Measuring urban maturation processes in Dutch and Chinese new towns: Combining street network configuration with building density and degree of land use diversification through GIS

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1. Introduction

This inquiry started with an experiment to combine various spatial analyses methods with one another through the use of Geographical Information System (GIS). The original aim of this experiment was to design metrics for identifying how new towns differ spatially from old towns. As it turned out, however, repeated testing on numerous case studies revealed a new means to quantify and interpret various degrees of urban maturation.

Recent advances in software development make it possible to combine various spatial analysis methods to handle large amounts of data from whole towns. The aim of this paper is to present a spatial index method by combining space syntax, spacematrix and Mixed Use Index (MXI) into one model through the use of Geographical Information System (GIS). The challenge of this idea is to render various spatial features that can be quantitatively compared on a reasonably weighted basis, and then explore what this method can contribute to our overall knowledge of urbanism. This paper also reflects upon the results gleaned from the application of this new spatial index method to several case studies. As it turns out, the combined methodology makes it possible to measure the various degrees of urban maturation processes.

The proposed spatial index method is tested on three new towns and one old town in the Netherlands, and one new town in China. Preliminary results support a hypothesis that the spatial configurations of a street network innately determine the urban maturation process. By contrast, the interrelationship between the various degrees of the three spatial variables (i.e., the ‘match rate’) affects a town’s maturation process over time. Based on these initial findings, two hypotheses for further empirical testing are proposed. The first is that a suitable matrix will help to better evaluate a town’s urban maturation process. The second hypothesis is that current planning practice seems to conflict with natural urban maturation processes, which results in new urban areas lacking economic vitality and vibrant street life. These understandings represent a first step towards designing spatial strategies for dealing with the urban challenge of promoting lively new towns in Europe and China.

Keywords: New town, urban maturation, space syntax, density, land use mix.
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...ates better socio-economic performance to tackle this current urban challenge.

As an introductory matter, we should better define some terms used in this paper. Firstly, the concept of ‘maturation’ is borrowed from biology and psychology. It is a description of personal and behavioural processes of somebody or something that matures through organic growth processes. Whereas a person’s development is judged by age, the urban maturation process is evaluated by how both spatial and socio-economic parameters gradually develop over time. A newly implemented town would be considered to have successfully transformed into a mature town on achieving the spatial framework for generating and facilitating street life, various cultural activities, small business development, land use diversity, and so forth. Secondly, note that the concept of ‘urban maturation processes’ differs from the concept of ‘urban transformation processes’ used in the urban morphology tradition. Whereas ‘urban transformation processes’ describes urban changes over time in a particular area, ‘urban maturation processes’ are about how an urban area becomes balanced or complete over time.

Thirdly, the concept of ‘urbanity’ is used in this paper to describe lively urban centres of mature towns. This concept has been discussed in different disciplines such as sociology, economic geography, and spatial planning and design, etc. Wirth (1938) approaches the issue of urbanity from a sociological perspective and defines it as the gathering of a large, dense and heterogeneous mass of people. Jacobs (1961), Cook (1980) and Gehl (1989) all claim that urbanity emerges through various socio-economic activities that occur in and through buildings and open spaces. Inspired by previous research, Montgomery (1998) points out that urbanity is the interrelationship between activity, urban image, and urban form to generate urban sense. Marcus (2010) describes the notion of urbanity as socio-economic performance developing from urban form. A consensus emerges from these varying definitions that defining and clarifying the spatial properties of the built environment contribute to providing better descriptions of the spectrum of urbanity.

The first part of this paper outlines the concepts used within, as well as identifying current problems with which new towns are dealing. Next, the problems and challenges of combining various analysis methods are demonstrated and discussed. After that follows the experiment section, where the exploration of maturation process tested on the cases is elaborated, conducted, and discussed. Finally, some reflections on the indications of the results and what this new methodology may contribute to the practice of promoting lively urban areas are summarised.

2. Understanding urban maturation processes from a quantified spatial research perspective

Recently, advances in new quantitative spatial analysis tools such as space syntax, spacematrix, and mixed use index (MXI) make it possible to identify and measure spatial properties that trigger the built environment’s socio-economic life. For instance, the space syntax method has been applied to develop strategies for handling the spatial flaws of new towns (Karimi et al., 2009). Meanwhile, the use of Geographical Information System (GIS) as a tool for combining a large amount of place bounded socio-economic data is slowly entering the urban research domain. The GIS platform already demonstrates the potential of integrating quantitative tools to gain an understanding of the interrelationship between the various elements of urban morphology and their morphological transformations as compared with traditional morphological studies (Moudon, 1997; Stanilov, 2010; Ye and Van Nes, 2012).

