A simulation design for the regional lock-in effect of urbanisation in Taiwan

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Abstract: This study was divided into two phases. The first phase is theoretical discussion, including new economic geography, theory of increasing returns, lock-in effect, and the Polya process. The second phase is simulation design for the regional lock-in effect of Taiwan's urbanisation, that is, constructing a regional development system to simulate manufacturers' location selection (the dynamic process), where the rules of system design are based on the theoretical discussion in the first phase, and the world view will be through the simulation of four regions according to the Taiwan Regional Planning Act, then scenario analysis with or without the development strategies will be adopted to compare the effect, before and after the restructure of the five counties and cities, on the behaviour of firms' location selection, and further on the change and balance of Taiwan's regional development (that is, to examine whether any region would be locked in).

Keywords: regional development imbalance; increasing returns; lock-in effect; core-periphery model; agent-based modelling; Taiwan.

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1 Introduction

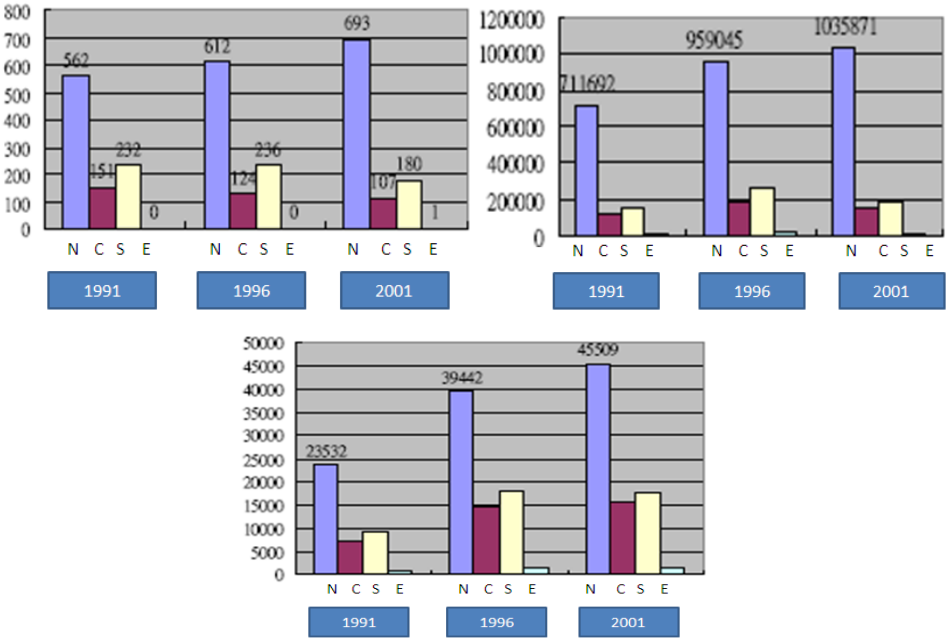
How do urban and regional spatial patterns develop? And what mechanisms drive the configuration of the overall land use and population, the spatial distribution of economic activity and geographical configuration? The problem has always been addressed by scholars of related fields (Prosperi and Oner, 2015; Sisodia et al., 2016, 2018). The phenomena of 'regional development imbalances[1]' (that is, population and industrial distribution are aggregated in few areas) have also been the issue that academics and governments are anxious to resolve.

In Taiwan, many homeland spatial planning strategies were utilised to achieve 'national competitiveness' and 'balanced regional development' purposes. For instance, the purpose of five counties and cities[2] in Taiwan being merged and upgraded in 2010 was to enhance 'urban growth pole' function of the five municipalities in their respective regions, driven by growth itself and the surrounding area (growth and diffusion effects). It was expected to achieve the purposes through administrative restructuring, financial division, and resources integration. Likewise, large-scale construction of transportation planning such as Sun Yat-sen Freeway, high-speed rail, and Hsueh-shan Tunnel, also with the same purposes, is to promote transport high-speed flow to increase traffic accessibility, to achieve spatial and temporal compression, to re-shape the spatial structure, and then to help adjust and improve inter-regional uneven distribution of population and industry (Hong, 2009).

However, as argued by Xue and Lai (2009), it has already found that these large transportation constructions failed to effectively achieve the overall regional balance although they changed the opening of the new road network along the town's population aggregation. Besides, many studies (see Chou, 2000; Lee et al., 2005Ke, 2009) also pointed out that Taiwan's urban polarisation phenomenon and the regional development gap situation does have growing evidence. For example, industry distribution mainly aggregated in the northern Taiwan (as shown in Figure 1).

