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Towards a Theory of 3D Property Rights – With an Application to Nordic Legislation

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***Abstract.** Division of real property is traditionally defined in two dimensions only, but in recent decades several countries have introduced possibilities of independent 3D property formation.*

This article investigates and analyses the economic principles underlying the introduction of 3D property formation, in relation to optional legal possibilities in the conventional property rights system. An overview of 3D property rights alternatives in the Nordic countries is presented, and some fundamental premises regarding 3D property formation are formulated. One principal feature of 3D property formation is to economise on transaction costs for vertical real property utilisation, in the presence of scale or scope diseconomies.

***Keywords:** 3D property rights, 3D property formation, institutional transition, transaction costs.*

1 Introduction

The territorial parcelling of real property into separate legal units has traditionally been defined in two dimensions (2D), but the use of real property for different purposes, such as housing, infrastructure or recreation, normally proceeds within a three-dimensional space. In recent decades a number of the Nordic countries have enacted legislation introducing various forms of three-dimensional (3D) property division in their systems of property law. This development is also observable internationally, outside the Nordic area (cf. Paulsson, 2007).

In an economic perspective there exists a firmly established body of theory on the emergence and importance of property rights in general.¹ There is also a growing corpus of literature on 3D property rights and 3D cadastres, for the

¹ The contributions mainly fall within the field of property rights economics, e.g. Demsetz (1967), Alchian & Demsetz (1973), Umbeck (1981), and Anderson & McChesney (2003). Many of the findings have also proved applicable within the so-called new institutional economics, see e.g. North & Thomas (1973) and Eggertsson (1990).

most part in a practical and technical perspective.² However, there has yet to be presented an open-ended analysis of the economic principles underlying the institutional choice between two-dimensional and three-dimensional property formation.

The present article sets out to analyse more closely the economic prerequisites and consequences of the new possibilities of 3D property formation, in relation to legal alternatives in the conventional property rights system, which may be referred to as “traditional” property formation. The main theoretical contribution involves the role of 3D property formation as a means of economising on transaction costs of possession, transfers and the granting of rights.

The method used is standard law and economics, and involves a combination of jurisprudential and economic perspectives. Particular use is made of property rights theory, whereby economic outcomes from different legal property rights structures are analysed. An overview of 3D property rights alternatives in the Nordic countries is followed by an evaluation of benefits and costs of 3D property formation.

2 General aspects of traditional property rights

As a background, before proceeding to examine multi-dimensional property formation, it may be useful to comment briefly on the existing property rights theories regarding the division of land into property units and other real property rights.

2.1 Property division, ownership and property rights regimes

The division of land into property units serves a number of purposes, probably the most important of them being to individualise objects of ownership and other rights in land.

In a property rights perspective, ownership is not indivisible. On the contrary, it can be described as a bundle of various rights and obligations which the law, at any given point in time, confers on the owner of a property unit in relation to other individuals (cf. Alchian & Demsetz, 1973). In other words, ownership is a legal institution whose content at any point in time is defined by legislation.

Even though the content of ownership is not a foregone conclusion, certain powers have to be included – to a greater or lesser extent – if the term ownership is to be of any relevance (cf. Snare, 1972): the right to *use* the property, the right to *transfer and grant rights* in the property, and the right to the *value* of the property.

These rights can – through legislation – be vested in individual parties, in limited collectives or in no one at all. The term “property rights regimes” is sometimes used (e.g. Bucht, 2006) to describe how rights in a certain resource can be structured. The central feature distinguishing the property rights regimes is

² E.g. Paulsson (2007), Stoter & van Oosterom (2006), and Sandberg (2003). Many of the recent contributions are in the form of conference and workshop papers, e.g. van Oosterom, Stoter & Fendel (2001) and Thellufsen (2009).

the degree of exclusiveness in the relation between a certain resource or a certain area of land and the user, vis-à-vis other individuals. When discussing Nordic conditions, it may be appropriate to divide property rights regimes into three main types: open access, common property, and private property.³

Resources subject to *open access* can be claimed and utilised by anyone. There are no exclusive and transferable rights in them (Bromley, 1991).⁴

Resources which are *common property* are jointly owned – held in common – by a limited group of individuals. That group is entitled to exclude other individuals from using the property, and use of the property is decided and supervised by the group (cf. Stevenson, 1991).