Redefining the most representative spatial properties of urban form from the urban morphology...
tradition requires a review of Conzen’s ‘town-plan analysis’ method. The basic elements of Conzen’s method are (1) town plans (streets, plots, and buildings), (2) patterns of building form, and (3) patterns of land use (Conzen, 1960; Whitehand and Conzen, 1981). The tangible components of urban morphology proposed by Conzen can thus be regarded as (1) the street system, (2) the building system (plots and the buildings located on it), and (3) the land use pattern. Simply speaking, applying space syntax to measure the various degrees of integration of the street network configuration can be considered as the variable representing the street system. Meanwhile, the quantitative measurements of the building system can be represented in the way that the spacematrix method measures degrees of building density, building types, non-built space, and so forth, which, to some degree, represent both plots and building properties. Land use patterns can also be quantified using the MXI model to measure the degree of land use diversity. Therefore, combining the degree of spatial integration of the street network (space syntax), with the degree of building density (spacematrix), and the degree of functional land use mixture (MXI), can be equated to quantitatively describe the morphological properties of the built environment, making possible a measurement of urban maturation degrees.

3. The hypothesis, methodological approach and case selections
Street network configuration, building density, and land use diversity are not independent variables. Streets can exist for thousands of years; therefore, as towns mature over decade and centuries, their street network configuration tends to change very little. A building typically exists for only a hundred years; however, the functions inside it change constantly (Van Nes, 2002). Thus, building density and land use will incrementally adjust to the street network integration. Therefore, our proposed hypothesis is that a town’s maturation process is spatially dependent on the street network configuration that has streets with high integration values on various scales that aggregate high building density and a high degree of land use diversity (Figure 1). As such,
the match rate between the three spatial variables should be a linear index that increases as a town matures over time.

The first step in testing this hypothesis is to analyse street pattern, building morphology, and land use diversity separately, before combining them to check whether the combination of the three variables accurately reflects various degrees of maturation. The next step is integrating these three parameters into one formula to reveal the interdependence between them. The challenge is to compare them quantitatively. Then, based on that quantitative data, the interrelationship between the three spatial variables can be used to evaluate how the spatial elements of an urban maturation process interact with one another. Therefore, the ideal case study is a town with detailed records of street networks, building types, floor numbers, and building functions during their various maturation stages over decades. Unfortunately, such detailed data are difficult to find. The next best method is to select a set of new and old towns at different stages of development.

Several new towns were planned and built to prevent massive urban sprawl around cities in the Netherlands in the 1960s and 1970s. Although these new towns were planned during the same period, their maturation rates differ significantly after half a century of urban transformation. Meanwhile, new town developments are currently taking place in China on a large scale. More than a hundred new town plans have been made and implemented since the 1990s (Keeton, 2011; Zhou, 2012). Although Chinese new towns have several spatial features that significantly differ from European ones, both generally lack desirable levels of urban vitality and street life. The comparative approach contributes to revealing the robustness of the proposed method and verifies the hypothesis by applying it to different cultural contexts.

Lelystad, Almere, and Zoetermeer are chosen as examples of Dutch new towns, while Haarlem is an example of an old town that has developed over several centuries. Haarlem is closely located to Amsterdam and has a similar size in terms of built-up land as Lelystad, Almere, and Zoetermeer.
The construction of Lelystad started in 1967, and it is now the capital of Flevoland province. Few large alterations or adjustments have taken place in Lelystad since then. Almere was originally planned to provide a solution for housing shortages in Amsterdam. The plan was implemented in 1974, and now it is the seventh largest city in the Netherlands with around 190,000 inhabitants. During the last two decades, a new large city centre has been implemented along the most integrated streets in Almere. Alternations and adjustments have constantly taken place in Zoetermeer, which had a long history before this small village was turned into a new town in the 1960s. At present, it has approximately 12,580 inhabitants and is acknowledged to be an important Information and Communication Technology (ICT) city. Finally, Haarlem has a rich history tracing back to pre-medieval times. It was an important city during the Dutch Golden Age in the 17th century. There are currently 150,611 inhabitants in Haarlem.