Several regional development indicators in Figure 1 show that the industry distribution obviously tends to aggregate in the northern Taiwan. In addition, if we observe the population distribution in Taiwan through power law[3] coefficient values, it will also be found that the evidence of population distribution information presents Taiwan's highly polarised phenomenon[4] [please refer to Ko (2009), Lai et al. (2010), Ko and Lai (2014)]. The result also shows that the regional development policy enacted by the government has long been difficult to be effective. According to Hong (2009), the development of a very high-speed flow and urban growth pole may be able to achieve balanced regional objectives, but the improper development is also likely to deteriorate the excessive aggregation in the northern Taiwan. Furthermore, the latest domestic report based on the latest statistics from the Ministry of the Interior, from 2007 to 2012, also pointed out that Taiwan's internal population movements still show a continuous focus towards the north (especially in New Taipei City, Taoyuan County, for the most), and that other regions (in central, southern and eastern Taiwan) are outward. Accordance to another survey, Accounting Internal Migration Survey, by Directorate General of Budget, the results indicate that metro area population mobility trends and preferences accelerated towards the north did not change although five counties and cities in Taiwan were merged and upgraded in 2010.

Figure 1 Statistics from directorate general of budget: Taiwan social development trends survey (2002) (see online version for colours)



Notes: N means northern Taiwan, C means central, S means south, and E means east. In the left figure shows the regional distribution of the corporate headquarters, in the middle figure shows the regional distribution of the number of employees, and in the right figure shows the regional distribution of the number of service space, those results of the charts show whatever chart indicators are the agglomeration of the north (N) is increasingly apparent.

Source: Ke (2009)

In short, how to deal with the phenomenon of uneven regional development is an important issue in Taiwan. In the future, the government will still promote 'five ports and one airport city' and Taipei megacity (combine with Taipei, New Taipei city and Keelung), however, the current domestic research about population and industry aggregation tendency is still limited, which probably causes much uncertainty about the effectiveness of related policy (for example, can either restructuring of administrative divisions or regional integration achieve regional balance?). Therefore, this study focuses on investigating the regional development process of firms' location and aggregation imbalances through the construction of a dynamic process model (computer simulation). In other words, this research includes the following:

1 Literature review: reviewing the new economic geography (NEG).

2 The experimental design and model construction of computer simulation: with the theories based on the previous literature review and the collation of relevant research model [include Chen (2010)], simulation model of path dependence (netlogo5.0.4[5]) (Ko and Lai, 2013a, 2013b), a dynamic process model was constructed to describe

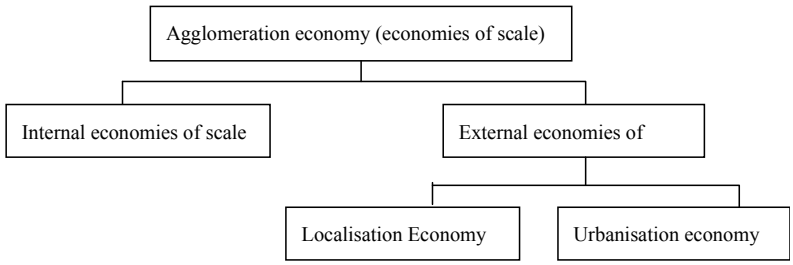
the regional development process of firms location and aggregation imbalances. The research approach and tool adopts agent-based modelling. The major purpose of the experiment is to compare the effects on Taiwan urban and regional development balances before and after the restructuring of five counties and cities in 2010 through a computer simulation of scenario analysis.

2 Literature review

2.1 The characteristics of industrial and urban spatial aggregation and regional evolution: interpretation of new economic geography[6]

'Aggregation' of economic activity is most prominent geographical features (Krugman, 2000). Just as Hua (2009) said, "National and regional developments are from urban development, and urban development from the aggregation economy." Through agglomeration economy, the city has become a place for millions of people and things to communicate and interact and thus to result in communication and innovation.

Figure 2 The implications of agglomeration economy



Notes: Figure 2 shows the connotation of agglomeration economy, including scale economy, external economy, agglomeration diseconomy, and external diseconomy, etc. Scale economy is also known as increasing returns to scale.

Source: Yin (2011)

Furthermore, the aggregation contains two situations: manufacturer (production activities) aggregation and population aggregation (urban comprehensive economic activity) (Yin, 2011), in which manufacturers' location selection can lead to the fixed establishment of related industries, creating jobs, and attracting people gathered to form a positive feedback, but it also results in the development of inter-regional imbalances (Lai, 2006a, 2006b). However, agglomeration economy was often assumed to be an exogenous condition in the past research and hence lacked further investigation (Yin, 2011).

After the 1990s, Krugman, Fujita, Venables led the development of NEG, which focuses more on exploring 'internal mechanism' of the economic system to seek the factors forming 'endogenous forces' that caused human economic activity to produce aggregation. NEG emphasises the concept of manufacturers, increasing returns, transportation costs and production factors (labour, etc.) and their mutual interactions (to be discussed in the following pages). NEG adopts the monopolistic competition model (Dixit-Stiglitz type monopolistic competition) to establish a spatial dimension of the model to analyse the increasing returns, imperfectly competitive market, and international (regional) trade, which are different from the traditional economics perspective with its

basic assumptions of diminishing returns and perfectly competitive market. NEG thus brings a different impact and new horizons, which may be refer to as in Tables 1 and 2 for a comparison.

