Conceptualising the Valuation of 3D Property

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SUMMARY

The valuation of 3D property has received a lot of attention in the recent years due to the possibilities open to land administration through the advent of the 3D cadastre. This paper aims at looking back at the development of valuation approaches in relation to cadastres, to interrogate the needs for a 3D property valuation approach. The study finds that there are two approaches to defining 3D property – the Surface-Oriented 3D property, and the Independent 3D property. However, most 3D valuation approaches place focus on the former, at the expense of the latter. The paper recommends further research into the development of a 3D Property Valuation approach with the independent 3D property as the basic unit.

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1. INTRODUCTION

Despite human activities being undertaken in a multidimensional space – in terms of a plane (2D), volume (3D), and spatio-temporal (4D), the processes for the management and administration of these spaces rely upon two-dimensional approaches and models. The inadequacy of these current processes for determination, recording, dissemination of information about tenure, use, and value of land has gained increasing audience. From the multi-dimensional use of land, especially in terms of space, and the rising multi-level and vertical developments to cope with the limited space available needed to meet the unlimited wants of the populace, emerged the concept of 3D Geo-Information (3D Cadastres/3D Property). The push towards a 3D Cadastre has also been a result of the advances in technologies that have been supportive of the concept. A cadastre deals with three main information, land use, land tenure, and land value. Under the 3D cadastre, land use and land tenure have been explored a lot. However, this has resulted in a very slewed research focus on the technical side of the 3D Cadastre, through a theoretical lens. Fewer studies yet have also considered the legal and institutional components of the concept. In terms of the land value component of the 3D cadastre, this aspect has been explored mostly on a case by case basis, within the context of current statutory frameworks. That is to say, the current studies base the valuation of the 3D property on current 2D valuation approaches, with a vertical dimension. However, studies agree that the idea of a 3D Cadastre challenges the idea of what land is in a cadastre, and thus the valuation approach needs to be explored theoretically to identify the needed general adjustments to be made for the 3D property value to reflect and reconcile with the land use and tenure components.

This paper explores the key aspects of the Valuation of 3D Property. The paper starts with theoretical background of the nature of value, from the classical and neoclassical concepts. A background of current valuation approaches is also provided to provide a foundation for the later literature review. The evolving nature of the conventional cadastre is then discussed, with emphasis on the changes that gave rise to the 3D cadastre and its various forms. A review of the current approaches of valuation in the 3D cadastre is then undertaken. To round off,

2. PROPERTY VALUE AND SPACE

Property valuation is the process of estimating the amount at which a real property will be exchanged on a stated basis having regard to the nature of the asset, and the purpose of the valuation (RICS, 2017). Three key areas determine the nature of the valuation process, and in the end, the value – the purpose of valuation, the basis of value, and the nature of the asset. This

section will provide a background on the nature of value in the context of the theories of value as well as current advances in property valuation, with regards to space.

2.1 The Nature of Value

The two key modern theories of value – the utility and exchange value largely stem from the classical economic theory that identifies the four factors of production as land, labour, capital, and entrepreneurship (Chen, 2018; Russell, 2004; The Appraisal Institute, 2013). The further examination of the linkages among these factors result in the concepts of demand, supply, and value, in terms of utility, scarcity, desire, and effective demand. In what is seen as the first treatise of modern economics, Smith (1776) views value as an objective and existential phenomenon. In other words, the existence of an object creates utility for it, - with its value corresponding to how much it costs to produce it. This line of approach is one of the larger influences of the current cost approach to property valuation. Later economists such as von Thünen and Ricardo offered further improvement to the classical model on the cost of production as the source of value. However, neither challenged the root of the classical model. In their seminal works, Ricardo (1817) and von Thünen (1826) independently develop a rent theory, albeit from different approaches. They base land rent on the differences in the value of different outputs of labour and capital as a result of the varying fertility of land, the effects of the location, as well as the intensity of the cultivation. They also highlight the effects of marginal land, and the law of diminishing returns. These theories contributed to the modern notion of highest and best use of land, in which the residual returns to land are classified as rent. This theory contributed to the current income capitalisation/investment approach to valuation used today.

