The Future of Property Rights: Digital Technology in the Real World

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Abstract Digital technology can open new frontiers in the formation, registration, and enforcement of property rights in land. This chapter explores the prospects—but also the limits—of digital technology in streamlining efficient land use and land markets. In particular, it asks whether the digital production and dissemination of information can enhance a more optimal use of land, such as by the three-dimensional (3D) delineation of real estate into distinct segments and specific rights thereto, including for subsurface infrastructure, or by the digital pooling of non-adjacent assets for purposes such as creating collective security interests in them. This chapter shows that while aligning the digital production of information with a corresponding system of "legal volumes" and 3D zoning regulation can innovate land markets, the growing multiplicity of property rights in multi-layered tracts faces a genuine collective action problem, having both commons and anticommons features. Digital technology should thus be matched with a legal reform on the institutional governance of multiple uses and interests in and across tracts, somewhat like in the case of condominiums.

Keywords Collective action · Condominium · Governance · Land · Property· Strata title · Zoning

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A. Lehavi, R. Levine-Schnur (eds.), *Disruptive Technology, Legal Innovation, and the Future of Real Estate*, https://doi.org/10.1007/978-3-030-52387-9_4

1 Introduction

The Fourth Industrial Revolution, embedded in the rapid development of digital technology and other technological/scientific advances, purports to transform all walks of life, such that "the real opportunity is to look beyond technology, and find ways to give the greatest number of people the ability to positively impact their families, organisations and communities" (World Economic Forum, 2020). Land use and land markets are definitely instrumental for the future of families and communities. Yet at first glance, land seems to be a less natural candidate for outright revolution, given its finite supply and physical traits, unlike other forms of economic activities.

This chapter looks at how digital technology can be utilized to advance a more extensive and efficient use of land, primarily by the 3D digital slicing or pooling of land, dissemination of this information to all relevant actors, and matching of such geographical and technological data with a more flexible multi-use approach to land-use regulation (and zoning in particular) and a multi-layered allocation of property rights. Such a legal development could extend beyond the current closed list (numerus clausus) of types of property rights to meet this changing landscape.

At the same time, the growing sophistication of digital technology and its application to land-use regulation and to legal aspects of property rights do not inherently solve genuine collective action problems that typify intensive, multi-use, multi-party land developments. In fact, the growing intensity of use and multiplicity of stakeholders enabled by digital technology can also increase potential frictions among such stakeholders: from neighboring (vertical or horizontal) users of land, to multiple financiers holding competing or overlapping security interests in land. Such collective action problems can implicate both issues of commons (Hardin, 1968), in which multiple stakeholders in the same asset will tend to over-exploit and under-invest in it—and ones of anticommons (Contreras, 2018; Heller, 1998), in which over-fragmentation of private property rights in legally separate but practically interdependent assets can lead to inefficient results or outright deadlocks, by preventing coordination or integrative use of such assets. These collective action problems can result from either strategic behavior, such as holdouts or free riding, or from genuine heterogeneity among stakeholders about their preferences and priorities.

While digital technology can provide better information to all parties about the spatial features of land, and a corresponding reform in zoning regulation and the composition of property rights can potentially give them more flexibility in exploiting physical space, such developments do not in themselves offer a mechanism for resolving potential frictions and deadlocks among parties. What is therefore needed is a dynamic decision-making framework that would accompany various types of multi-use, multi-layered land developments, facilitating institutional governance that draws inspiration from the legal design of condominiums and other forms of strata title.