Table 1 The Comparison between NEG and classical economics

	Fundamental assumption	*Analytical method*	*Typical model*
Neoclassical economics (and urban and regional economics)	Diminishing returns (or constant return), perfect competition, comparative advantage	Exogenous location factors, linear and static analysis methods.	Neoclassical theory of location, central place theory, Bid-rent model, recent developments of central place theory, …, etc.
NEG	increasing return to scale, imperfectly competitive market, mechanisms of self-growth industrial agglomeration	In addition to considering transportation costs, etc., also emphasised the endogenous location factors and industrial agglomeration mechanisms[1], and analytical methods is biased nonlinear dynamic research methods	CP model (Krugman, 1991), urban development model, industry diffusion model …, etc. (shown as Table 2).

Note: [1]Including system and technology, the advancement of knowledge and learning, etc.

Source: Being collated from Huang et al. (2012)

Table 2 Related theories and models of NEG

Follow-up research of CP model[1]
Model of liberal capitalism FC: an increase of 'capital owners can not migrate' and 'capital gains flow restriction (cross trading)' hypothesis (the key is the initial condition is not balanced).
Free enterprisers FE model.
Core-periphery vertical contact CPVL model: manufacturing firms increased demand for intermediate inputs, agricultural population can also join the local manufacturers' assumption.
Capital creation (CC) model
Global overflow (GS) model
Freedom of entrepreneurs vertical contact FEVL model
Sharing effect model, *match effects model, learning effect model*
The internal mechanism of the agglomeration factors Is divided into knowledge spillovers and knowledge creation.

Note: [1]The model and CP models use the same model of monopolistic competition and melting ice transportation costs (Iceberg Trade Costs) assumptions.

Source: Being collated from Yin (2011)

Krugman (1991) proposed the core-periphery model for the development of an important milestone of NEG, which used the monopolistic competition model (also known DS model) proposed by Avinash Dixit and Joseph Stiglitz in 1977 as a methodology, assuming economic system is imperfectly competitive markets and with effects of 'increasing returns' to discuss how firms setup factories in space, selected the location, and overall, how aggregation imbalances (core-periphery) occurred. The model took into

account factors such as manufacturers, transportation costs, factor mobility and scale economy (details will be described later). Based on this model analysis, aggregation strength lies in long-term reduction of transportation costs (trade costs).

Past 'economic geography' mainly studies production location (Krugman, 1991), and Krugman called the theory he himself proposed NEG. Other related NEG theories and models can be referred to in Table 2.

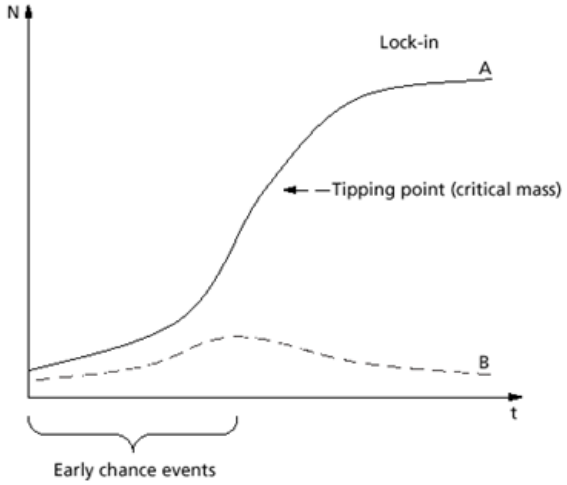
In short, this study will try to construct a dynamic model by the concept of the CP model and industrial agglomeration mechanisms.

2.2 Increasing returns and lock-in effect

The rise of complexity science[7] contributed to the application of non-economic dynamic model in the research of urban and rural areas, using cellular automata to simulate urban complex systems (CS), using MAS computer simulation model to establish the CS, which is considered quite persuasive (Lai, 2006a, 2006b).

Increasing returns means a cycle of 'positive feedback[8]', as a 'self-re-enhancement' mechanism. The so-called Matthew effect also has the same concept. In the industrial economy, the self-re-enhancement mechanisms frequently occur, such as scale economy, learning effects, coordination effects, and expectations. In the aggregation of spatial location, the regional increasing returns are such a virtuous circle amplification effect, like snowballing, that regions subject to increasing returns effects can continue to attract more manufacturers (or population) stationed. When firms aggregate in a certain region with a scale of more than one threshold, it will produce lock-in effects and more companies will be willing to move into that region (Lai, 2006a, 2006b).

