An Evaluation System of Policy Alternatives based on TRANUS from the Viewpoint of a Compact City

Chapter 3

An Evaluation System of Policy Alternatives based on TRANUS from the Viewpoint of a Compact City

Kazuaki Miyamoto
Varameth Vichiensan
Muhammad Sani Roychansyah
Yukiya Sato

Abstract: A concept of sustainability has become a paradigm in urban development and there is also a belief that the sustainability could be achieved by compact development. Although there are many definitions of compact city such as a high density city, a mixed-used city, or a city with efficient public transportation system; most have been discussed descriptively or qualitatively. Compact city has been dominated in many fields of study including urban planning, urban/built environmental design, and urban geography; however, there are many shortcomings there. For instance, the discussion is too descriptive for the real implementation, or lack of empirical evidence of the environmental impacts such as energy consumption, transport emissions, loss of open land, etc. This paper presents a quantitative analysis scheme that considers a long range of time over generations of the residents. This approach of analysis has made the compact city and sustainability be discussed more clearly and effectively. The discussion in this paper is based on the empirical result of TRANUS Sapporo model. The simulation framework is set to have a decrease of population in the later year. It is found that the city will be sprawled if no appropriate policy measure is taken. In contrast, the city becomes more compact when combinations of appropriate policy measures are taken. The compactness is evaluated from several aspects: as land-use, transportation, environmental, and, most importantly, financial viewpoints which consider the development cost.

1. INTRODUCTION

The idea of sustainable city is a new paradigm for urban development in the world. The principle of sustainability is known as the development that meets the needs of the present without compromising the ability of the future generation to meet their own needs'. Furthermore, there has been growing support in the recent years, mainly in the industrialized countries since the idea of a compact city is one of the popular alternatives for urban form facing the sustainability paradigm (Jenks, et al., 1996; De Roo and Miller, 2000). This concept has emerged primarily in response to the acknowledged need to find more sustainable models for towns and cities in the world. On the other hand, there are also various definitions for the compact city, although it is generally regarded as a high density and mixed-used city with an efficient public transportation system that encourages walking and cycling (Burton, 2002; Newman and Kenworthy, 1999; Breheny, 1997). However, both sustainable city and compact city have been mostly discussed qualitatively; but rarely discussed quantitatively. The present study has objectives to produce an analysis scheme for a city where the policy alternatives can be discussed quantitatively from the viewpoint of compactness and sustainability over generations of the residents as shown in Figure 1.

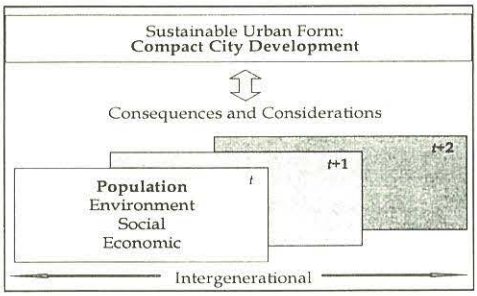


Figure 1 Compact City Development and Intergenerational Consideration

2. COMPACT CITY STUDY: THE PRESENT SITUATION

In this section the state of the art of 'Compact City' literatures is briefly summarized. It is now widely accepted, particularly in urban development, that the most important in the urban planning is a sustainability concept. It plays an important role in shaping and raising the quality of urban living conditions. Despite important recent progress in measuring urban environment quality and performance, we know little about what makes a city sustainable. We only keep that plans should address the economic, environmental and social health of the city and this task can only be accomplished by approaching each of these issues at different scales (see for example Marcotullio, 2001). Alberti (1996) has stated that there is no consensus on how to define sustainability, nor is there consensus on city size, form, and spatial of activities best facilitate the rational allocation of natural resources and minimize environmental impacts.

The search to make realization of urban form and sustainability is currently one of the most interesting tasks on the planning fields. The way that cities should be developed in the future, and the effect of their form can have on resource depletion and social and economic sustainability are central of these tasks (Jenks, et.al., 1996). One common answer seems to be used planning systems to achieve environment improvement, and in turn, use the planning systems to achieve greater urban compaction (Breheny, 1996). The arguments that compact city can be as a representative urban form to describe a sustainable urban form, have been commonly accepted that a degree of compactness, in any several forms, reduces demand for car travel. However, the indications are that the success, desirability, and achievability of compact city are equivocal (Thomas and Cousins, 1996).