The rest of this chapter is structured as follows. Part 2 discusses the traditional allocation of property rights in land, which is based largely on a two-dimensional identification of a single tract's surface, with certain particular exceptions that still fall short of a flexible spatial approach. Part 3 shows how different forms of common interest developments, including condominiums, have been able to create an institutional and legal framework for the governance of multi-party, multi-layered use of land, mostly in the residential context, despite their reliance on a static, pre-digital delineation. Part 4 demonstrates recent experiments with the digital production of 3D spatial data and a corresponding adaptation of zoning regulation and 3D land registration of "legal volumes." Part 5 suggests that, in addition to innovative 3D slicing, digital technology can also facilitate the pooling of non-adjacent properties for purposes such as cross-asset collective security interests. Part 6 shows that while digital technology can facilitate a more dynamic and intensive use of land, it cannot in itself resolve potential collective action problems that persist or may be even exacerbated by the growing multiplicity of property rights and numbers of stakeholders. Any such innovation must be matched with the legal design of multi-party institutions of governance.

2 Traditional, Suboptimal Slicing of Property Rights in Land

Prior to discussing how current digital technology can transform the spatial allocation of property rights in land, this part briefly identifies the piecemeal development of legal and regulatory doctrine on multi-layered property in the face of previous generations of economic, social, and technological changes. In principle, such exogenous changes may implicate demand and (to a lesser extent) supply of physical space, as well as the relative costs and benefits of following a certain system of property rights, thus leading to potential changes in legal and regulatory policy (Demsetz, 1967). While such changes have indeed occurred for land, especially over the past two centuries, it would be fair to say that longstanding principles of property in land have not been entirely disrupted, but were rather gradually adjusted and fine-tuned. Moreover, this development has often been unsystematic, leaving much room for ambiguity, such that the overall spatial system of allocating property rights in land is presently suboptimal.

The starting point is that of the *ad coelum* rule. Under the Latin maxim, which dates back to the times of Gaius and Justinian: "Cuius est solum eius est esque ad coelom et usque ad inferos" ("Whoever owns the land owns the property all the way to heaven and all the way to the center of the earth"). While exceptions to this rule have already been introduced during Roman times through the *actio de superficie*, allowing for the creation of horizontal surface rights owned by subjects other than the owner of the estate, it has proven resilient over centuries (Parisi, 2002). In the common law system, the *ad coelum* rule became influential after it was cited by

Edward Coke in the seventeenth century and William Blackstone in the eighteenth century (Rule, 2011).

At its core, while referring to a three-dimensional space, the *ad coelum* rule is in fact dominated by the two-dimensional delineation of the land's surface for establishing property rights. The identification of a two-dimensional space and title thereto automatically governs rights over open space above and below the surface. Moreover, such delineation controls rights to other valuable objects: from subterranean minerals and other materials, to above surface human-made structures through the principle of accession, or 'fixtures' in Anglo-American legal terminology, mostly in a landlord-tenant context (van Erp & Akkermans, 2012).

In Continental Europe, nineteenth-century civil codes, including the 1804 Code Napoléon, adhered to the *ad coelum* rule by disallowing the horizontal severance of land into multiple surface and subsurface estates. But property owners occasionally continued to do so. While such agreements on the partition of land into multiple surface and subsurface estates could not formally commit to conveying real title to the various land strata, parties to such transactions sought to bypass this impediment by agreeing not to invoke accession rules for any structures (such as buildings) erected on the land. With time, civil courts developed a more accommodating approach and allowed such atypical forms of property fragmentation to survive in the shadow of the law. Subsequently, twentieth-century civil codes, including the 1900 German BGB, moved away from applying the strict principle of physical unity, allowing in effect for limited forms of fragmentation, involving typically not more than two layers: surface and subsoil (Parisi, 2002).

A more systematic legal challenge to the *ad coelum* rule began in regard to airspace with the start of aviation in the early twentieth century. In the seminal case of United States v. Causby (1946), the US Supreme Court moved away from a strict application of the *ad coelum* rule—reasoning this doctrine "has no place in the modern world" (p. 261). It distinguished between an upper altitude that serves as a "public highway" for air travel, and the lower layer of airspace above the land's surface that may be practically usable, such that the "landowner owns at least as much of the space above the ground as he can occupy or use in connection with the land" (pp. 264–265).