Where *private property rights* subsist in a resource, the various powers not circumscribed by legislation are vested exclusively in individual persons.

2.2 Economic implications of alternative property rights regimes

From an economic viewpoint, private property rights are normally seen as the more efficient institution.⁵ This is due to the occurrence of externalities in connection with open access and common property, and to the incentives which they create.

The foundation for this theory was formulated by Harold Demsetz, who in his pioneering article (1967) analysed the emergence of private property rights in land among American Indians of the Labrador Peninsula. When private rights in a particular resource – game in the article – are lacking, no hunter has any incentive for limiting his own hunting, because the benefit of restraint will mainly accrue to other hunters in the same area. First come, first served, one might say. These externalities may lead to the overhunting of game. A similar situation applies concerning fisheries, water sources, and other depletable resources. The upshot can be depletion and disappearance of the resource (Hardin, 1968).

The reverse applies to the supply side. If a resource or an area of land is individually owned, a direct relation subsists between investments/work input and the income obtained. Under other property rights regimes – open access or common property – the link between individual inputs and returns will be weaker. There will be a risk of others free-riding, in which case the rational course for all individuals will be to make less effort.

The establishment of exclusive, individual rights is the solution often advocated. If, for example, the land is divided into property units, both the cost of resource utilisation and the proceeds of management measures will devolve on the individual property owner – the *externalities will be internalised* by the transition to a private property rights regime.

³ It may be pointed out that the different regimes of property rights merely indicate whether and if so by whom a certain resource can be owned, but specify nothing about the content of ownership. Apart from these dimensions, public law regulations of land uses may restrict the right to utilize a certain resource or to undertake a certain measure, regardless of the different property rights regimes.

⁴ The legal term is *res nullius*, which originates from Roman law and means “nobody’s property”.

⁵ This general position does not hold true for all conditions, see e.g. Ostrom (1990) and Ekbäck (2009).

But there is also a cost side to property rights. Creation and maintenance of exclusive rights in land entails expenses. The territorial subdivision has to be documented by means of reference points, registers, maps or suchlike. Boundaries have to be marked and monitored. It must be possible for infringements to be proceeded against and prevented through public sanctions. These expenses are all *institutional costs* (Ekbäck, 2009).

In order for a resource-demanding property rights regime to be economically justifiable, its institutional costs must be offset by positive land use effects – *higher land values*. The positive effects come about through changed incentive structures and lower transaction costs for agreements on grants of rights, transfers etc.

“[P]roperty rights arise when it becomes economic for those affected by externalities to internalise benefits and costs.” (Demsetz, 1967 p. 354)

Population growth, changed production technology or the appearance of new markets can boost demand for the land resources, leading to an increased demand for the establishment of private property rights. The effect will be the same if new technology reduces the costs of the new property rights regime.

3 The economics of 3D property rights

In order to develop some basic assumptions regarding the economic implications of 3D property rights, the purpose is to make use of the concepts presented in the previous section, and to identify and analyse benefits and costs arising out of the creation of 3D property rights in relation to traditional property rights.

3.1 Do 3D property rights constitute a new property rights regime?

Legislation sanctioning the formation of 3D property units is a radical modification of the traditional Nordic systems of property law, in which property units are defined in two dimensions only.⁶ One of the first questions thus needing to be addressed is whether the introduction of 3D property division involves a transition to a new property rights regime.

As stated in the preceding section, the various property rights regimes can be classified according to different degrees of exclusiveness, which in turn entails an internalisation of externalities in discrete steps.

Where the Nordic countries are concerned, however, the transition from 2D to 3D property unit definition does not imply any change as to which individuals or collectives are entitled to utilise the three-dimensional space above or below ground, as the case may be. In Denmark, Finland, Norway and Sweden alike, the traditional property units extend both upwards and downwards – even though they are only defined in two dimensions (Lantmäteriet, 2003). In other words, the space above and below the surface of the ground also belongs to the traditional property units to a certain extent.

Thus the owner of the property units is exclusively entitled to use this space. On the other hand it is not normally possible for parts of these spaces to

⁶ At present Norway and Sweden are the only Nordic countries to have introduced statutory rules for the formation of independent 3D property units; see table 1.

be separately conveyed, any more than part-spaces can be mortgaged as security for credit. However, limited rights – easements, right of way, leaseholds etc. – can still be granted within a defined 3D section of the traditional property's space.

