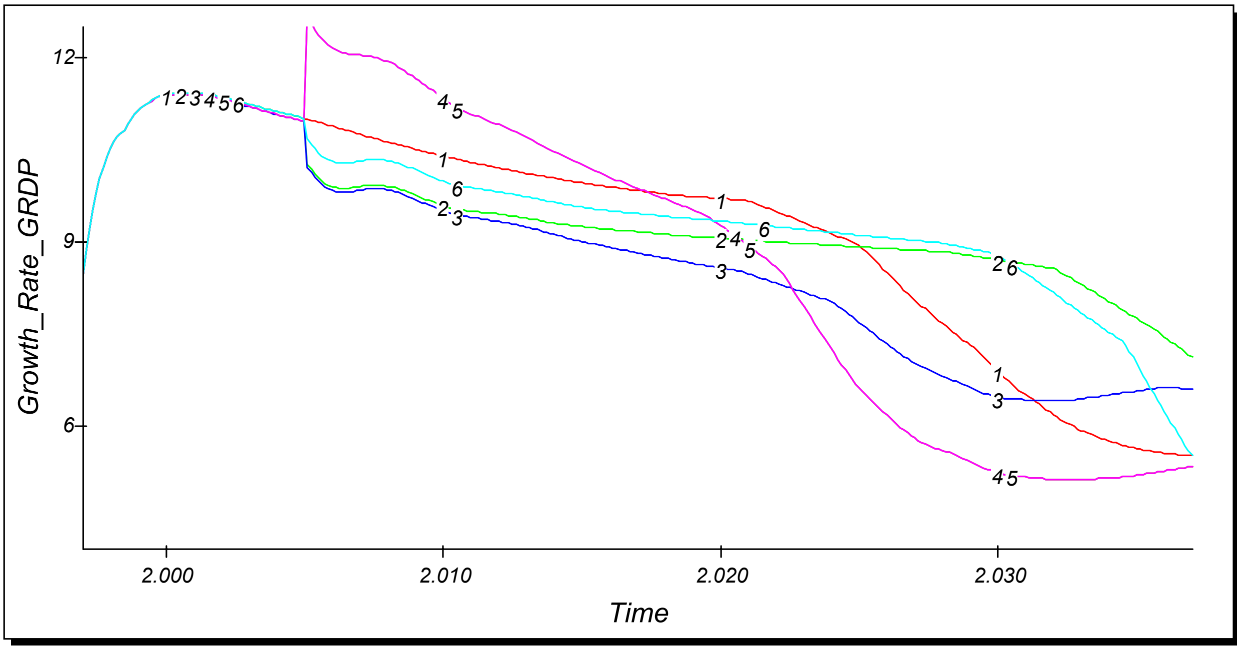

Figure 20. Simulation result of GRDP growth rate

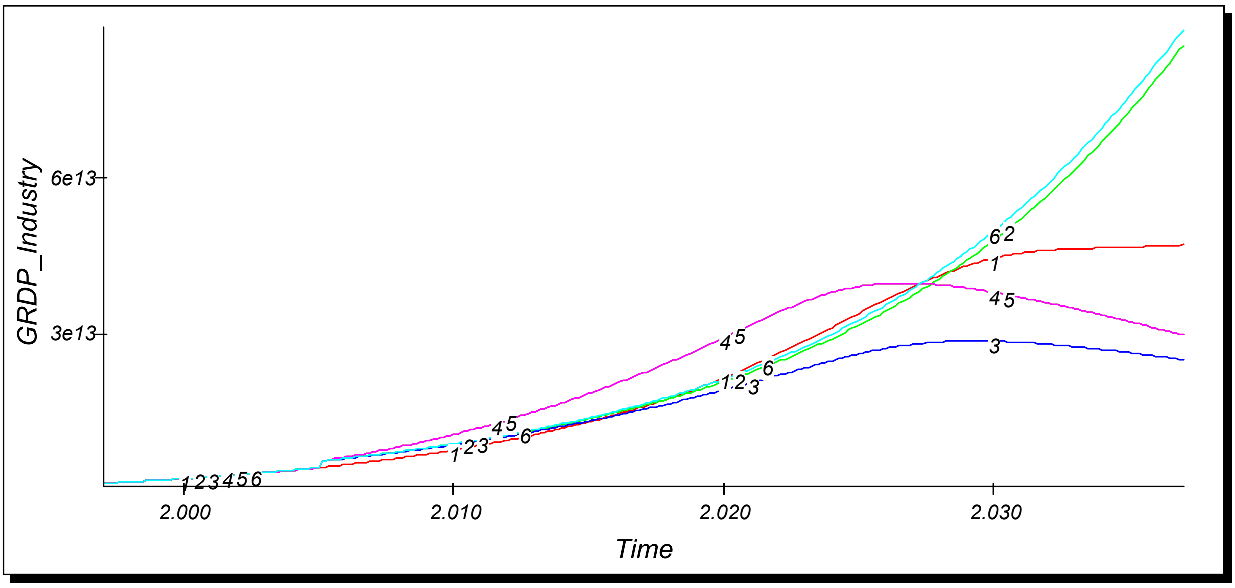

Figure 21 Simulation result of GRDP in industrial sector

An interesting situation is found in policy 6. Without pushing industrial investment, but emphasizing more in the service sector, besides restructuring existing industry, yield the expected outcomes: longer sustainable urban economic growth rate in industrial sector, which, in turn, could absorb more workers and decreasing in unemployment rate compared with the base-run. In addition, this policy, along with the policy 2 pushes as well the GRDP total higher than other policies in the long run. In sum, it is able to trigger the development of other sector.