That said, the *ad coelum* rule, and the underlying dominance of the two-dimensional delineation of the land's surface for establishing property rights and legal control, are far from abolished. For both airspace and subsurface, the *ad coelum* rule has been occasionally adjusted to accommodate economic, social, and technological changes, but it otherwise maintains the control of the surface owner over usable spaces or those in which invasions might otherwise impact such use and enjoyment. Thus, regarding unauthorized invasions to the lower airspace and immediate subsurface, courts generally adhere to a strict version of the *ad coelum* rule (Smith, 2015).

The complexity of managing a multiplicity of layers in the face of the *ad coelum* rule, and not less importantly, in a system of property rights and land registries that still generally follows a two-dimensional approach, manifests itself even more vividly in the case of subsurface rights.

Subsurface rights are created most frequently through the voluntary creation of easements on relevant routes across/in the subsurface or materials located in the subsurface. Easements—defined generally as an irrevocable license to enter and use land owned by or in possession of another person—are recognized as property rights in the various legal systems and can be registered accordingly in the land registry. In the case of the right to enter the surface and/or the subsurface in order to remove materials such as timber, minerals, oil, and gas, such an easement is traditionally referred to as a *profit à prendre*, or simply as a profit (Restatement, 2000). In particular, the law governing easements relating to subsurface oil, gas, and minerals has developed into a separate and complex branch of doctrine, with unique rules applying to such subsurface interests (Dukeminier et al., 2018; Kostrub & Christenson II, 2012). The multi-layered structure of a subsurface right of easement is further challenged in light of recent technological developments, such as horizontal drillings or hydraulic fracturing (Wilkerson, 2015).

In addition to transaction-based easements, the need for surface or subsurface public infrastructure, such as roads and railways, electricity lines, water pipes, fiber-optic cables, etc., may require the government to use its power of eminent domain to obtain an easement or right of way in the surface or subsurface (Morriss, Brandys, & Barron, 2014). Some legal systems—including those of many US states—may also grant private entities, such as oil and gas companies, the right to use the power of eminent domain to obtain such easements or rights of way (Klass, 2008; Righetti, 2016). That said, the *ad coelum* rule continues to play a major role, such that any form of permanent physical invasion of the surface or subsurface requires either the consent of the landowner or exercising the power of eminent domain for public use against the payment of due compensation. This may be so even if such a physical invasion is very limited in scope and does not practically deny current use and enjoyment of the land by the owner, as famously articulated by the US Supreme Court in the case of Loretto v. Teleprompter Manhattan CATV Corp. (1982).

Another type of multi-layered fragmentation of property rights in land, which emerged as an exception to the *ad coelum* rule, concerns the ability to separate ownership of a building or another structure from the ownership of the land. In Roman law, it is known as a *superficie*s. While as a general rule, civil law systems adhere to the maxim of *sepreficies solo cedit* (adopting the rule of accession for any such building or another structure), civil codes were amended and other pieces of legislation or regulation were introduced to recognize a self-standing right of superficies. That said, the exact content of the right of superficies (for example, in regard to future construction rights, or the right to enter the land to access the building) is often not set by law, but should be specifically determined between the parties (van Erp & Akkermans, 2012).

The separation of land ownership from property rights in structures or buildings has also been gradually introduced in Anglo-American systems. However, such fragmentation is done in specific contexts, when the practical need for this manifests, often with little or no statutory or regulatory provisions linking such exceptions to the *ad coelum* rule or to the law on fixtures.