2.1 Compact City and Smart Growth

Recent issues in worldwide urban planning strategy approach, mainly the idea of concentration activities in central city, as proposed both by compact city strategy and smart growth strategy receive greater supports to real actions, mainly in Europe and the US. The philosophy of both strategy are quite the same, that is based on assumptions and also greater facts that low density residential development in general, and large lot home sites in particular, are frequently held up as the epitome of inefficient, costly and wasteful for urban land use. Low density, dispersed development is often portrayed as harming the environment. In particular, the argument is made that this pattern of growth spreads air pollution as a result of more commuters and increased automobile trips. The anti-sprawl growth as well as the supporter of concentration growth's arguments are often heard to the effect that land use policies should limit growth to areas served by mass transit, and to encourage higher density developments within the areas so as to make public transit more economically viable. With greater public transit use, air pollution generated by cars would be reduced. Table 1 provides the comparison in detail between these two strategies, compact city and smart growth strategy.

Table 3.1 Comparison of the Concept of Compact City and Smart Growth

Aspects	**Compact City Strategy**	**Smart Growth Strategy**
Country	Europe Australia Japan?	America Canada
Policy	Government regulation Top-down approach Local government initiative	Community based Bottom-up approach Nation wide movement
Core	Compactness	Anti-Sprawl
Definition	An urban policy strategy in line with sustainable urban development efforts that a process to perform higher density urbanization, mixed use development in central area, towards benefits in all dimensions of urban life	A movement to stop any dispersed development outside of compact urban and village centers along highways and in rural countryside that caused uneconomic of services and doubtful social value
Objectives	A concentrating positive growth and activities in appropriate areas, all at once avoid negative impacts on natural resources, and getting more benefits on social/economic factors by a compactness development process.	A desired pattern urban development that designate boundaries areas and create economic incentives for development to take place within an appropriate area together with a strong comprehensive plan, with broad public input for the best way of a community or region
Principles/ Attributes	Higher density Mixed use Process (concentration etc.) Urban scale (economics, structure) Transport efficiency (environment dimension) Social dimension	Accessibility and existence of community Sense of place Housing and building opportunities Mix land use Transportation environmentally choice Effective development
Issues	Social equity Traffic congestion and pollution Quality of life and lower standard of living Prospects of delivering compaction Worsening community position Reduction in privacy Reduction in present amenity space Perceived lack of greenery, open spaces High price of housing Appropriate land use	Loss of sense of space (genius loci) Land consumption and threat to farmland Costs to local government The dependence on the automobile Inner city: social impacts Health impacts Environmental impacts Design
Scope concern	Economic Social Environment Policy	Community quality of life Economic Environment Health Housing Transportation Design
Causal factors	Land use planning Regional planning/cooperation Highway building Housing policies Competition for tax revenue Sub-urbanization	Zoning policies Regional planning Highway building Housing policies Competition for tax revenue Lifestyle choice
Benefits	Support equity in some respects Reducing the need for travel by facilitating shorter journeys as well as car dependence and inducing greater supply and use of public transport. Opportunities for emission-efficient modes of transport and pollution problems Accessibility to goods and services is more	Managing growth effectively (cooperation). Decreased public expenditures Open an isolation from the heart of the community Decreased auto usage and commuting time Urban rural development synergy Rational extension of urban service Help to preserve rural lands outside the city

	equitably distributed by higher density settlements Deliver other environmental benefits, such as reductions in loss of open land and valuable habitats. A milieu for enhanced business and trading activities	Generate center of city and its activities Eliminate competition for retail development and the loss of associated tax revenues. Provides both flexibility and certainty to the planning process.
Actual efforts	New policy implementation Process of intensification-concentration Transportation strategy Higher densification Land use control/planning trends	Sense of place creation Growth concentration Preservation of open space and farmland Transportation strategy Regional cooperation Demographic trends
Case	Urban intensification efforts in England Transportation strategy in the Netherlands Urban planning policy amendment in Japan	http://www.plannersweb.com/sprawl/places.html http://www.sierraclub.org/sprawl/50statesurvey/states.asp http://www.nemw.org/Gov_sgi.pdf
Note	Tough debatable strategy and need for further more uncontentious evidences, compact city claimed its advantages, include: conservation of the countryside; less need to travel by car, thus reduced fuel emissions; support for public transport and walking and cycling; better access to service s and facilities; more efficient utility and infrastructure provision; and revitalization in inner city.	In general, smart growth invests time, attention, and resources in restoring community and vitality to center cities and older suburbs. New smart growth is more town-centered, is transit and pedestrian oriented, and has a greater mix of housing, commercial and retail uses. It also preserves open space and many other environmental amenities. But there is no "one-size-fits-all" solution.