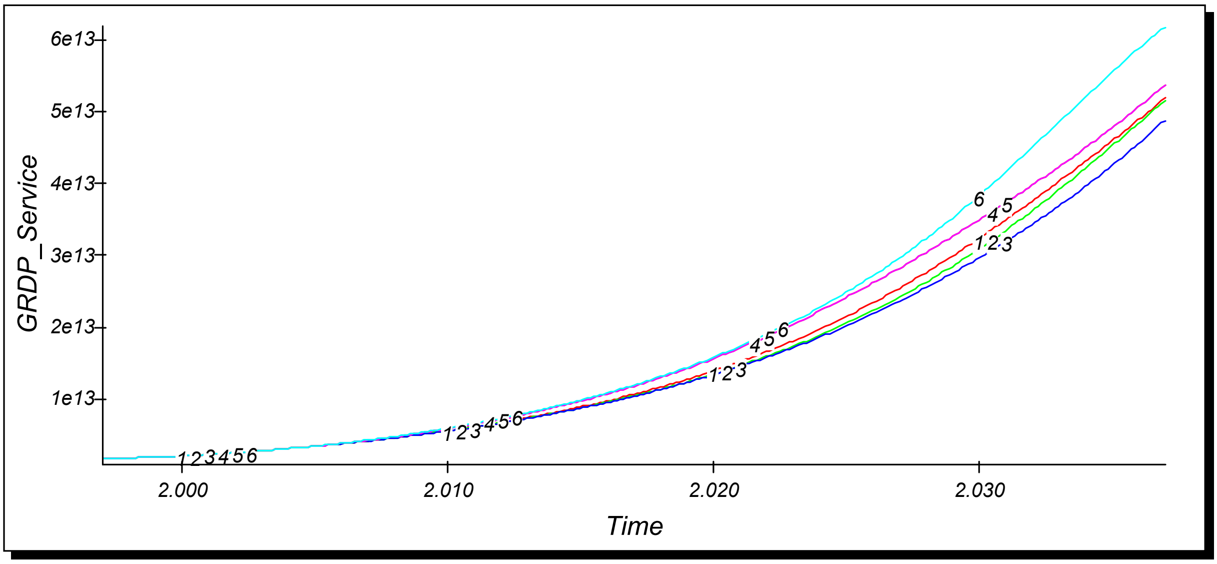

Figure 22. Simulation result of GRDP in service sector

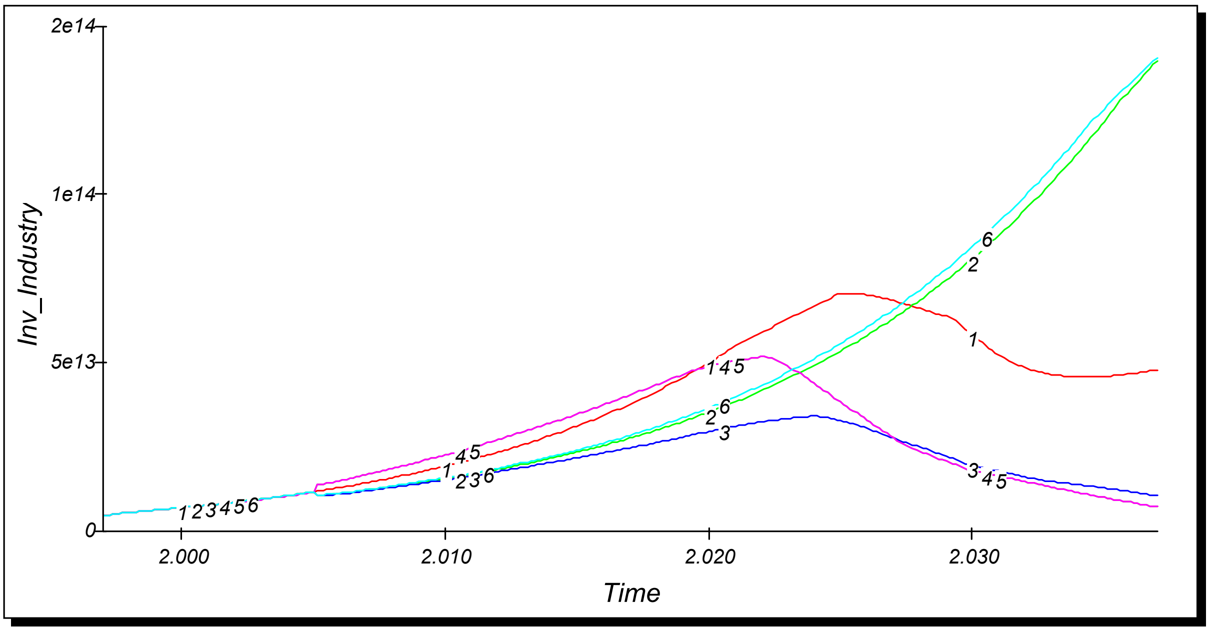

Figure 23. Simulation result of investment in industrial sector

The result could be reached because in the model we also integrate the input-output computations which consider the linkage among sectors. In other words, what we strive to show from above policy option that measurement to push in one sector could create demand even improvement in the other sector.

The reason behind choosing other sector (in this simulation, service sector) to push urban economy is the consideration concerning the position of Semarang City with surrounding area, Central Java Province in general, and its role as a major traffic route that connects west part of Java Island to East Java. Semarang seems to become the "transit" place for all movement (people and goods) from east to west and reverse; and Semarang can take benefit from this condition without having to force itself to become an industrial center as well; in fact it is unable to compete with other surrounding areas.