Figure 3 Path dependence characteristics of lock-in effects



Source: Ebbinghaus (2005)

As shown in Figure 3, when manufacturers aggregate in a certain region (like 'A' in Figure 3), the aggregation benefits will attract more manufacturers to station in this region, and when increasing returns gradually accumulate, positive feedback will follow,

making aggregation scale enlarge rapidly; when aggregation scale reaches a tipping point, lock-in effects will occur. Since then, the entire region cannot be moved and its scale and rank will be difficult to be surpassed. This is also viewed as the irreversibility of the location selection.

As discussed above, increasing returns may be one of the important mechanisms for urban and regional imbalances. Many studies are based on increasing returns to explore the aggregation phenomena, such as Chen (2004, 2010) and Lai et al. (2010), etc. Chen (2004) used the Polya probability function model to investigate the increasing returns of different urban growth and the proportional change in population size. Chen (2010) also used Krugman's (1991) CP model simulation, combined with the Polya process to explore the characteristics of distributions of manufacturing. Among them, The results of the simulation are consistent with today's trends. The study also verified Arthur's proposition: manufacturers' spatial distribution and regional lock-in effects depends on early chance events, manufacturers' stationed order, and geographic conditions, and then will be subject to aggregation benefits and increasing returns.

3 Theory and research methods

3.1 Research methods: a computer simulation of the dynamic method

Multi-agent simulation (MAS) is based on agents of multiple categories (that is manufacturers and labours). Each agent can play a different role. The model focuses on multi-agent interactions and agents' self-adaptability (Torrens, 2010; Ko and Lai, 2012). This study adopts MAS[9] to display the self-organisation process; the bottom level of the model is the rule setting of manufacturers' spatial location selection behaviour; manufacturers' spatial location selection behaviour is affected by variables of this model (such as aggregation benefits, geographic benefits, distance costs and labour input, etc.).

Moreover, just as stated in the previous section, literature review, some scholars in the past simulated firm space selection by agent-based model. To further understand different concepts and design patterns, this study collated them in Table 3 and tried to find out the referable section.

Table 3 Collation and comparison of other models

Chen (2010)	Chen (2010) in Krugman's (1991) theory attempted to modify production behaviour, included the non-market gathering effect into the model to examine the characteristics of spatial development process, and, in the experiment, applied location decision model and Polya process to describe how workers move and produced a dynamic process (Chen, 2010).
Ko and Lai (2013a, 2013b)	Try to propose an idea: to partially modify the rule of spatial garbage can model which was changed into open systems; to apply to dynamic system simulation of the regional level (i.e., the basic elements of the 'location' are divided, split into 'location A' and 'location B'); to combine the concept of spatial garbage can with the concept of increasing returns; construct a simulation system of firm location selection; to explore whether the phenomenon of aggregation is locked in a particular region by observing data output of the model (the number of individual location decisions).

Source: The information above was collated from Chen (2010); Netlogo5.0.4 Library; Ko and Lai (2013a, 2013b)

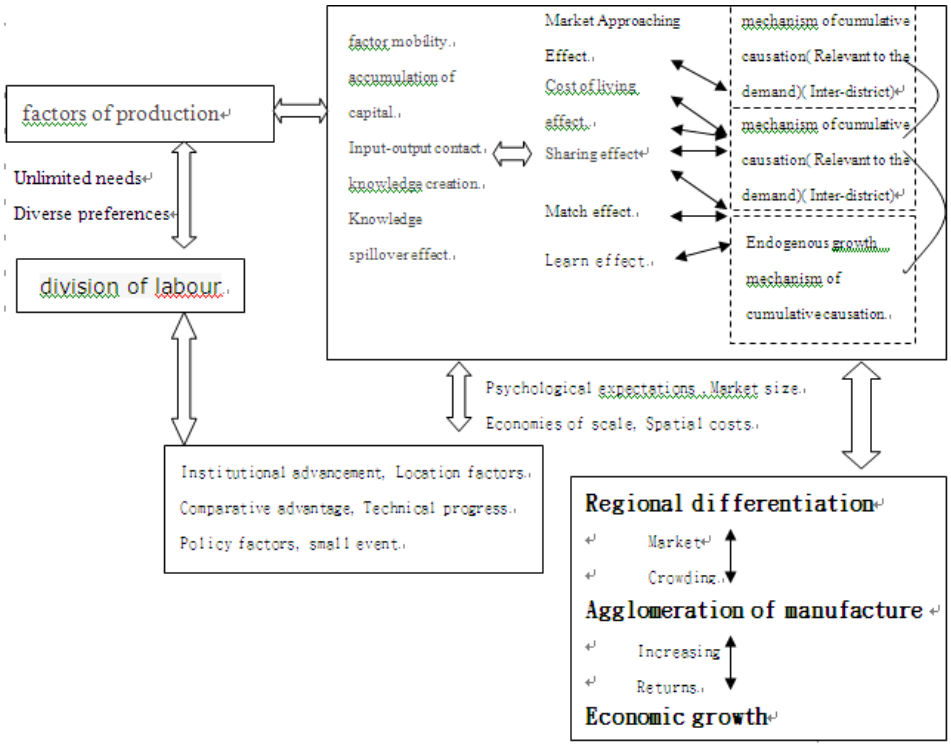
Simulated research of the lock-in effect of firm gathering area, which is similar to the topic of this study, adopted non-economic model to explore firm spatial agglomeration process, while Chen (2010) used Krugman (1991) model for analysis. Both can be referred to by model design and subsequent analysis of this study.