Both the compact city and the smart growth strategy are designed to prevent the urban growth from the negative effects of growth which is believed to be happened if there exists a sprawl growth pattern throughout the city. This pattern is influenced by suburbanization which is characterized by such low density population in the suburb area and automatically increasing automobile dependencies (Newman and Kenworthy, 1999).

2.2 Scope of the Study of Compact City

The compact city studies have been dominated by urban planning study, including urban/built environmental design, and urban geography respectively area. It is based on literature, journal, and manuscript on related major which has high frequency to take compact city concept into their consideration. This finding supports an argument in Jenks et.al (1996) that compact city becomes a great magnitude to architects, planners, and urban designers to discuss and debate this vision. However, the compact city study in the urban economics still has a little attention. Figure 2 summarizes the presentation situation of the compact city study.

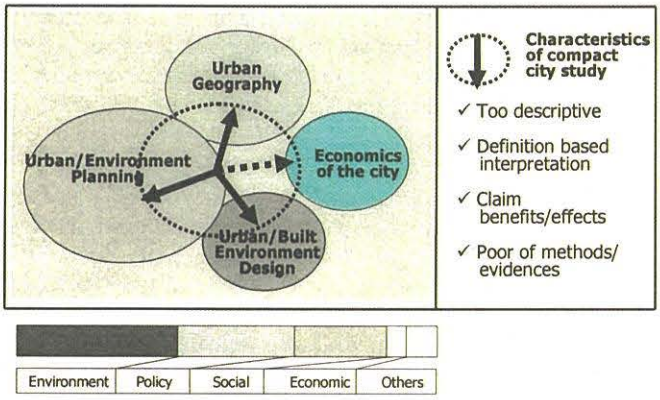


Figure 2 Scope, range, and characters of compact city studies

Although many studies have been conducted on compact city and its relevant aspects, including enshrinement in land use planning policy in many countries, the studies still remain contentious, mainly shortcoming in evidence to support both many claims and counterclaims in its favour (Burton, 2002, Jenks, et.al, 1996). Almost of its lack empirical evidence is exclusively on the environmental impacts, such as energy, transport emissions, loss of open land, natural habitats and resource depletion (Breheny, 1997). This shortcoming also influences range composition of compact city studies which has been dominated by environmental study followed by policy, social, economic, and other studies (history, psychology) respectively. Moreover, this concept appears to have a variety of attributes or characters (Burton, 2000; 2002), since many authors propose different characters of compactness. It is caused that compact city studies is too descriptive with lack evidence and only depend on the author assumptions and knowledge of what the compactness is.

2.3 Approach for the Evaluation of Compact City

Since the compact city could be defined in many ways and involves many influenced factors, indeed the evaluation analysis on compact city should also design to reflect objectives of compactness concept in broadly effects. It should include an assessment of effects of policy measures on urban factor and its entities. Van der Walls (2000) has also argued that the effect of compact (urbanization) depend strongly on social developments in one hand, and policies in other areas, like housing policy, traffic and infrastructure policy, energy policy environmental policy, and nature policy on the other.

To be a relevant evaluation as has been argued by Burton (1996), they do not have to be related directly to urban form, because the most important think is their concerns on assessment in general of actions designed to improve sustainability The following topics are covered: environmental impact assessment; policy evaluation techniques; monitoring technology; environmental threshold methods; forecasting; modeling; capacity evaluation methods; sustainable management; and perhaps, most important, sustainability indicators. However, assessments need constant updating, and measurement, as well evaluation techniques for local authorities with high access in database, thus the rise in interests of developing indicators.

Indicators allow assessment to be made using limited, representative information, with different capacity approaches. Burton, et.al. (1996) have stated that the advantage of the indicator approach is that it can accommodate the whole range of issues, including subjective criteria (Burton, 2000, 2002). Indicator approach also allows better judgements to be made at the local level through comprehensive, structured framework. However, it has several drawbacks. One is that it dose not resolve the problem of the relative weight of each indicator and the interrelationships between them. Another one is limitation of indicator scope to be implemented in different levels (Jenks, et.al., 1996). It is likely urgent that the tools should be developed by a wide variety of different interested level and between

the different approaches to be effective one. As described many times that there is no consensus on the definition of sustainable development on practice, including compactness. And interesting to cite the argument of Burton, et.al (1996): whatever the quality of monitoring and modeling, it is of little use unless linked to appropriate action, but how can this be determined without an explicit understanding of the goal?