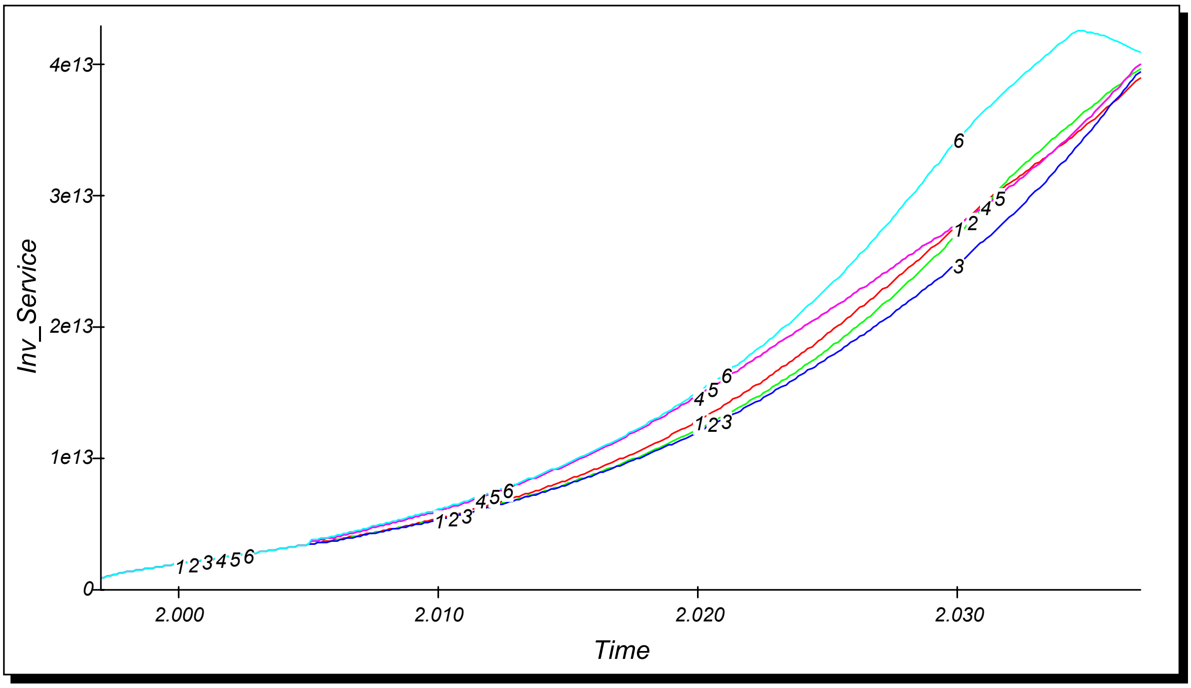

Figure 24. Simulation result of investment in service sector

Hotels and Restaurants sectors are more prospective sectors to be developed. It is essentially service sector, but in the model is separated due to its highest contribution the GRDP of Semarang City (around 40.96% to the total Semarang GRDP in year 2001, compare with the contribution from agriculture sector 1.84%, industrial and mining sector 27.94% and 29.26% from other service sector (financing, ownership and business services, transportation and communication, electricity, gas, water supply and construction). However, we experimented with service sector alone without hotel and restaurant sector because the latter has proven its contribution. If we dig out further regarding Semarang, it has some facilities which can take advantage of the industrial development in surrounding area as well as the movements of people and goods between the east and west. This is the main reason to alter the direction of its policy to service sector in our simulation.

However, if we observe more carefully, it can be obtained because of an optimist projection that the land prices growth rate, both in and around the city are similar. Unless, uneven land price growth rate would lead to different results. Then, the policy 4 or 5 is better to produce higher economic growth and at the same time, more controlled population growth rate than pushing the service sector.

Land Sector

The main purpose to demonstrate the land sector simulation result is to recognize how much the measurements to push the industrial sector will affect the land occupied in each sector. Based on the simulation result we can see that without any intervension, land occupied for industry will increase faster than all five other policies, before it becomes stagnant (Figure 25). The cause of this behavior is the measurement to restructuring industrial sector applied in whole policies and requiring lower number of laborers and smaller space. However, if we view from the effectiveness the land use for industry, the situation seems worse in policy 3 where industry is totally not developed or *land fraction occupied* only around 0.3 of its availability. It is because in this policy we assume that the rate of land price in the city doesn't grow at the same speed as the peripheral areas. Subsequently, in policy 4 & 5, land fraction occupied for industry seems higher but the same stagnation is taken place in the long-run (roughly 0.45). With both policies to change industrial structure (2) and increase the investment in service sector (6), the growth of occupied land seem very slow but its trend is steadily upward, and if we relate to the GRDP production, it creates the highest growth rate.