3.2 The theoretical basis: the core-periphery model

Then, further illustrate the preliminary architecture of the simulation design, and how it is to establish a link with the CP model.

As mentioned above, this study adopts a NEG core-periphery model as the theoretical basis, from economic theory perspective to explore the regional development imbalances caused by market forces, while the base model is a combination of increasing returns and technology competition model; in other words, through the viewpoint of economic theory, the mechanisms of manufacturers' location selection are explained and extended as a basis of agents' (manufacturers') behaviour patterns in the simulation experiments.

Figure 4 The mechanisms of manufacturers' aggregation: interpretation of NEG (see online version for colours)



Source: Yin (2011)

First, agglomeration economy (scale economy) can promote industry aggregation (Yin, 2011), which is due to specialisation and division of labour. The increasing returns caused by internal scale economy will make individual firm try to aggregate factors of production and to expand the scale of production (to reduce costs). The spillover effects

of external scale economy (such as knowledge and technology spill) will cause manufacturers to keep close to each other in space as much as possible (Yin, 2011), which is also shown in Figure 4.

Figure 4 reveals the theoretical framework of the mechanisms of manufacturers' aggregation constructed from NEG, and it can induce four main factors, namely scale economy, consumer preferences, space costs and psychological expectations.

Moreover, the core-periphery model assumes that the consumer has the same tastes for both manufactured and agricultural products. And there are two divisions in the market: a monopolistically competitive manufacturing division and perfectly competitive agricultural division, of which manufacturers have scale economy and they need labourers for production.

'Consumers' and 'labourers' will influence production and consumption capacity of a region. A market, in the initial expansion phase, will lead to rising real wages. There are four endogenous variables for the consumer's and producer's behaviour of every region (Chen, 2010): income (wages), price index of manufactured products, labourers' nominal wage rate and real wage rate. Of them, real wage rate will affect labourers' migration decisions.

Figure 5 Basic concept of C-P model

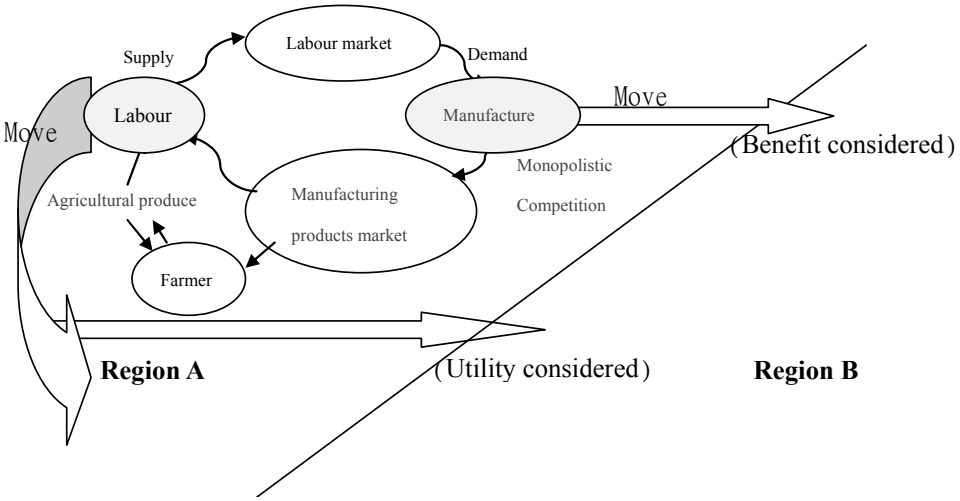
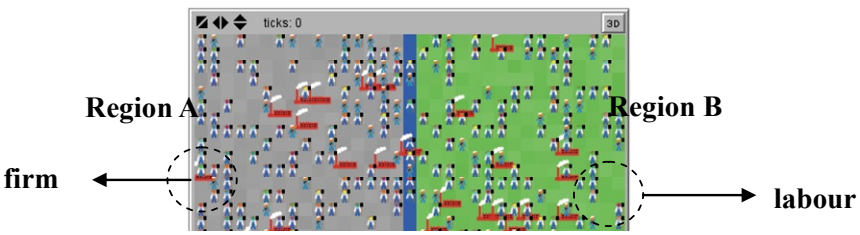


Figure 6 Simulation design (interface part) (see online version for colours)



Note: Description: regular design is demonstrated in Section 4 and Section 5.