Today's visionary solution in answering a sustainable urban form can initially be inspired by compact city concept. From academics, practitioners, and politicians have all been quick to adopt this as an all-embracing remedy for urban ills. Yet this contemporary vision displays the same lack of attention to the crucial question of feasibility. The case for the compact city remains largely unresolved as indicated in previous discussion that a range of issues which there is a degree of uncertainty. Competing and conflicting claims, which of necessity are argued from an incomplete knowledge base, exist theory, in the concept of sustainability, and in relation to environmental, economic, and social issues.

In spite of the concept of compact city as a model of sustainable development is only just beginning to be recognized, and associated complexities disclosed, there is an imperative to gain a deeper understanding of the compact city and its action to implement it. This particularly, important as policy is promoting new compact city forms, while at the same time results of implementation are largely unknown and hard to predict. Nevertheless, defining more concrete a compact city in line with searching a sustainable urban form, developing its policies, and overcoming implementation problems are all steps which need to be taken first to determine compactness rationally and reasonably.

Regards to introducing the implementation of compact city, firstly, it is necessary to cope with characteristics of the city before implementing such compactness policies is fundamental requirement, including better understanding of the criteria of urban agencies, range of methods, as well as scale and legitimating of the policies. Secondly, to introduce any degree of compactness in the future and to avoid the negative excess of compactness in such a city, city planning would require stronger regional guidance and planning, closer cooperation between regions and their individual local authorities, together with the development of suitable policies through government actions. The compact city approach will probably succeed, but with patient, balance, and by examples.

3. QUANTITATIVE ANALYSIS WITH AN URBAN MODEL

The basic functions that are required for the analysis system in this study are to be capable of space and time with adequate details. The interactions between measured indicators and the condition of urban change over time should be able to be represented in expected sequenced time series. In addition, indicators to measure the compactness are strongly related to land use, transportation, and environment. Therefore, this study has employed TRANUS as a core urban model for the analysis system, for it is one of the most general urban models that can deal with land use, transportation, and environment both temporally and spatially.

3.1 TRANUS Model of Sapporo

Developed by De la Barra (1989), the TRANUS modeling framework is one of a few operational urban and regional models, which are really used in the professional urban modeling (US EPA, 2000; Wegener, 1994). The framework is very similar to MEPLAN (ME&P, 1995), especially in the representation of spatial allocation of activity. The main feature that distinguishes TRANUS from MEPLAN is the use of "scaled utilities logit" model for allocation of activity rather than a standard logit model. TRANUS is a general spatial input-output modeling framework. When the general TRANUS model is to be applied for a specific urban/regional area, a certain set of model design must be specified. In this study, TRANUS model is applied to Sapporo Metropolitan area. Locating in the northern main island of Japan, Sapporo is markedly monocentric with a population of about 2 millions.

It has high level of service of public transportation systems, which include three subway lines and the commuter railway of Japan Railway (JR).

Figure 1 Study Area of TRANUS Sapporo

The TRANUS Sapporo model is described as follows. In the activity model (or known simply as land-use model) there are three groups of sectors, namely resident, employment, and land sectors, respectively. The resident is represented by the only one sector of household sector. The employment is represented by the three categories of economic sector namely primary, secondary, and tertiary employment sectors respectively. This employment category follows that used in the Sapporo transportation planning and analysis. The land is represented by the three types of urban land sectors namely residential, commercial and total developable lands respectively. The relationship among these sectors is represented in a table called Social Accounting Matrix as shown in Table 1. In the transportation model, two types of trips are modeled: work and private trips respectively. The work trip is derived by household going to work while the private trip is derived by tertiary workers providing goods and service to household. The transportation condition from 1980 to 1995 is represented by the major transportation projects in the urban area such as new subway section, highway, and new railway stations, etc.

Table 1 Social Accounting Matrix of TRANUS Sapporo

	Producing Sectors						
Consuming Sectors	Primary	Secondary	Tertiary	Household	Res Land	Com Land	Dev Land
Primary				•			
Secondary				•			
Tertiary				•		•	
Household			•		•		
Res Land							•
Com Land							•

Work				•
Private			•	

The model is calibrated for the base year (1980), and its base year forecast is accurate as it could be expected, i.e., the forecast of household in the base year versus the real number of household. Clearly, the model has been calibrated and adjusted well enough that the goodness of fit is perfect. Since TRANUS structure is quasi-dynamic, only the base year calibration is not relevant to represent the change of urban condition in time. So the interval calibration is conducted for the period of 1980 to 1985. And to validate the calibrated model, the model is to forecast the household distribution in 1995.