Meanwhile, the development of land for trade & service as well as land for housing (not shown in this paper) tend to rise until the end of simulation time. However, the main cause of both behaviors is the growth of the population since the needs assesement for both in the model is affected by population prediction and using the existing land standard required either for housing or service in spatial planning. The change in population is influenced indirectly by the rise in output and number of workers and in turn it has impact on income percapita, death and birth rate as well as in and out-migration. In sum, the policy option most triggers the development of land use for housing and service is policy 2 and 6; in our simulation this also is most influential in increasing the number of population.

Although it is not shown in this paper, the simulation shows that the land for agriculture is declining. Meanwhile, the land for conservation remain unchanging in all policies because the model assume it is untouchable.

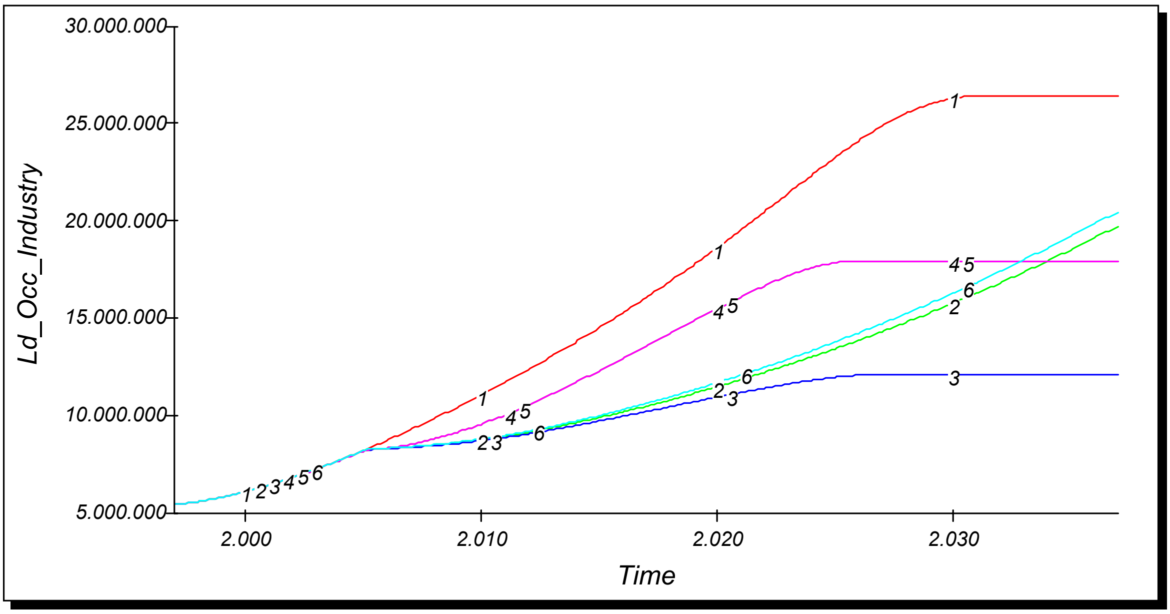

Figure 25. Simulation result of land fraction occupied for industry

Transportation Sector

All policies have been tested in the model and originally yield the high fluctuation in transportation sector in producing high level congestion. It concurs with development of economic activities, but only in the short run. In the long run, in all policies the situations tend to decrease and its fluctuation value is around 1-1.05, a tolerable ratio which means that the traffic congestion level is not too complicated.