The plan for Songjiang new town, Shanghai, China was prepared in the 1990s and implemented after 2000. Songjiang new town is one of the first finished new towns in China with more than 300,000 inhabitants. However, the town lacks urbanity in terms of street life, land use diversity, and small business variety. The space syntax method encompasses a set of theories and techniques for analysing the street network configuration in terms of topological, geometrical, and metric distances (Hillier and Hanson, 1984; Hillier et al., 1993; Hillier, 1996; Hillier, 1999). In this inquiry, angular analyses with both topological and metric radii are applied. The space syntax method will be used to measure the degree of spatial configuration of the street network, spacematrix will measure the degree of various types of building density on the urban block, and MXI will measure the degree of land use mix. Through the application of GIS, it is possible to integrate the results of the space syntax, spacematrix, and MXI analyses to compare the various spatial variables. As Figure 3 shows, the vector-based space syntax data, and polygon-based spacematrix and MXI data can be converted into the same grid using ArcGIS software.

The basic method in this inquiry is developed from techniques applied by Van Nes et al. (2012) and then further developed in Ye and Van Nes’ earlier research (2012). To correlate the vector-based data with the polygon-based data, the size of the grid must cover part of the street and a building adjacent to the street. The size of the grid’s raster cannot be too small, or it will separate building block variables from street network integration variables. However, too large a grid raster size will reduce the precision of the vector-based analysis. In this research, a raster size of 150 x 150 metres for each cell is chosen. The results of the spatial analysis are then separated into three levels – high, middle, and low values – for comparative ease.

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4. The method of integrating various spatial analysis methods into one model

Many scholars point out that the configurative street network analysis can be correlated with other layers of data to reveal various aspects of the built environment (Ratti, 2004; Marcus, 2010; Stanilov, 2010; Karimi, 2012; Sevtsuk and Mekonnen, 2012). In this research, the space syntax method will be used to measure the degree of spatial configuration of the street network, spacematrix will measure the degree of various types of building density on the urban block, and MXI will measure the degree of land use mix. Through the application of GIS, it is possible to integrate the results of the space syntax, spacematrix, and MXI analyses to compare the various spatial variables. As Figure 3 shows, the vector-based space syntax data, and polygon-based spacematrix and MXI data can be converted into the same grid using ArcGIS software.

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centres and the degree of vitality of main routes simultaneously. First, the results from all the space syntax analyses are converted from Depthmap into ArcGIS. The numbers are then roughly divided into high, middle, and low value ranges using the natural break method to minimise each class's average deviation from the class's mean value, while maximising each class's deviation from the mean values of other groups. The final configuration rates are shown in Figure 4.
An important contribution of the spacematrix method is that it presents both building density and various building types at the same time (Berghauser-Pont and Haupt, 2010). This classification makes it possible to quantitatively describe the combination of intensity, compactness, pressure and non-built space and height, which can be used to differentiate urban form in a more efficient way than before (Berghauser-Pont and Haupt, 2007, p.63). Spacematrix is inspired by the work of Johan Rådberg (1988, 1996) and correlates the following measures with one another: floor space index (FSI), ground space index (GSI), and the average number of floors or layers (L). The classifications shown in Figure 5 are based on Berghauser-Pont and Haupt's matrix. The building types are classified into low-, mid-, and high-rise based on floor numbers. The building types are also separated into point type, stripe type and block type based on building forms. The entire built environment can be divided into nine categories (from A to I). According to the building type’s influences on urbanity, low-rise point and low-rise stripe types belong to the low value, while mid-rise stripe and block types and the high-rise block type belong to the high value. The other categories belong to the middle value (Figure 5).

The Mixed Use Index (MXI) was developed by Van den Hoek (2009) to measure various degrees of multi-functionality of land use. The MXI model deals with the degree of functional mix in a quantitative manner in terms of the percentage of dwellings, working places, and amenities in urban blocks. The function ‘Housing’ includes various buildings for residential living, such as apartments, condominiums, and townhouses. The function ‘Working’ implies places of work such as offices, factories, and laboratories. The function ‘Amenities’ implies all kinds of commercial facilities such as shopping and retail, schools and universities, and leisure facilities such as sporting arenas, cinemas, concert halls, and museums. Figure 6 shows a triangle matrix illustrating how these three functions can be correlated and divided into high, middle, and low values of multi-functionality, based on Van den Hoek’s MXI matrix. An area consisting of three functions is a multi-functional area, which may have a high positive influence on urbanity, thus belonging to the high value. An area consisting of two functions is a...
Figure 5:
The division of high, middle and low values in the spacematrix analysis.