2.2 Land Value and Space

The quality of a property valuation exercise is largely dependent on the nature of the variables involved. Out of these factors, location, based on its link with human needs is seen to be a key factor. This has spurred several studies from the mid-20th century to understand and determine the effects of spatial factors in the valuation of property. These studies looked at the differences in location by fluctuating the value of the land, as with the Bid Rent Curve Theory from Alonso (1960) and the transportation and value theory from Wingo (1961). Mills (1972) further accounts for the differences in the value of the land based on the amount consumers are able and willing to pay for the product from the land. These neo-classical marginalist models build up from the previous theories of Ricardo (1817) and von Thünen (1826). These neo-classical models further fuelled thoughts on the growth of cities at the time, including the Concentric Zones Model from Hoyt (1939), the Sector Theory from Park & Burgess (1925), and the Multiple Nuclei Model from (Harris & Ullman, 1945). The city growth models relied on the CBD as the centre of all activities, and later studies deconstruct the oter areas in the city, shifting focus from the CBD as the sole epicentre of the economic, social and cultural activities in the city. These models, referred to as classical models, were seen as well established in North American cities. However, the seemingly unrealistic assumptions of the distance-city relations is the urban setting has been rigorously put to test, with Needham (1981) describing the approach as ignoring the differences between plots, save for the location, which also have a significant influence on the value of land. Evans (1983) further asserts that the land value

theories should assimilate the possibility of future rents. During these developments, other studies challenged the notion of location itself being a major factor of property value, with McDonald & Bowman (1979) showing that the negative relationship between the distance from the CDB and land value are not necessarily true, and further describing the relationship as a complex curvilinear shape.

Towards the 21st century, there arose a significant drive towards the use of Geo-Information Systems for property valuation and management (Wyatt, 1996, 1997). Here the focus lay with the valuation single properties. Property value here didn't just look at the locational aspects, but rather encompassed the physical, legal, and economic factors. However, Wyatt (1996) observes that locational factors were only seen to be explicitly considered in mass valuations, with valuers' expert knowledge of the locality being the traditional approach to locational factors. With this, Wyatt (1997) develops a GIS based approach to the valuation of individual properties, merging spatial and non-spatial factors explicitly. It is however worth noting that the attributes used in the GIS based approach includes factors such as the number of floors, the heights of the floors, etc. This indicates a consideration for the height factors in the physical attributes of the property.

In the locational analysis of the property values, accessibility and the environments are considered the most important factors, the level of demand for the accessible place is informed by the type of the property, as well as the proposed use of the property. Developing a spatial property information system allows for a more open and structured approach to the quantification of the efforts of the location when comparing similar properties using the sales comparison approach.

3. THE CADASTRAL EVOLUTION AND 3D PROPERTY SYSTEM

The 3D property system has seen a rise in research interest in the past three decades, challenging what a cadastre represents. This section explores the evolution of the cadastre into what we know today. The section will further attempt to interrogate what the evolution means to the concept of land as is commonly known. The section concludes with an overview of the 3D property System.

3.1 Land and the cadastral evolution

A single definition of a cadastre is an elusive venture, as no two cadastres are the same. However, Williamson (1985) makes an attempt at a general definition as "a complete and up-to-date official register or inventory of land parcels in any state or jurisdiction containing information about the parcels regarding ownership, valuation, location, area, land use, and, and any buildings or structures there on." This definition though not recognised as adequate, and somewhat antiquated due to the changing times, contains the basic ingredients of a cadastre – the geometric descriptions of land parcels, linked to other records. The other linked records here, depends on the context of the cadastral operations. For the purposes of this paper, the focus will be placed on the Europeans-styled cadastre, as this has influenced the development of cadastres in many parts of the world.

The development of the cadastre, as described by Williamson, Enemark, Wallace, & Rajabifard (2010), has centred around the purposes of the cadastre – as a fiscal tool, a land market tool, a planning tool, and a land management tool, with functions added on depending on the needs of the society. The changing purposes of the cadastre was also accompanied by the changes in the type of cadastre, with the Juridical Cadastre being a register of ownership of the parcels, the Fiscal cadastre, being a register of the properties recording their value, the land use cadastre, registering land uses, and the multipurpose cadastre that includes many attributes of the parcels. Following the expected technological trends that will allow for more representations on the cadastre, FIG's Cadastre 2014 declares, "Cadastral Mapping will be dead, Long Live Modelling!" (Kaufmann & Steudler, 1998). Notably, this document defines land as inclusive of the surface, below, and above the ground, with the basis of the cadastre being a spatial representation of the surface. Not long after the publication of the document, the drive towards a 3D Cadastre caught on.