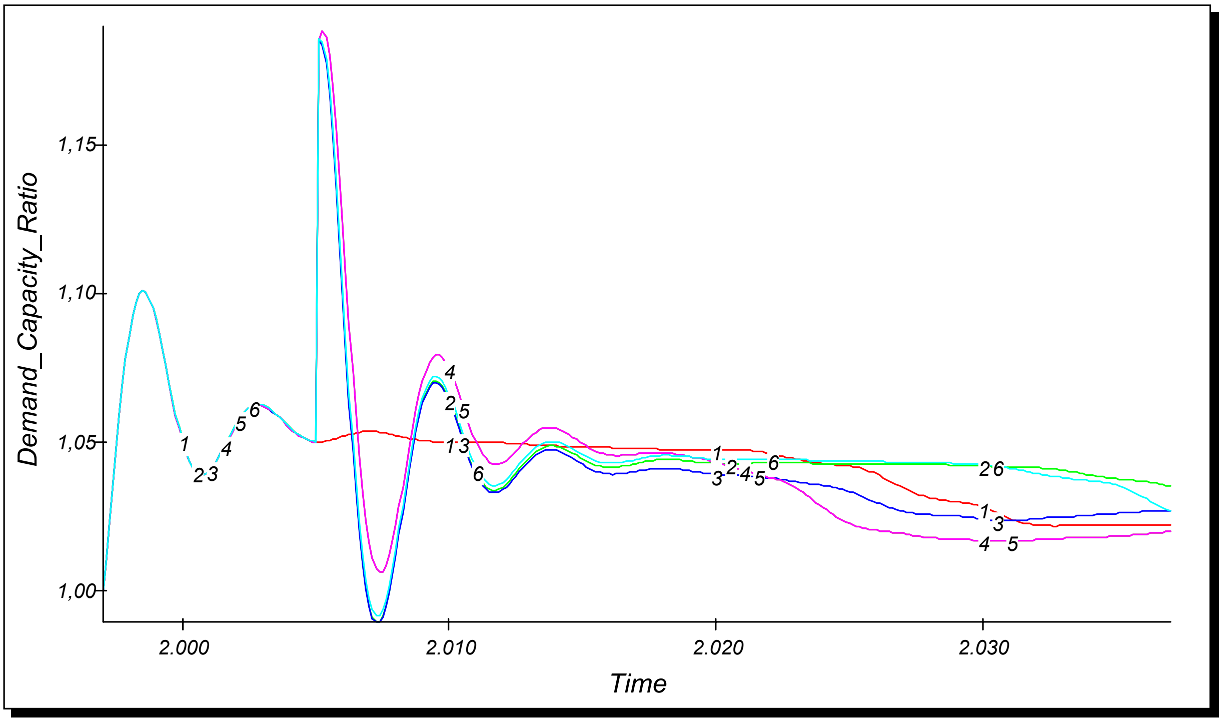

Figure 26. Simulation result of demand capacity ratio

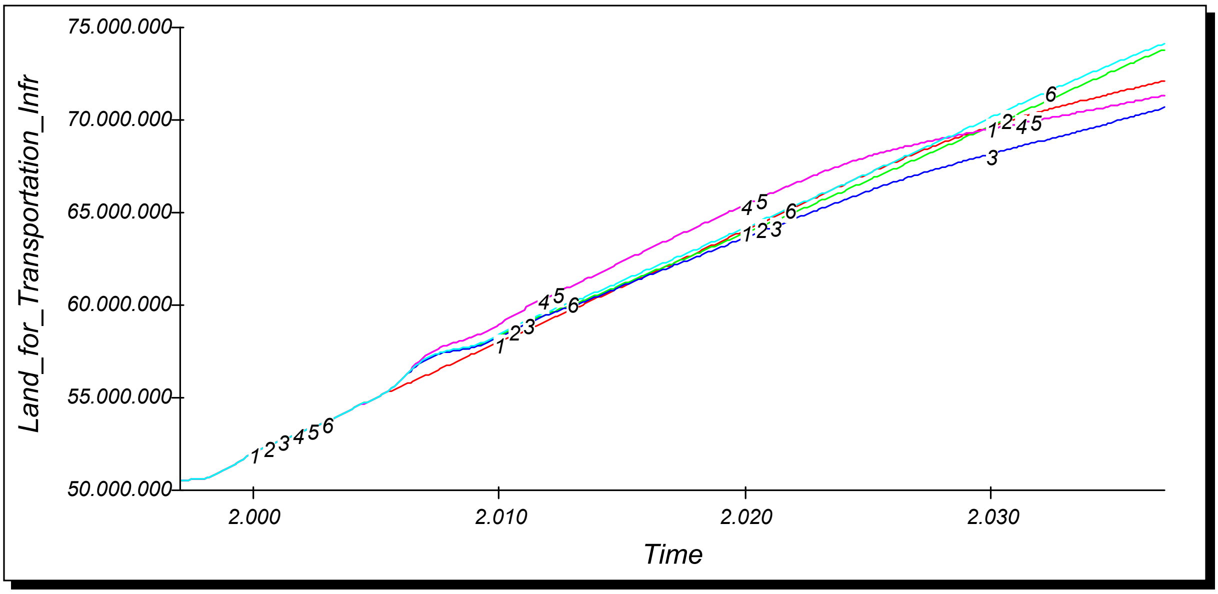

Figure 27. Simulation result of land for transportation infrastructures

And we relates this to the Semarang situation itself whose space area still large enough to accommodate the existing growth (its area scope is 37.367 ha and its density around 37 people/ha compared with Bandung that area scope is only 16.750 ha and density 151 people/ha based on prediction for year 2000).

In addition, the simulation results demonstrate almost similar behavior with our base run model behavior. It can be said that for Semarang City, the congestion level hasn't become a constraint yet to the investment growth rate (in all economic sectors), which in turn will affect the GRDP growth rate. In contrary, the reduction of traffic congestion level in the long run might concur with the slow down process of industrial sector as a one source which generates both output and industrial workers movement. From the simulation result, we also can grasp that shifting in industrial structure produce higher traffic congestion level higher in the long run than base-run result. If the ideal value of DCR is around 1, the nearest value achieved by policy 4 and 5 which is fairly good in yielding expected outcome.

However, we want to note that, although simulation of transportation results represented by a picture of DCR can lead us to draw a conclusion that the congestion level doesn't affect the urban economic situation, but it might occur because of optimistic assumption within the model. This can be seen in Figure 27, that expansion in the land for transportation infrastructures always complies with the development of modeled economic sectors.

IV. Conclusions

This work is an attempt to provide urban planners and policy makers in Indonesia with a "micro-world" in which they can experiment with their policy options, prior to adoption. This helps them test their mental models regarding the solutions they see for the problems associated with rapid urban growth in Indonesian metropolitan areas.