In Figure 5, the force leading the whole region comes from the migration (aggregation or dispersion) of the manufacturers and consumers (including labour), while migration trends (namely, the competition between agglomeration force and dispersion force) will be affected by increasing returns, transportation costs and the flow of production factors (Yin, 2011). Figure 6 tries to explain how to integrate the concept of CP model into simulation design (interface part).

In the conception of this study, two original choices of path-taking are:

1 Incorporating the concept of CP model into the regular construct of models, just as the way described above.

2 First constructing a firm location selection model (mainly based on increasing returns), and then comparing and analysing the simulation results with CP model.

If the latter is adopted, it is necessary to know about the research result by Krugman (1991), according to Krugman's findings, long-term reduction in transport costs (trade costs) is the major strength for aggregation. When transport costs are large, the distribution of two regions becomes balanced, but with progressively reduced transport costs, the distribution of two regions becomes imbalanced.

However, according to Tabuchi's (1998) study, his findings were quite different from Krugman's: when transport costs are large or small, aggregation will occur. (That is, the distribution of two regions becomes imbalanced.) Only when transport costs are medium will the distribution of two regions become balanced. Owing to such different results, the model is still likely to be modified and discussed.

4 Experimental design and modelling

This study is based on the concept of CP model and increasing returns (including technological competition model). Multi-agent-based model (Netlogo 5.0) is used as a simulation platform to construct its regional economic systems, rules and spatial structure evolution patterns.

First, a mechanism with endogenous economic system needs to be constructed. In this system, manufacturers and labourers (also consumers) will follow the respective rules in migration. Labourers' migration depends on real wages (see Figure 5). Moreover, the CP model assumes that the consumer has the same tastes for manufactured products and agricultural products, and that the market has two divisions: monopolistic competition in the manufacturing division, and the perfectly competitive agricultural division (with fixed remuneration). The CP model also assumes that manufacturing has scale economy, and that the production needs labourers' inputs, so manufacturers' location selection depends on the comparison of benefits (including aggregation benefits and geographical benefits of production factors, the concept of which is the same as what Arthur proposed in 1997).

The new entrants' (manufacturers') decision-making behaviour of location selection is described as equation (1):

$$\pi_i + g(N_i) > \pi_j + g(N_j) \tag{1}$$

In equation (1), π_i represents the geographical resources advantage from region i; $g(N_i)$ represents the aggregation benefits when N manufacturers exist in region i; after the two

add up, if the total value of region i is bigger than that of region j, then the manufacturer will select region i.

Furthermore, the migration behaviour of the manufacturers who has stationed in a region is closely related with migration costs which is dependent on costs of two considerations:

1 opportunity costs π_{ij}

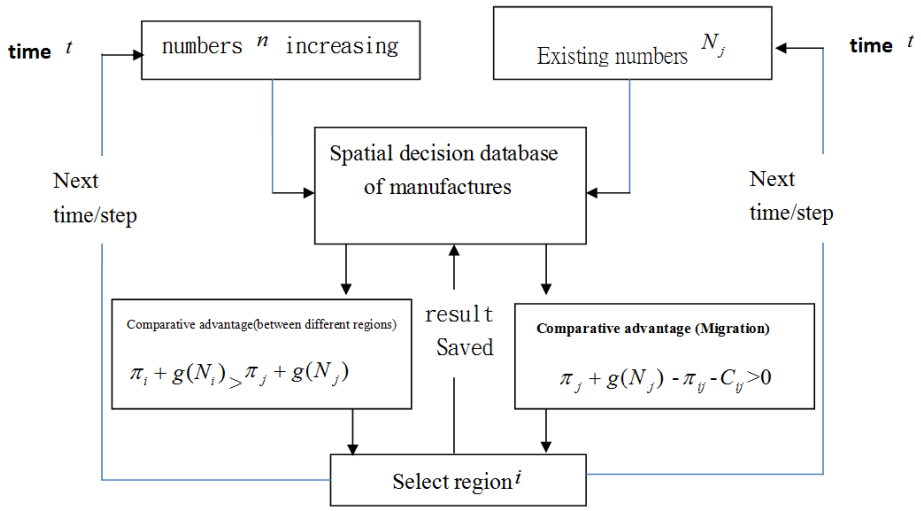
2 the distance costs C_{ij} (distance and relocation costs).

When the benefit $\pi_j + g(N_j)$ is greater than the total cost $\pi_{ij} + C_{ij}$, the manufacturer will consider migrating from region i into region j. Such is expressed as equation (2):

$$\pi_j + g\left(N_j\right) - \pi_{ij} - C_{ij} > 0 \tag{2}$$

The concept of the above equations (1) and (2) are organised in Figure 7.