Figure 6:
The division of high, middle and low values in the MXI analysis.
bi-functional area belonging to the middle value. An area that only has one function is a mono-functional area that belongs to the low value.

The three different types of spatial integration values, density values, and land use mix values can be equally combined into one framework. Based on these values, it is possible to classify various types of urban morphological developments into seven categories. The seven categories are ranked from low to high value: from suburban to low urban, various in-between areas, middle urban and finally highly urban areas (Figure 7). The high or low value of categories should, to a certain extent, coincide with the degree of urbanity because spatial properties represent urban morphological developments, which are the spatial foundation for emerging urbanity. For instance, the suburban category consists of urban areas containing two or three low values and one middle value in all measurements. Thus, the area is labelled as an area with a low stage of urban development. Conversely, a highly urban area contains high values in all measurements or two measurements with a high value and one with a medium value.

5. Measuring the natural urban maturation process from spatial perspectives

Several research projects have been carried out to evaluate the degree of maturation of Dutch towns from a socio-economic perspective (Reijndorp,
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A set of indicators has been used, including population density, employment opportunities, population diversity, facilities, and percentage of creative class, etc., which are illustrated as the size of the dots in Figure 8.

Specifically, population density can signify market potential for the localisation of economic functions, while employment density influences the quality of business climate and job opportunities. Meanwhile, population diversity and the percentage of young people can reflect the attractiveness of cities to some degree. Moreover, the percentage of creative class and amount of cultural amusement capacity represented by the presence of theatres and concert facilities, etc., can be regarded as a measurement of creativity and cultural engagement. The amount of office space correlates to the rate of business development, while the amounts of retail and restaurant facilities indicate a metric for social life and economic activity. According to these indicators, the Dutch towns can be ranked as follows: Haarlem scores highest, followed by Zoetermeer, Almere, and Lelystad. Only a slight difference exists in the office space analysis, where Zoetermeer possesses the highest amount of office space due to its successful ICT development. This socio-economic maturation ranking should also be mirrored in the ranking of spatial aspects.

Figure 8:
A set of indicators illustrating the socio-economic development of Dutch towns (CBS NL, 2009; Selezneva, 2011).
Figure 9 shows the combination of three different types of spatial integration values, density values, and functional mixture values for all four towns. There are considerably more urban areas with high or middle values of street network configuration, building density, and land use in the old town of Haarlem than in the new towns. Moreover, the number of urban areas containing high or middle values of the three spatial variables increases with the town’s degree of maturation. Lelystad has

![Figure 9: Visualising degree of urbanity in the Dutch cases (Ye and Van Nes, 2012).](image-url)
the lowest values, followed by Almere, and then Zoetermeer, whereas Haarlem has the highest values. These spatial results correspond with the towns’ socio-economic performances as previously mentioned (Reijndorp, 2009; Selezneva, 2011). Lelystad consists of only 3.4% middle and highly urban areas, with 89.4% suburban and low urban areas. Owing to improvements to its centre over the last decade, Almere performs better than Lelystad (4.9% middle and highly urban areas, versus 84.6% suburban and low urban areas). Zoetermeer has a higher number of middle and highly urban areas than Almere (6.8% middle and highly urban areas, versus 78.5% suburban and low urban areas). It appears that new towns do undergo a kind of spatial maturation process with the increase in the towns’ socio-economic maturation, reflected in the combination of these three spatial variables.

Since the combination of the three spatial variables can illustrate degrees of urban maturation, revealing the interrelationship between these variables in various urban maturation degrees should make sense. Figure 10 shows the changing percentages of high, middle, and low spatial integration values, density values, and functional mixture values from a poorly-developed new town (Lelystad), to a newly-developed new town (Almere), to a relatively well-developed new town (Zoetermeer), and finally to a historical town (Haarlem). The bars in the table reflect the developing stage situations in the three spatial variables. Specifically, the red, green, and grey bars represent the developing stage situations in spatial integration, functional mixture, and building density, respectively. The higher the bars, the better developed the variable. A low degree of building density and land use mix can be seen in the most poorly-developed town (Lelystad). A clear increase in the degree of building density can be seen in Almere, although its degree of land use mix is still very low. In the well-developed new town of Zoetermeer and the historical town of Haarlem, the land use mixture is finally increased and adjusted in accordance with the degrees of integration of the street network and building density.