The model is evaluated by comparing the change in household from 1985 to 1995 with the change produced by the model. It is found that the model can represent the change satisfactorily with R^2 of 0.6116. Therefore, the validated model could be used for the further for this study.

3.2 Additional Indicators for Compact City Evaluation

Regarding the indicators for the evaluation, some of TRANUS outputs can be directly used for the compact city indicators. In addition, a large number of variables related to transportation and land use are produced either explicitly or implicitly in TRANUS. In the application of TRANUS for this study, several extensions are made to the original system. Table 2 summaries the indicators of the present system, which are originally produced by TRANUS and additionally produced outside TRANUS. The additional indicators are the congestion cost, air pollution emissions, and development cost, which is of the most interest to estimate the costs of infrastructure development and the maintenance/ operation by year and generation of the residents.

Table 2 Indicator for Compact City Evaluation with TRANUS Sapporo

Type	**Measure Indicators**	**Objectives**
Indicators obtained directly from TRANUS	Number of trips	Calculate number of trips. Indicate level of attractiveness by zone
	Travel distance	Average and total distance to travel
	Travel time	Average time to travel. Indicate level of nearness among zones
	Travel costs	Average travel costs related to time, distance, and transfer
	Energy consumption	Average and total energy consumption by zone
Additional indicators calculated in this study	Congestion costs	Level of congestion costs by zone
	Air pollution emission	Level of air emission (CO, NOx, HC) by zone
	Development Costs	Development costs related to growth pattern and households distribution

4. COMPACT CITY POLICY MEASURES

In this study, the simulation and evaluation is made at interval of fifteen years, from 2000 to 2015 and from 2015 to 2030 where a number of policy measures are taken.

4.1 The Population Decrease Framework

The simulation framework is set to have the population increase in the near future and the population decrease in the later future, as shown in Figure 3. This is the general tendency of not only cities in Japan but also those in other industrialized countries. The system, however, is also able capable of other different scenarios of population changes.

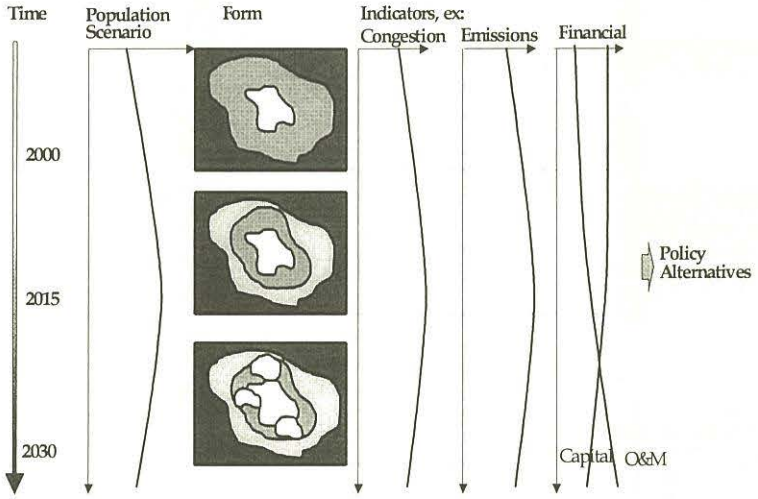
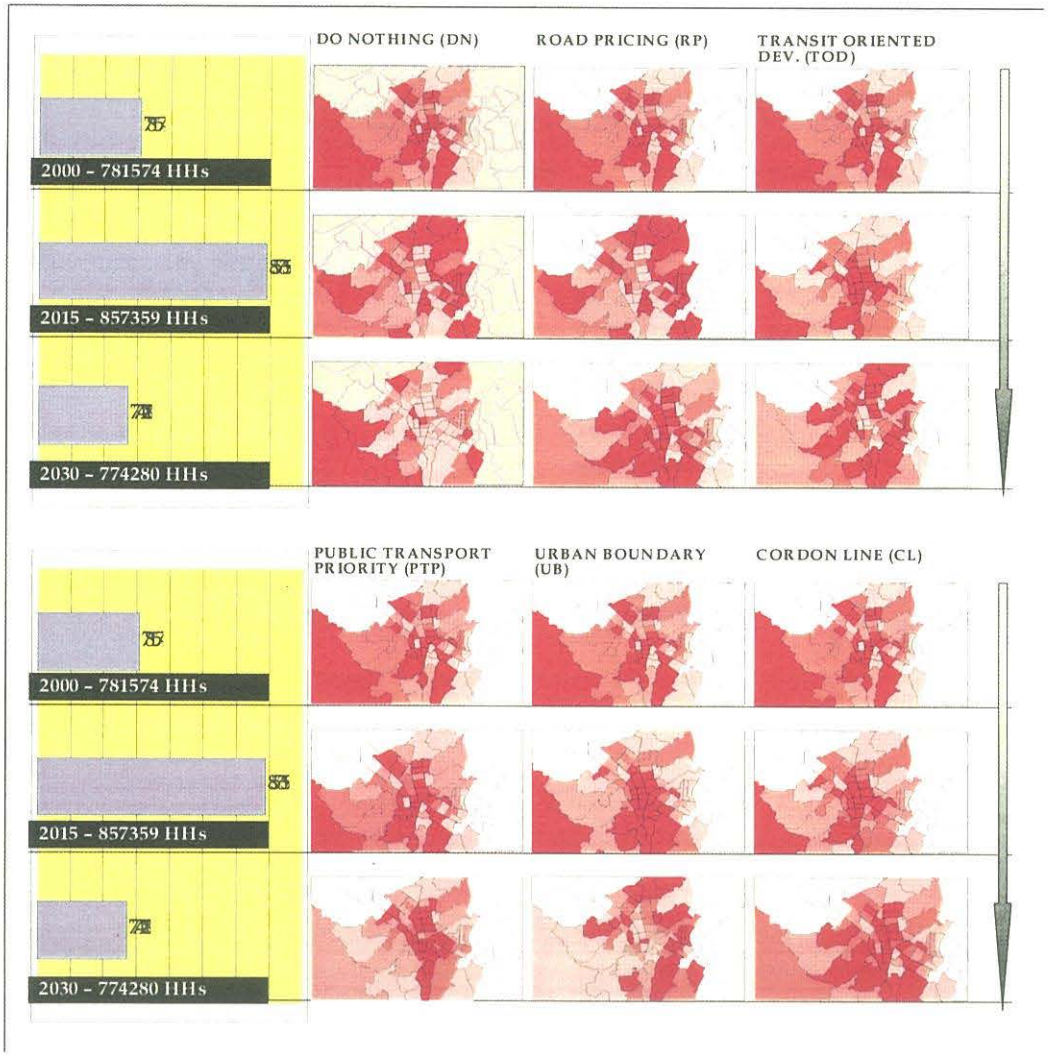