3.2 The Rise of the 3D Cadastre

The changes seen in the cadastral world with the 3D Cadastre represents the societal demand for better land management approaches with the rapid urbanisation, and technological push of modelling. 3D modelling afforded the ability to form a representation of objects closer to reality than its 2D counterpart, offering a more vivid representation of reality. This ability of 3D modelling created a potential to move from the 2D geometric descriptions of land parcels, into a 3D description.in areas with intensive human activities above and below the surface of the earth, such as urban areas, there is a propensity to use spaces above and below buildings (Drobež, Fras, Ferlan, & Lisec, 2017). The traditional 2D based cadastre is however appropriate for the representation of built environments with less complex structures such as in rural areas' agricultural lands. Current attempts at representing the complex property structures in urban areas include the use of multiple layered cadastres which result in a complex system that is difficult for non-experts to grasp. Most studies on the 3D Cadastre has focused on the legal and technical frameworks such as Paulsson & Paasch (2013), Stoter et al., (2013), and Vučić, Mađer, Roić, & Vranić (2017).

The basic unit of the 3D Cadastre is the 3D real property unit, which refers to a legally delimited real property vertically and horizontally (Paulsson, 2007). The property unit is inclusive of all the rights inherent – including ownership, hence has more flexibility compared to a legal right (Bennett, Wallace, & Williamson, 2008). With the approach of modelling, 3D property units have the ability to combine an interest and spatial representation into a single unit defined by law. With the ability to map the legal and physical objects, the 3D cadastre has the potential of improving the multipurpose cadastre, and the widen the scope of its urban applications.

The scope of the 3D property system is however not as defined as the 2D parcel. Paulsson (2007) and Stoter & van Oosterom (2006) describe two forms of 3D cadastral registrations – the Surface Oriented approach and the independent 3D property. The surface-oriented approach relates property rights to space to the property of the earth surface parcel. Hence the basic property unit here still refers to the 2D parcel as the only real estate object. The remaining information is appended to further describe the property. The independent 3D property exists more commonly in countries with the deed property record system. These are sometimes

referred to as air rights. The model presents an independent form of ownership, providing for a separate regime of 3D property units. The extent of these properties are determined by their legal frameworks. However, having seen a lot of interrogation into the technical and legal aspects of the 3D Cadastre, how is the 3D property system being valued, and how is property valuation affected by the 3D property system?

4. THE 3D PROPERTY SYSTEM AND VALUE: WHAT NOW?

The valuation of properties as shown in the preceding sections has been based on the 2D geometric representation of land parcels. Much like the previous approaches to property valuation, where the locational factors are held implicit in the analysis, the factors relating to the property height (the third dimension here), are held implicit. However, the valuation of 3D property, much like the development of the 3D property system itself, has been focussed on the technical aspect. Recent insights into valuation in the 3D Property System have based the basic property unit on a 2D parcel, with vertical attributes, much like the current 3D representation in the cadastres of many countries.

In two case studies in the city of Xi'an in the People's Republic of China, Ying et al. (2019) and Zhang (2019) assess the value of 3D properties at two different levels of detail, the building and the neighbourhood levels using remote sensing data. Ying et al. (2019) finds that the inclusion of factors that have to do with height, including the property orientation, the sky view factor, sunlight were significant indicators, however the quality of the view was not. However, in general, the study's analysis showed that with a higher R^2, the 3D model explains the variation in the property value better. Zhang (2019) develops a framework for integrating 2D and 3D data using remote sensing technologies for property valuation in China. This study demonstrates that the current 2D approaches already attempt to incorporate valuation indicators that relate to height. However, with the technology used, the influence of these factors in the property value is not shown. The results of the study showed that a 3D model not only helped with visualising the property, but also the height information significantly increased the ability of the models to predict the property values.

Tomić et al., (2012) examines the possibilities of mass real estate valuation based on the 3D Vector Terrain Model, created from the digital cadastral map of the Zagreb City Centre. Here, it is shown that the visibility analysis of real estate, which requires a detailed 3D physical model provides a better understanding and explanation of the real estate value spatial distribution and a basis for an expert system based on the multicriteria decision-making. Isikdag et al., (2015) further identifies the valuation approaches and the role of 2D and 3D geometric representations in Turkey, the United Kingdom, the United States, Germany, and the Netherlands. It is found that though 3D information is considered in the planning and building codes, for example the volume of the admissible bounding solid in Germany, and the Building Coverage Ratio and the Maximum Allowable Building Height in Turkey, these have limited use in property valuation.

5. CONCLUSION

As shown from the paper, the nature and scope of the valuation of 3D property needs a lot of further research, to first understand; What is meant by land in the 3D property system; Whether the current approaches to property valuation is adequate enough for 3D property valuation, with the inclusion of the factors relating to the third dimension; how the 3D property system affects the various purposes and bases of property valuation.

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BIOGRAPHICAL NOTES

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