The introduction of 3D property division, then, does not amount to the creation of a new property rights regime, in the sense of the term as used here. The statutory reform is better described as a discrete step forward within the framework of an existing property rights regime, normally private property rights.⁷ The change means the investment of more resources in documentation of reference points, registers, maps and suchlike – the transition implies higher institutional costs.

The economic justifications for this can be several in number. The value of a certain resource – e.g. centrally situated land in urban areas – may have risen, or the cost of vertical parcelling may have declined – e.g. through new digital techniques of mapping and recording (cf. Ekbäck, 2009 p. 62). This question will be further considered presently.

3.2 Prerequisites for 3D property rights demands

If 3D property rights do not imply a new property rights regime, and do not internalise any additional externalities, it is logical to ask what the positive effects of 3D property division can be.

In addressing this issue, it is useful to begin by clarifying two necessary preconditions of demand for 3D property rights developing in the first place, namely vertical separation of real property employment and diseconomies of scale or scope.

3.2.1 Vertical separation of real property employment

One basic assumption is that building and civil engineering costs are higher for a high-rise building or facility than for a low-rise one at ground level, e.g. when building homes on top of existing offices or shop units. The increased cost of a given area or volume is due mainly to the additional cost of the framework⁸ and services⁹ (electricity, heating, water supply, drainage etc.). Tall buildings, moreover, are often of greater technical complexity.

As another example we can take the construction of a railway in a tunnel, at the same time as the ground level and the space above it are used for other activities. In the normal instance, the construction cost of tunnels exceeds that of ground-level railway facilities by a factor of between 5 and 10 (Fröidh, 2010). Finally, we can take the example of installing power lines below ground, the cost of which is at least 10 times greater than the construction cost of overhead power lines (Svenska Kraftnät, 2010).

⁷ It is possible in Sweden to form 3D joint property units (*tredimensionella samfälligheter*) which by definition are classed as common property rights. In Norway, 3D construction properties can also constitute common property (*realsameie*).

⁸ See Sektionsfakta (2010a).

⁹ See Sektionsfakta (2010b and 2010c).

In all these instances, the construction and civil engineering costs would have been lower if the work had taken place at ground level instead. To justify building on a vertical axis, therefore, the marginal cost of land must exceed the increase in construction and civil engineering costs.

High land values in relation to construction and civil engineering costs can thus justify the utilisation of vertical fractions of real property. Using comparative statics, this means that if *either the value of land increases or construction costs decrease*, the effect will be an intensified demand for vertical separation of real property employment.

In a Nordic perspective, these factors tally with reports of increased demand for developable land in urban areas, high land values, new construction techniques, and improved, less expensive methods of drilling in bedrock (Onsrud, 2001).

3.2.2 *Diseconomies of scale and scope*

Vertical separation of real property employment cannot be taken as the sole factor accounting for the occurrence of demand for 3D property rights. The utilisation of separate vertical segments could be accomplished by the same person or company if it were not for the second precondition – diseconomies of scale.

Diseconomies of scale are a special case of the standard economic problem of optimal scale. The cost curve in figure 1 illustrates the standard relationship between unit cost and output. As the output increases in the left part of the figure, the average cost decreases due to economies of scale. This occurs because the initial fixed costs are shared over an increased number of goods or services (Kreps, 1990).

At a certain point (Q_{OPT}) the economies of scale are exhausted, while diseconomies of scale start to influence the unit cost. The diminishing returns may have different causes, e.g. increased costs for management, communication, and co-ordination (Coase, 1937), increased complexity, moments of inertia in decision-making and implementation (Williamson, 1975). The result is that the unit cost increases as the output increases. In a competitive market this implies that the company should be divided into several smaller firms.