The application to Semarang City is a case study, and a part of a larger project aiming at building a generic model for spatial planning for metropolitan areas in Indonesia. In this particular case, we found that the original idea of investing in the industrial sector, shifting the industry from upstream to downstream, and making more inner-city land available for industrial purposes turns out NOT to be the best strategy for improving the quality of life and solving urban problems in Semarang City.

Alternatively, it appears that investing in the new and increasingly attractive service sector may produce better outcomes to Semarang. The reason behind choosing service sector to push urban economy is the consideration concerning the position of Semarang City with surrounding area, Central Java Province in general, and its role as a major traffic route that connects west part of Java Island to East Java. Semarang seems to become the "transit" place for all movement (people and goods) from east to west and reverse; and Semarang can take benefit from this condition without having to force itself to become an industrial center as well; in fact it is unable to compete with other surrounding areas. In addition, Semarang has some facilities which can take advantage of the industrial development in surrounding area.

While these are only preliminary results, we feel confident that this approach is useful because it is able to show the trade-off among sectors and times. In our experiments by using the model, for example, it is able to demonstrate that almost all policies directed to raise the economic performance of urban area have an effect in the raising population number. Therefore, any policies in population sector are unavoidable measurements that have to be undertaken and can't be excluded from any other policy option. The early warning from our simulation is expected to yield policies that are able to anticipate the unintended impact in other sectors. In our experiments, it should produce the policies that can be hold down an ever increasing population in urban areas.

The next steps in this research project are:

- to incorporate some important variables that are not embraced in the model, such as environmental issues and public revenue that can limit the levels of infrastructure investment.

- to continue our experiments with some alternative policies in order to obtain the better results.

- to continue our analysis of the roots of problems that influence complexities of metropolitan areas in Indonesia.

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