Figure 7 Simulation process (each manufacture's behaviour rule) (see online version for colours)



The research model will be incorporated into other economic factors affecting the location selection, such as regional labour or demand and supply of the consumer market. According to the process of the experimental design, the simulation of this study will be divided into different experimental stages:

1 First, a simple simulation system is constructed, by using virtual parameter values (see Chen and Lai, 2002) for simulation, and by controlling and adjusting parameter values for 'yes or no' scenario analysis.

2 According to the system constructed at the first stage, the computer simulation experiments are performed, and the tipping point value is calculated.

3 Then, the actual historical data about 30-year manufacturers' location selection in Taiwan (rather than random generation method) are incorporated into simulation model for analysis.

4 According to the results of the simulation at the third stage, the tipping point value is calculated, and then whether any region of Taiwan has reached the lock-in tipping point is investigated.

5 Geographic information systems (ArcGIS) are combined with the simulation of the study, and then the rules are applied in a real map of Taiwan.

Table 4 shows the current known variables, whose data collection and measurement methods are summarised.

Table 4 Data collection and measurement methods of simulation model

Variable	*Explanation*	*Required data*
Number of manufacture N_j	The number of basic industrial manufactures N of region j	Refer to 'Taiwan statistical report – numbers of business registration and its capital of Taiwan Province.'
Geographic benefits π_j	Assuming each region j as 'non-homogeneous' geographical environment. π_j is the control variable, it has the following implications: the difference of urbanisation rate, infrastructure, production inputs, resources, and socioeconomic environment between regions. Its statistics data collection can refer to CEPD statistics, and county or city governments' statistics in each year. Besides, convenience of transport will affect the geographical benefits π_j. The links degrees between region j and region i can measured through the application of network science. GIS layers can used for estimating the convenience of transport.	
Aggregate benefits $g(N_j)$	The aggregate benefits of each manufacture of industrial a in region j. It can measure by location quotient (LQ) estimated.	The total employment of industrial a in region j, the total number of employment in region j, data collection according to different regions and industrial.
Opportunity cost of migration π_{ij}	π_{ij}: total benefits $\pi_i + g(N_i)$ that manufacture (from region i) migrate to region □	
Distance costs C_{ij}	Migration costs related to the distance, the distance cost variables can be estimated and modified by the geographical distance and road network connectivity between different regions. The links degrees between region j and region i can measured through the application of network science.	It can be calculated by GIS layers.

Source: Lai (2009)

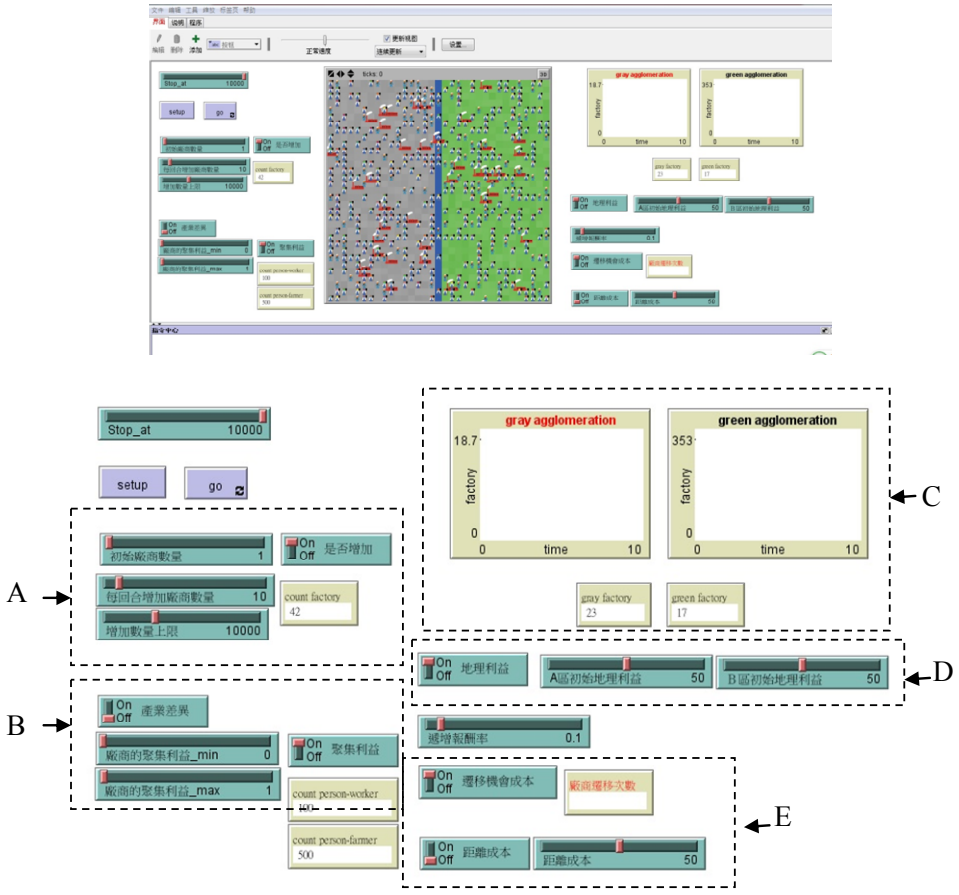
5 Conclusions

The experimental design concept presented by this study aims to propose a possible research direction and method, attempts to compare and discuss the results of Krugman's analysis through dynamic computer simulations, and also compares with the effects of both before and after the restructuring of five counties and cities in 2010 by way of 'yes or no' scenario analysis. The results of this study are expected to guide the development