As the results from the four Dutch cases show, it is possible to conclude that in a natural urban maturation process the degrees of building density and land use mixture increase over time. Spatial integration of street networks tends to remain stable for a longer time period than building density and land use. In addition, the combination of Figures 9 and 10 indicate that more cells obtain higher values in all three measurements at the same time. Therefore, it is reasonable to assume that the urban maturation process is spatially based on the accumulation of building density and land use diversity with well-integrated street networks. Nevertheless, the validity of this hypothesis needs to be further explored through detailed quantitative calculations. The next step is to research the relationship between the percentages of well-integrated cells from the space syntax analysis and other well-valued cells with the other two spatial variables.

Here, the areas with middle and high-level values are defined as ‘well-valued’ or ‘mature’ urban areas. For instance, a well-valued street network integration is defined as cells that obtain middle and high values in the space syntax analysis. The combination of mature spatial integration, density as well as degree of land use mix, creates areas that obtain at least three middle or even higher values, which means middle urban and highly urban areas. Therefore, the match rate is equivalent to cells with highly urban and middle urban values, divided by cells with high and middle integrated values obtained from the space syntax analysis. As this index method implies, the higher the match rate, the higher the balance between street network integration, building density, and land use diversity. Meanwhile, a higher degree of urban maturation may be expected.
### Various values of street network integration, building density, and land use diversity in the urban maturation processes.

<table>
<thead>
<tr>
<th>City</th>
<th>Values</th>
<th>Spatial integration</th>
<th>Mix</th>
<th>Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lelystad</td>
<td>High</td>
<td>80 (7.2%)</td>
<td>7 (0.6%)</td>
<td>36 (3.2%)</td>
</tr>
<tr>
<td></td>
<td>Middle</td>
<td>475 (42.8%)</td>
<td>172 (15.5%)</td>
<td>90 (8.1%)</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>556 (50.0%)</td>
<td>932 (83.9%)</td>
<td>985 (88.7%)</td>
</tr>
<tr>
<td>Almere</td>
<td>High</td>
<td>160 (7.9%)</td>
<td>22 (1.1%)</td>
<td>96 (4.8%)</td>
</tr>
<tr>
<td></td>
<td>Middle</td>
<td>1007 (49.8%)</td>
<td>322 (15.9%)</td>
<td>292 (14.5%)</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>853 (42.3%)</td>
<td>1676 (83.0%)</td>
<td>1632 (80.7%)</td>
</tr>
<tr>
<td>Zoetermeer</td>
<td>High</td>
<td>78 (7.6%)</td>
<td>47 (4.5%)</td>
<td>91 (8.8%)</td>
</tr>
<tr>
<td></td>
<td>Middle</td>
<td>405 (39.2%)</td>
<td>312 (30.2%)</td>
<td>240 (23.3%)</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>540 (52.2%)</td>
<td>674 (65.3%)</td>
<td>712 (68.9%)</td>
</tr>
<tr>
<td>Haarlem</td>
<td>High</td>
<td>103 (6.9%)</td>
<td>166 (11.1%)</td>
<td>231 (15.5%)</td>
</tr>
<tr>
<td></td>
<td>Middle</td>
<td>541 (36.3%)</td>
<td>521 (34.9%)</td>
<td>455 (30.5%)</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>848 (56.8%)</td>
<td>805 (54.0%)</td>
<td>806 (54.0%)</td>
</tr>
</tbody>
</table>

**Figure 10:**
Various values of street network integration, building density, and land use diversity in the urban maturation processes.
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MATCH RATE = \( \frac{C_i}{C_j} \)

- \( C_i \) = cells with values from middle urban areas + cells with values from highly urban areas
- \( C_j \) = cells with middle values from the spatial integration analysis + cells with high values from the spatial integration analysis.