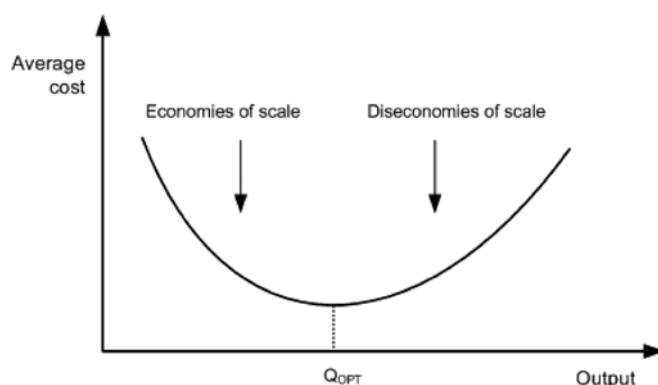


Figure 1. *Illustration of relationship between unit cost and output (Kreps, 1990)*

The fact that such disparate operations as railway tunnels, multi-storey car parks, retail units and housing – in vertical fractions – can be achieved more efficiently with different principals is if anything an expression of diseconomies of scope.¹⁰ But retail units or offices on several storeys, for example, can also result, for certain enterprises, in a size at which diseconomies of scale occur.

Thus it may be efficient to separate the different activities in the vertical fraction into separate legal units. Which leaves the question of what different legal solutions are available and how one should choose between them.

4 3D property rights alternatives in the Nordic countries

When the preconditions mentioned in the preceding section are in place, the aim should be to legally secure 3D property rights at the least possible cost. Introducing opportunities for 3D property division can in certain situations be the efficient solution, but this is not always the case! Much depends on the options available within the traditional system of property rights.

It is possible in many cases for 3D property rights to be created as easements and different forms of indirect ownership, without the establishment of independent 3D property units. Table 1 gives an overview of alternative 3D property rights solutions in Denmark, Finland, Norway, and Sweden. The categorisation follows Paulsson (2007 pp. 32–42). It will be noted that the table shows a down-up timeline, with the more advanced and independent 3D property rights structures being introduced more recently.

Table 1. Overview of 3D property rights alternatives in the Nordic countries.

	Denmark	Finland	Norway	Sweden
Independent 3D property			Anleggseiendom	3D-fastighet
Condominium ownership	Ejerlejlighed			Ägarlägenhet
Condominium user rights	Boligsamejer	Delning av besittning	Eierseksjoner	
Indirect ownership	Andelslejlighed	Bostadsaktiebolag	Burettslag	Bostadsrätt
Granted rights	Servitutt Brugsrettigheder Etc.	Servitut Nyttjanderätt Etc.	Servitutt Leieretter Etc.	Servitut Nyttjanderätt Etc.

Independent 3D property provides for ownership and registration of separate three-dimensional property units, independent from the underlying parcel. There is no need for any connection with the ground parcel. Units can be created in subsurface space in the same manner as in tracts of air.

Condominium ownership implies individual ownership of premises in a building. The condominium is owned, and connected to it is a share in the common property. The condominiums are registered as independent units and can be owner-registered and mortgaged. The condominium right must relate to a surface parcel on which the building containing these rights is erected. One

¹⁰ Diseconomies of scope arise when multi-product production by a single firm is less efficient than having separate firms each specialising in a single product.

difference from the independent 3D property type, which legally is completely separated from the land parcel, is that condominium ownership always includes a share in the related land parcel.

Condominium user rights means that the building and the surrounding grounds are owned jointly by the condominium owners. These owners only own a certain share in the common property, and connected to that share is a permanent exclusive right to use a certain condominium apartment in the building. The share and the right to use the condominium are treated as one unit, i.e. there is no physical division of the property.

Indirect ownership implies that there is a legal person of some kind (co-operative, association, or company), which is the formal owner, and as such stands between the resident and the property. Membership of such an association gives the right to use an apartment in the building.

Granted rights can involve limited real property rights or personal rights for certain purposes. The powers that may be included in the rights are normally constrained by legislation.

4.1 Denmark

In Denmark the formation of independent 3D property units is not possible at present, but it is possible to form condominiums (*ejerlejligheder*) in buildings of different kinds.¹¹ A condominium is a property unit in its own right and can be individually conveyed and mortgaged. Condominiums can be formed in residential buildings and may also include business and office premises. In some cases condominiums have been established in indoor car parks and other complex buildings (Thellufsen, 2009).

Buildings alone can be divided into condominiums; land cannot. Instead the land and other parts of the building are owned jointly by the condominium owners. Ownership of a condominium automatically confers obligatory membership of an ownership association (*ejerforening*), the body which manages the common property. This association, however, is not a legal person.