Figure 3 Population Decrease Framework of TRANUS Sapporo

Policy	**Purpose/Implementation Measure**
Do Nothing (DN)	No action beyond existing (as forecast)
Road Pricing (RP)	Reduce car dependencies in city as well reduce trips lengths and improve traffic conditions in the city/Charge road usage by kilometer drive. (Transportation side)
Transit Oriented Development (TOD)	Increase residential and commercial areas located along transit in center area to maximize access by transit and non motorized transportation/Promote development around railway stations. (Land use side)
Public Transport Priority (PTP)	Reduce car dependence by supporting residents to use public transportation in city/ Improve service of public transport. (Transportation side)
Urban Boundary (UB)	Introduce urban boundary to limit growth in the suburb and promote more development in central city (Land use side)
Cordon Line Pricing (CL)	Reduce car dependencies certain areas in city as well reduce trips lengths and improve traffic conditions/Charge cars when crossing cordon line. (Transportation side)
UB + RP	Combination of Urban Boundary and Road Pricing
UB + PTP	Combination of Urban Boundary and Public Transport Priority
RP + TOD	Combination of Road Pricing and Transit Oriented Development
RP + PTP	Combination of Road Pricing and Public Transport Priority
TOD + PTP	Combination of Transit Oriented and Development Public Transport Priority



4.2 Results

The results of the simulation are partly summarized in Figure 4 and 5. In general, compared to Do-Nothing (DN) case, all policy alternatives are certainly effective making better condition from the viewpoint of tested transportation indicators, such as reducing travel by car, promoting public transportation (subway) and non-motorized mode, reducing travel distance and travel costs, as well as reducing air emission and energy consumption to be lower. The policy alternatives related to transportation attempts seem to be more effective to realize quick results for transportation indicators in line with compactness objectives. Thus, from the modeling viewpoint, compactness is easier to be experimented with the transport related policies.