of the industry and to provide regional planning and population control policies for future reference[10], and to compare and interpret the imbalances of Taiwan's urbanisation which has long been concentrated in the north.

Secondly, they are also expected to compare and discuss with analysed results of Krugman's CP model (which can be operated by regulating a variable of transportation costs) through another view (dynamic simulation system) of firm location selection model, and then examine the pros and cons of different methodologies (through the comparison to the situation of the real world[11]).

Figure 8 The prototype model construction (see online version for colours)

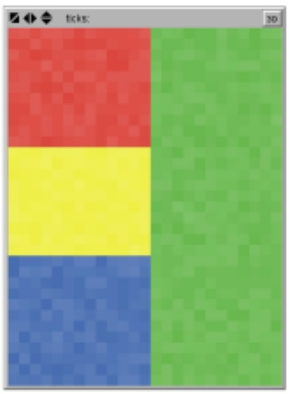


Note: A = the basic parameter settings; B = aggregation benefit settings; C = number of firms and lock-in case observation; D = geographical setting of benefits; E = migration costs settings).

However, there are still several problems to be clarified and solved, such as the setting of simulation rules of agents and the choice of influential factors (controlled variables; sliders of Netlogo).The current model of stage one is under construction. According to the needs of simulation, the regional structural patterns can be designed as shown in Figure 8. At the top of Figure 8 is a simplified pattern in Taiwan regional structures

(division of the North, Central, South, East by Regional Planning); at the bottom of Figure 8 is another simplified pattern designed by CP model. Analogue prototype is as shown in Figure 8.

Figure 9 Abstraction of regional configuration in Taiwan (see online version for colours)



In the modelling, on the basis of the characteristics of CS, a huge number of agents (manufacturers and labourers) interact. In the initial state of the simulation, the distribution and the number of agents may be controlled by the slider. Next, in the following steps of the simulation, the number of newly added agents is randomly generated. Then, agents act by following the process of simulation rules (as shown in Figure 8). So far, controlled variables should include the number of manufacturers, geographical benefits, distance costs (transportation costs), incremental return rate, migration costs, etc.

In Figure 9, assuming that the pattern is divided into four regions, of the grid (patch) of the same region can be configured with the same geographical benefits or aggregation benefits.

In conclusion, it is the core of this research model design (also complex scientific concept) to use simple rules to create complex real-world phenomena. Regarding the design of simulated experiments, it is expected to be achieved and further developed in the future.

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Notes

1 Gaps exist in regional development, which is not a phenomenon unique to a few areas but a worldwide problem (Liu et al., 2000), such as China (a gap between the east and the west), Thailand (Bangkok and the middle vs. other regions), Mexico, France (the east vs. the west), Italy (economic gap between the north and the south), etc.

2 Include Taipei City, New Taipei City, Taichung City, Tainan City and Kaohsiung City, as for their development orientation (vision) strategy, please refer to explanatory report CEPD.

3 The introduction of power law can be referred to Cristelli et al. (2012).

4 For instance, power law coefficient values of Taiwanese cities are about –0.5 (Ko, 2009), higher than the empirical results of the world city system (–0.7~–2.0).

5 Created by the SLUCE project at University of Michigan (2007).

6 Factors affecting urban and regional development is quite diverse and complex, yet economic factors are one of the most important factors, while in this study was to investigate the firm's location choice behaviour, it will be to economic theory as a basis.

7 About recent developments in complexity science, please refer to Philip (2012) and Briassoulis (2008).

8 So-called Matthew effect is similar to the concept of increasing returns.

9 Netlogo is a software used for agent-based or multi-agent simulation, whose applicability is quite diverse; in addition to simulation design, it can also be used to make simple games (Ko, 2012). Besides, Barrett et al. (2005) also use agent-based model to construct 'If Smallpox Strikes Portland' model: this model simulated urban social network via computer to predict outbreaks of infectious diseases (middle and right figure).

10 However, this study verified and explored the origin of regional imbalance through quantitative analysis.

11 Empirical research, which can be referred to Yin's (2011) method, not only collected the data of national population and firms, but also used employment statistics, GDP (economic change), rate of mobility, changes in the proportion of the urban population and other indicators to verify that the development gaps among different regions (under time evolution).