The condominiums issue was already broached in Denmark at the beginning of the 1960s. Reasons advanced for the reform included the need to create funding facilities for new building development and for the more extensive renovation of older buildings, as well as a desire to give tenants more influence (Betænkning nr 395/1965 pp. 129–131).

The flexible application of this 3D solution to different types of buildings and facilities appears today to be working satisfactorily (Sørensen & Bodum, 2009). No need has emerged for more independent 3D property units.

Supplementary forms of 3D property rights exist in the form of condominium user rights, indirect ownership, and different granted rights; see table 1.

¹¹ See the Act on Condominiums (*lov om ejerlejligheder*).

4.2 Finland

The Finnish system permits neither the formation of independent 3D property units nor condominiums with ownership rights. It is possible to conclude an agreement to divide possession (*delning av besittningen*) of a traditional property unit in cases of joint ownership, which can thus mean dividing the right to use the real property into separate 3D volumes.¹² The agreement may be registered.

In addition, 3D property rights may be created in different forms of granted rights, such as easements, usufructs etc.

For apartments it is common for a so-called Housing Company (*bostadsaktiebolag*) to own the property (both land and building).¹³ The shareholders have a right to possess a certain apartment, or some other part of a building owned by the company. The company is responsible for the property, the day-to-day management of which is handled by a board of directors and a CEO. This solution is to some extent also applicable to business and office premises.

The present 3D property rights alternatives in Finland are today perceived as falling short of existing needs. The lack of legal instruments for establishing security of tenure and means of securing finance is especially keenly felt where complex and large construction and civil engineering projects are concerned (Thellufsen, 2009). Use is often made of agreements to divide possession, which in turn necessitates joint ownership of the primary property unit. The agreement structures used create uncertainty regarding certain issues of responsibility and sometimes may lack legal authority, for which reason they cannot always be registered (MMM 2008:1).

Earlier the Finnish government appointed a task force to investigate the issue of introducing legal instruments for 3D property formation. The task force's proposal – recommending the creation of possibilities for independent 3D property formation – was submitted in 2008 (MMM 2008:1), but the formal legislative process has not yet started.

4.3 Norway

Formation of 3D construction property units (*anleggseiendom*) has been possible in Norway since 2010.¹⁴ A 3D property is an independent unit – delimited as a self-contained volume – which can be positioned above or beneath one or several traditional property units. The 3D property unit is not tied to any particular use but must among other things include an existing or prospective building or facility.

During the drafting of the law, the need for a new 3D property category was specially analysed. It was argued that a land shortage had developed in densely built-up areas. The possibility was needed for creating independent objects for various underground facilities, such as warehousing or indoor car parks. Facilities of this kind usually require considerable capital outlay, which in turn demands much in the way of security. The objective, therefore, was to be able to create

¹² See the Code of Real Estate (*jordabalken*) Chap. 14, Section 3.

¹³ See the Housing Companies Act (*bostadsaktiebolagslagen*).

¹⁴ See the Act on Real Property Registration (*lov om eiendomsregistrering*).

3D property units as independent title objects for conveyance, easements and mortgage (NOU 1999:1 pp. 77–79).

The Norwegian system also contains forms of condominium user rights (*eierseksjoner*), which mean joint ownership of developed property, each unit carrying an exclusive right of user to an apartment or other utilisation unit.¹⁵ In addition to housing purposes, condominium user rights can also be created for commercial activities of various kinds.

Supplementary forms of 3D property rights exist, e.g. in the form of indirect ownership and various granted rights; see table 1.

4.4 Sweden

Sweden introduced the possibility of forming independent 3D property units (*tredimensionella fastigheter*) in 2004.¹⁶ This type of property is not tied to any particular mode of use. 3D property units can be conveyed and mortgaged and can be made a subject of easements, just like traditional property units. They can be structured independently of the design of the traditional property units and accordingly may extend above or beneath several traditional property units.

Special conditions apply to a 3D property unit. Among other things, it has to include an existing or prospective building or other facility, and legal safeguards have to be made concerning necessary co-operation with neighbouring properties, e.g. regarding stairwells, lifts, water supply and sewerage etc.

Independent 3D property formation was introduced because the existing law was not found equal to the need of securing the right of disposal, conveyance and mortgaging of delimited three-dimensional spaces in buildings or for subsurface facilities on traditional properties. Problems also occurred with the assignment of rights in these buildings and facilities (SOU 1996:87). Surveys revealed, among other things, structures with easements which probably lacked support in the existing legislation (Julstad, 1994).