The match rate formula is tested on four Dutch cases (Figure 11). As shown in the figure, the match rate linearly increases with the towns’ socio-economic ranking in the natural urban maturation process. In Lelystad, the match rate is 6.8%. This number increases to 8.4% in Almere, to 18.3% in Zoetermeer, and to 36.8% in Haarlem. The preliminary results support this hypothesis as well. The proposed formula of match rate is at least a first step in making it possible to quantify the degrees of an urban maturation process in various urban areas.

6. Testing the role of the spatial configuration of street networks and match rate in a Chinese new town

To reveal the universal degree of robustness of the spatial index method, this method is tested on the Chinese new town of Songjiang. Figure 12 shows a combination of the results from the space syntax, spacematrix and MXI analyses for Songjiang new town. When comparing this map with the Dutch historical town Haarlem, it is clear that Songjiang new town has a lower number of cells belonging to the middle urban and high urban categories. Even compared with the new town of Zoetermeer, Songjiang’s degree of urbanity is comparatively low. A vital city centre and a strong urban network are clearly lacking. This situation is not unpredictable because Haarlem has been built up for centuries and Zoetermeer for five decades, whereas Songjiang new town was only built several years ago.

However, the match rate calculation in Songjiang new town shows interesting results (Figure 13). Songjiang’s match rate is quite high (35.7%); this figure is much higher than Zoetermeer’s (18.3%) and very close to Haarlem (36.8%). The reason for this is clear: because Songjiang new town features high-density development, the cells with high or middle values of spatial integration overlap with cells which have a high degree of building density, thus expressing a high match rate. However, this match rate cannot evaluate the spatial configuration of the street structure itself. The low integration of
Visualising the degree of urbanity through the combination of space syntax, spacematrix, and MXI in Songjiang.

**Figure 12:**

*The Match rate and values of three spatial variables in Songjiang new town.*

**Figure 13:**

*Match rate in Songjiang new town*

<table>
<thead>
<tr>
<th>Cases</th>
<th>Ci: cells with values from middle urban areas + cells with values from highly urban areas</th>
<th>Cj: cells with middle values from the spatial integration analysis + cells with high values from the spatial integration analysis</th>
<th>Match rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Songjiang</td>
<td>97</td>
<td>272</td>
<td>35.7%</td>
</tr>
</tbody>
</table>

**Various values of three spatial variables in Songjiang new town**

<table>
<thead>
<tr>
<th>City</th>
<th>Values</th>
<th>Spatial integration</th>
<th>Mix</th>
<th>Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>Songjiang</td>
<td>High</td>
<td>97 (8.4%)</td>
<td>46 (4.0%)</td>
<td>424 (36.8%)</td>
</tr>
<tr>
<td></td>
<td>Middle</td>
<td>175 (15.2%)</td>
<td>274 (23.8%)</td>
<td>514 (44.7%)</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>879 (76.4%)</td>
<td>831 (72.2%)</td>
<td>213 (18.5%)</td>
</tr>
</tbody>
</table>
the whole spatial structure in Songjiang new town limits the total number of cells containing middle or high values in the space syntax analysis, as shown in Figure 12. The limited number of cells containing high or middle values of spatial integration affects Songjiang’s degree of urbanity and maturation.

Therefore, it is necessary to revise the previous hypothesis. Whether and when a new town transforms into a mature town spatially depends on two factors: the street network configuration and the match rate between the spatial variables. Before the building of a new town is complete, the spatial configuration of the street network seems to be the key factor innately determining the future degree of urban maturation. During the later natural urban maturation process, the match rate between the three spatial variables may determine the future development over time. In other words, if a new town’s street network configuration has low integration values, then its urban maturation process may be delayed even with a high match rate.

7. Reflections on these results: Two hypotheses presenting challenges for future research

Based on the previous discussion, a matrix useful for both preliminary evaluations of urban maturation processes and predicting urban development potentials can be developed as a new hypothesis (Figure 14). The urban maturation process seems to be determined both by the spatial integration of the street network and the match rate between spatial variables. Clearly, both high values from the spatial integration analysis and the high match rate show an area’s high degree of maturation. A lack of high building density, land use diversity, or high integration values of the street network contributes to mono-functional urban areas with a lack of street life. Low values in the spatial integration analysis imply that improvements have to be made to the street network configuration if the intention is to generate vibrant urban areas. In a similar way, low match rate values reflect an area’s developmental potentials, which involve improving interrelationships between the three spatial variables.