Figure 4 Household Distribution Resulted by Different Single Policy

Combinations among policy alternatives being complementary to each other (i.e. combination of push and pull policies) revealed significant evidences for more successful implementation of compact city development. However, these synergy effects are not always significant in every model results. For example, one of the effective policies combinations is shown by CL and PTP combination, as

illustrated in Figure 6, in which CL represents a push policy and PTP represents a pull policy. This policy shows a significant reduction in travel demand (total number of trip is reduced). The resulting city is considered more compact since the travel distances of the residents are averagely shorter. However it is interesting that the average travel time is longer. One reason it is simply due to a modal shift from car mode to non-motorized mode that takes longer travel time. Thus, it is found by the simulation evidence that a policy being specific to one mode also affect the use of its relating mode(s). Similarly the synergy effect is pronounced when combining policies with different directions, e.g., push and pull together.

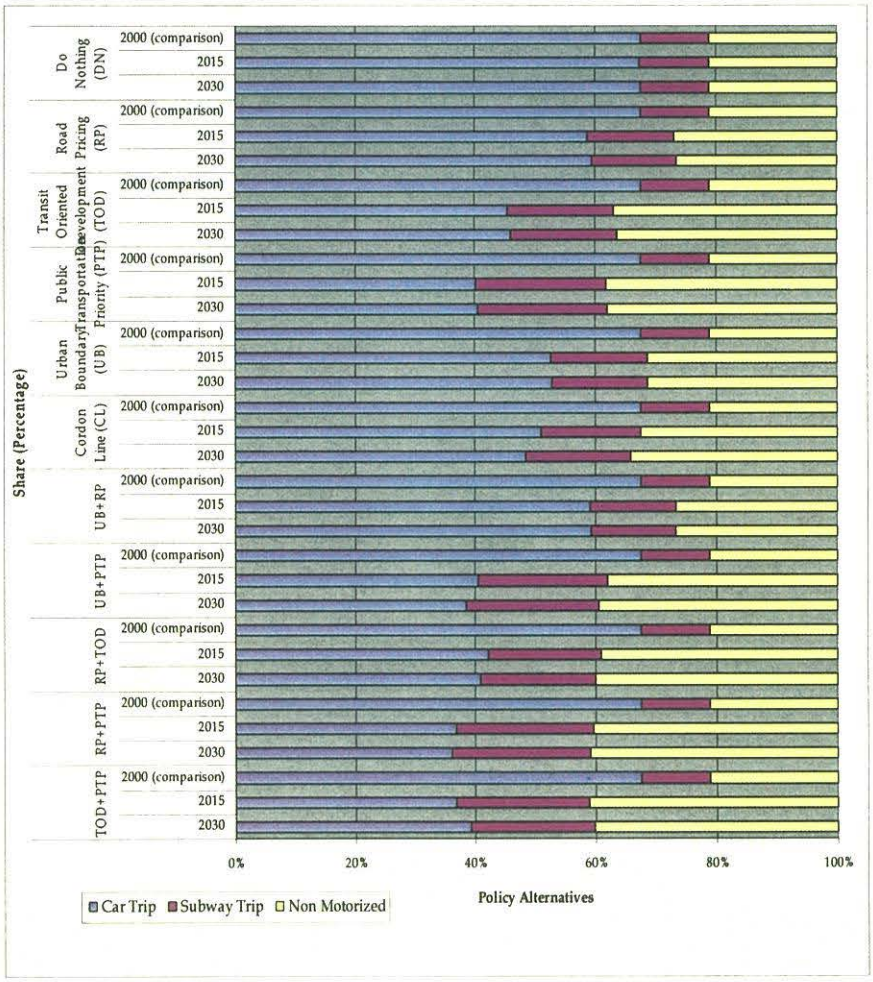


Figure 5 Transportation Indicators Resulted by Single and Combined Policies

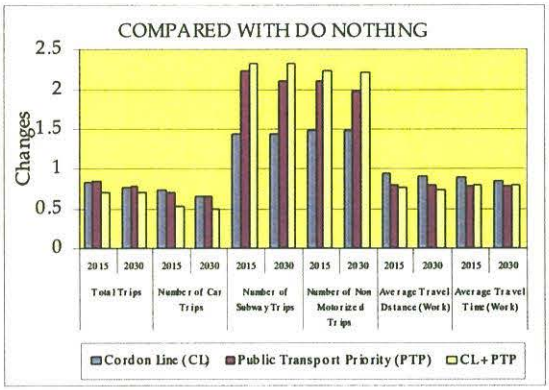


Figure 6 Positive Results from Policy Combination

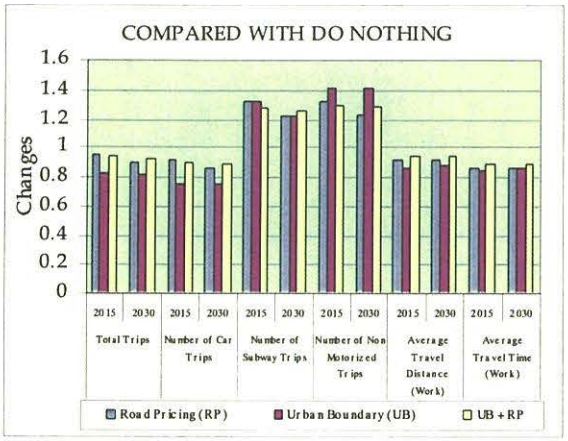


Figure 7 Less Pronounced Results from Policy Combination

On the contrary, combination of policies by RP (road pricing) and UB (urban boundary) which are both push policies shows the other interesting findings as illustrated in Figure 7. It is obvious from the graph that RP and UB policies reduce travel demand when compared with the Do-Nothing case. It might be expected that devising a road pricing and setting urban boundary (RP+UB) would further reduce travel demand when compared with the UB case alone. But the result is not as expected; all model results of RP+UB policy are more or less similar to the single RP policy. Thus it is found again by the simulation evidence that a combination of push and push policies would not always yield the synergy effects. In this case, the single RP has much stronger impact than the single UB so that the role of UB is unseen when it is combined with RP in the RP+UB policy.