Since 2009 there has also existed a special form of condominium ownership units (*ägarlägenhetsfastigheter*) which are only to include one unit for dwelling purposes. These condominium units can also be conveyed and mortgaged and made a subject of easements, just like traditional property units. The purpose of condominiums was above all to increase the diversity and options available in the housing market (prop. 2008/09:91 pp. 35–45).

There are supplementary forms of 3D property rights, such as indirect ownership and different granted rights; see table 1.

5 Benefits and costs of 3D property formation

The preconditions necessitating a need for 3D property rights are high land values in relation to construction and civil engineering costs on the vertical axis and the activity concerned being characterised by scale or scope diseconomies.

¹⁵ See the Act on Apartment Units (*lov om eierseksjoner*).

¹⁶ See the Real Property Formation Act (*fastighetsbildningslagen*).

These are necessary but not sufficient prerequisites for making 3D property formation economically justifiable. It also needs to be established that the total cost of legal partition of separate real property spaces for multiple use is cheaper with 3D property formation than with alternative property rights solutions within the traditional system. The objective should be to minimise total transaction costs.¹⁷

As we saw in the previous section, the Nordic countries have alternative ways of forming 3D property rights in the form of easements, different forms of indirect ownership and condominium rights. The available options must be evaluated in terms of benefits and costs, and compared with the effects of possible law reforms. In cases where contractual solutions are constructed unsupported by statute law, the transaction costs of using the traditional system will of course be very high.

In the review of 3D property rights alternatives in the Nordic countries, certain indications were mentioned of shortcomings and weaknesses in the traditional solutions. The arguments propounded in connection with law reforms suggest that a closer analysis of the benefits of establishing 3D property formation can be structured with reference to the basic powers of the ownership concept, as mentioned in section 2.1.

5.1 Benefits of institutional transition

On a general plane, the benefits can be said to consist in lower transaction costs of legally securing three-dimensional parts of real property. Benefits result regarding possession, transfers and granting of rights, which in turn enhances the prospects of securing the value of the real property utilisation.

Concerning *possession*, 3D property formation offers a higher level of security with regard to the endurance of rights with the passing of time. In all the Nordic countries, granted rights, indirect ownership and user rights afford inferior legal safeguards by comparison with direct ownership. These limited rights can lapse as a result of certain transfers or other legal transactions. They generally have inferior publicity in the real property and land title registers. The content of limited rights is normally defined in positive terms by contract or statute, which also reduces the scope available to the tenant for changes and adjustments. To sum up: 3D property formation reduces the transaction costs entailed by the long-term securing of possession of 3D segments of real property.

Ownership rights can be *transferred* at lower costs than limited rights. In the case of granted rights, the property owner's consent may be needed in order for these to be transferrable at all. Standardised transfer procedures also create incentives for long-term profit maximisation, in that the three-dimensional space can easily be conveyed to the party who values it highest.

Different types of *rights can be granted* at lower costs when the object is an independent property unit, compared to the alternatives. One specially important

¹⁷ Transaction costs – in general terms – comprise the cost of purchasing, exchanging, transferring or otherwise changing the rights to a certain resource (cf. Williamson & Masten, 1995).

right is the *mortgage* – i.e. a financial security – which can be granted in real property according to standardised procedures. However, a mortgage cannot be granted in limited rights. The costs of financing are thereby lower with 3D property formation.

Other *limited use rights* – both beneficial and encumbering – may be granted at lower costs in real property than in other granted rights. To grant rights in a granted right will often require the consent of the property owner. Such rights may not be possible to register, and they generally have a weaker security.

One final remark is called for concerning the benefits of 3D property formation. In all the respects mentioned above, there is a strong connection with the structure of the registration system, its legal effects and dependability. Space, however, will not permit us to elaborate on these aspects.

5.2 Institutional costs due to transition

The costs entailed by introducing 3D property formation, in common with its benefits, must be viewed in relation to the costs of the traditional solutions, i.e. be valued on the margin.

One major item of expenditure, of course, consists in the process of drafting and enacting new *legislation*. Depending on how the rules are framed, there may be knock-on effects on other parts of the system of real property law.