In all the five cases, this matrix seems to work well. Specifically, low match rate and high spatial integration values indicate that a new town has a well-integrated street structure but a less developed building density and land use mix. Since building density and degree of land use mix tend to increase linearly over time, the new town’s maturation process will increase in compliance with the match rate over time. Almere is an example where the development of a dynamic town centre was gradually built up.

<table>
<thead>
<tr>
<th>Urban maturation</th>
<th>Spatial integration</th>
<th>Match rate</th>
<th>The type of potentials for developments</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extremely low mature</td>
<td>Low</td>
<td>Low</td>
<td>Spatial integration; Density &amp; Functional Mix</td>
<td>Lelystad (except its town centre)</td>
</tr>
<tr>
<td>Low mature</td>
<td>High</td>
<td>Low</td>
<td>Density &amp; Functional Mix</td>
<td>Almere</td>
</tr>
<tr>
<td>Low mature</td>
<td>Low</td>
<td>High</td>
<td>Spatial integration</td>
<td>Songjiang new town</td>
</tr>
<tr>
<td>Highly mature</td>
<td>High</td>
<td>High</td>
<td>Spatial integration</td>
<td>Zoetermeer, Haarlem</td>
</tr>
</tbody>
</table>
along the town’s most integrated streets during the last two decades. In cases where there is a high match rate but a low value of spatial integration of the street network, the challenge is to improve the street network configuration if the intention is to create lively and vital urban areas shaping possibilities for economic development. Songjiang represents a case of this kind, where a low degree of street network integration seems the main obstacle to aggregating lively urban areas. Since street networks remain relatively stable over time, such cases might face difficulties in increasing their maturation rate. Therefore, the challenge for Songjiang might be to enhance new connections on various scales for improving inter-accessibility of the street network. When the match rate and street network integration values are high, the way urban maturation occurs depends on the dispersal of the spatial integration values for aggregating a balance between building density and land use mix.

Figure 15 suggests another hypothesis based on the previous discussion. It illustrates how the theory of a natural maturation process may conflict with current planning practice. First of all, there seems to be a dependency between spatial integration of the street network, degree of density, and degree of functional mix in the natural urban maturation process. The spatial configuration of the street network influences the degree of density and functional mix. Likewise, the degree of density influences the degree of functional mix. This paradigm seems to contradict with many normative post-war urban planning ideologies and practices, whereby density and spatial configuration are planned according to required functions. Most post-war towns are strongly influenced by The Buchanan Report (1963), where the role of the street network was interpreted to serve urban functions. The road engineer has been playing a significant role in urban development during the last five decades. In particular, they set up the spatial framework for socio-economic development of towns, which again affects their future maturation processes. This hypothesis requires a critical review of current new town planning practices and developing patterns. Likewise, improving the match rate may be considered in built-up new towns that need revitalising. Specifically, flexible planning rules, zoning regulations, and governance to facilitate and encourage a natural urban maturation process are needed, rather than resistance to change. However, more empirical testing on other cases should be conducted before these new ideas are applied in planning and urban design practice.
8. Conclusion

Thus far, initial results of this inquiry show that these techniques are useful for visualising and quantifying spatial properties of the built environment in terms of degree of street network integration, degree of density of buildings, and degree of functional mixture in the natural urban maturation process. The proposed method compares various spatial parameters in order to better reveal and interpret the quantitative aspects of the logic of spatial evolution, which differs from the traditional qualitative analysis.

Nevertheless, this research is still in a preliminary phase. The discussions of the relationship between the three variables and the testing of match rates are based only on the analysis of the five Dutch and Chinese new towns. The two hypotheses about the matrix reflecting urban maturation processes and the different paradigms between planning practice and natural urban maturation also require more case studies from various cultural backgrounds to be tested for generalisation proof and overall theory development. In addition, the research in this paper focused on spatial aspects. Other influential factors such as policy guidelines, governance structure, and regional development plans should be taken into consideration to construct a workable suggestion-making system to formulate future urban planning policy. In some cases, these political and organisational aspects can support a natural maturation process; in other cases, they may block it.

To conclude, street network configuration seems to be the underlying factor for the way in which a town matures in terms of building density and land use mixture degrees. A genuine understanding of the role of various spatial drivers can help to handle the urban challenge identified in this paper: promoting urbanity in the next generation of new towns and rejuvenating poorly functioning neighbourhoods in older towns.

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