Although the discussion here is based on the present version of TRANUS Sapporo, it could be improved and produce more meaningful results if it runs in a longer time-range with more comprehensive dataset. At least, TRANUS relies very much on land-use information, a careful consideration/expectation of future land-use condition as its model input will generate very much accurate and meaningful policy analysis.

Due to the population decrease framework, an assumption of developing costs for this study is shown in Figure 8.

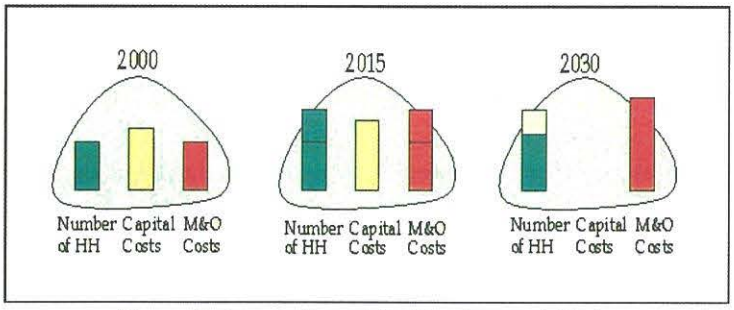


Figure 8 Assumption of the Development Costs

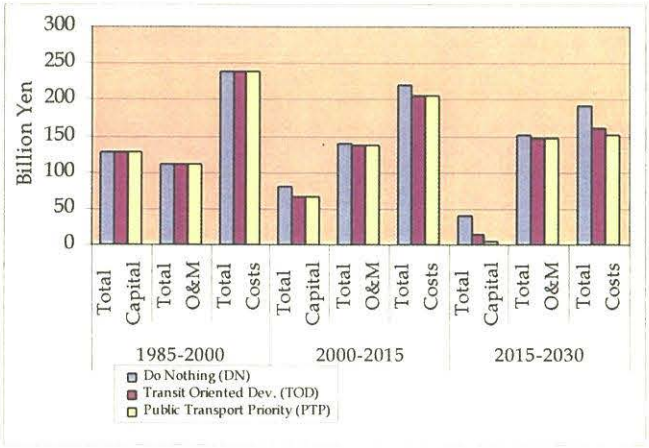


Figure 9 Development Costs Resulted by Different Policy Measures

Based on the estimated development costs, the costs for infrastructure development and the maintenance/operation are simulated for some policy alternatives, shown in Figure 9. The differences from the Do Nothing case are generally not as significant as were expected. The reason could be that the additional costs to keep the level of service for more densely development in the central area are almost equivalent to those required for suburban development. However, if the generation bears lower level of service for a while, the financial burden of the future generation will be relieved and recover the level of service again. The system can provide the degree of each indicator with alternative financing program of the city.

5. CONCLUDING REMARKS

The present study is going and so far has developed a pilot system with the quantitative analysis sheme of policy alternatives in terms of the level of public services and the financial expenditure in the future. Some representative policies, which were recognized formerly and descriptively, are discussed with the quantitative simulation results. Some useful interpretations are derived from the discussions. With alternative financial programs of the city, the financial burden by generation can be clearly presented. The system is expected to make it possible to discuss on policies taking benefits/costs as well as financial burden by generation into consideration. This is one of the most important aspects if we discuss a compact city.

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