The new legal possibilities may require the development of new *technical systems*, e.g. for boundary marking, documentation, cartographical presentation and registration. On this point we may note that the new digital techniques (e.g. 3D GIS and CAD software) have probably had the effect of reducing technical costs in these very respects during recent years, which in turn may go a long way towards explaining the institutional reforms which have taken place, for example, in Norway and Sweden.

A further item of expenditure is the build-up and dissemination of *knowledge* concerning the new rules and their application. This applies above all where national authorities and law courts are concerned, but it also includes individual persons and business undertakings affected by the changes.

It should be noted that the above mentioned expenses are non-recurrent, whereas the benefits can be capitalised over a long period of time. Stricter requirements concerning *accounting records, maps and documentation*, on the other hand, may be a recurrent expense occurring in each individual instance.

One important question to which there is no clear-cut answer is whether the cost of *co-operation* between the different three-dimensional spaces will be greater or smaller with 3D property formation than with the traditional options.

Increased costs of co-operation between different units with vertical real property employment in comparison with horizontal utilisation at ground level is a consequence of the more palpable interdependence of different units on the vertical plane (Sandberg, 2003 pp. 134–135). This is connected with the earth's gravity. An underlying unit will always serve as support for activities/facilities overhead. This dependence is a good deal greater than in the case of two neighbouring 2D property units. The strength of vertical dependence also makes itself felt with

regard to drainage, ventilation and access/exit (the last mentioned of which must of course take place at ground level).

All changes in the use of one stratum can affect the others. Moreover – and this is important – problems in the form of opportunism and hold-out strategies can very easily occur in the absence of special rules of co-ordination between the units.

These higher costs of co-ordination, however, are not linked to the choice of a 3D property rights solution but are a direct consequence of the vertical dimension of real property utilisation. The question of different forms of property co-operation, however, falls beyond the scope of this article.

6 Concluding remarks

Various forms of land use have always taken place in three dimensions, e.g. construction and civil engineering works, respectively upwards and downwards in relation to the ground surface. Consequently systems of property law have also included 3D property rights elements, such as granted rights.

A trend now current in the Nordic countries favours supplementing 3D property rights instruments with opportunities for independent 3D property formation. This can be put down to certain consequences of social development. Among other things, vertical separation of real property utilisation has increased, above all in urban areas, due to land values having risen in relation to the cost of buildings and facilities on the vertical plane. In situations of this kind, three-dimensional spaces need to be legally secured for activities characterised by scale or scope diseconomies.

The foremost benefit of independent 3D property formation (i.e., direct ownership) is probably that of economising on transaction costs for securing and managing three-dimensional spaces of real property, compared with legal solutions within the traditional system. Transaction costs of possession, transfers, and the granting of rights (mortgages, easements etc.) are reduced.

Whether the transaction costs are lowered, and if so by how much, depends of course on the framing of the alternative 3D property rights instruments which the traditional system provides. The introduction and utilisation of independent 3D property formation requires – just like traditional property rights – a balancing of benefits and costs on the margin.

Some reports suggest that in Sweden and Finland the traditional systems have no legal instruments at all for catering to certain needs. When contractual solutions are employed which have no support in legislation, then of course the transaction costs will be very high and the introduction of 3D property formation then confers palpable benefits. In Denmark, on the other hand, the system of condominiums appears capable of accommodating the existing needs, thanks to flexible, adaptable implementation. In that situation, the benefits of introducing independent 3D property formation are probably smaller.

Even though this article may constitute a step towards an improved theory of 3D property rights, several aspects remain to be further explored. Since this study mainly has investigated the system or legislative level, there is a future need to focus explicitly on the economic choice between alternative 3D property

rights solutions in an individual case, i.e. when legislation is treated as an external parameter.

Finally, a comment on the fallacy that the need for independent 3D property formation first appeared at the end of the 20th century. Needs of this kind have of course always existed, but institutional transition in that direction has not previously been economically justifiable. Today the benefits have grown, due mainly to rising demand for land in urban areas, at the same time as new construction techniques have reduced the cost of building complex structures above and below ground. Meanwhile the cost of the reform has been reduced by the new digital possibilities of documenting, presenting and recording boundaries in an additional dimension. Independent 3D property formation will not arise until it becomes economical for a society to replace or supplement the traditional 3D solutions with direct ownership property rights.

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