One such setting, introduced in the United States, is that of the Community Land Trust (CLT). The CLT is a community-based, non-profit organization that acquires land for the purpose of retaining perpetual ownership in it to facilitate affordable housing. An eligible buyer leases the land for a long period of time (typically 99 years) and becomes owner of the building erected on it. The lease agreement on the land divides the bundle of rights between the individual and the CLT during the tenancy and upon its transfer by inheritance or resale. In the latter case, to keep the land available for affordable housing in perpetuity, the CLT repurchases the property itself or monitors its direct transfer from seller to buyer, while ensuring that the resale price is restricted to a set formula. This is done to allow the exiting homeowner to receive a reasonable return on investment, while granting income-eligible buyers affordable access to the housing unit. Most US states allow for the legal fragmentation of rights between the land and the housing unit, whereas in a couple of states (Ohio and North Carolina) there is a gray area in the law, suggesting that such a separation of title is not permitted. In such cases, the CLT leases out to the buyer both the land and the building (Davis, 2010; Lehavi, 2013; Miller, 2013). The CLT model, with its division of property title, is now becoming familiar also in Britain (Chadwick, 2018).

Finally, another limited and often incomplete feature of multi-layered entitlements in land, which exceeds the paradigm of two-dimensional property rights over a single tract, concerns transferrable development rights (TDRs), also referred to colloquially as "air rights." TDRs are a regulatory mechanism that allows landowners to buy unused development rights from owners of other lots, under specific terms set out in statutory law or local zoning provisions, and to add such development rights to their own lots. The mechanism was originally introduced in New York City, prominently as in-kind compensation for owners of designated landmark buildings restricted from altering the building or building on top of it, by allowing them to sell such unused development rights to owners of other, non-restricted lots in the area (Ellickson et al., 2013).

Gradually, TDRs have come to be employed in a broader fashion, such that in New York City and elsewhere today developers can acquire unused development rights from owners of properties, whenever the two lots share a physical boundary, but the developers can then go on to assemble more development rights from consecutive lots (Wainwright, 2019). While TDRs start to have a substantial impact on land use and land markets, it should be noted, first, that the term "air rights" is misleading in the sense that landowners do not actually acquire the property rights in the physical unbuilt spaces in other lots, and secondly, that unlike property rights, unused development rights are typically not registered as such in land registries. In these and other respects, TDRs are limited in their ability to create a comprehensive and transparent system of efficiently allocating property rights, horizontally or vertically, across different tracts of land.

The large picture that emerges from the current legal landscape of multi-layered property in land is one of piecemeal, often ad-hoc solutions to address the growing complexity and intensity of land use and land markets in light of social, economic, and technological changes. The two-dimensional approach to land ownership,

expressed in the *ad coelum* rule, but also pertinent in traditional land registries and land use regulation, continues to serve as the default rule for the allocation and control of property rights in land.

Exceptions are carved out specifically and gradually, looking to solve particular problems with airspace, surface rights of way and subsurface exploitation of oil, gas, and minerals, etc.—but lacking a systematic approach to transform the two-dimensional tradition into a flexible, transparent, and accessible system of multi-layered property. Accordingly, easements (whether voluntary or compulsory), superficies, and other types of limited proprietary rights allowing for the use of—or the taking of profit from—certain subsurface, surface, or above-surface parts of a tract of land are subject to many intricacies and ambiguities, and are often not featured clearly and comprehensively in traditional land registries.

Moreover, to the extent that a certain legal system currently wishes to avoid ambiguities in defining a certain multi-level property right, it must often engage in excessive subdivision of parcels given the features of two-dimensional land registries. Thus, for example, in many countries, in the case of a right of superficies for a building that is constructed under, on, or over a part of a tract of land, the said object would be projected on a two-dimensional parcel map, and the parcel would be further subdivided into smaller parcels, to be able to register such a property right. Such a subdivision would often make little sense for the principal use of the land (Stoter et al., 2017). This means that the division or aggregation of pieces of land and rights thereto might not be driven by efficiency or other normative considerations, but rather by technical constraints, obsolete doctrine, or other varieties of path-dependency (Fennell, 2019).

The traditional system of multi-level allocation of property rights is thus often suboptimal. As the next parts will show, what is required is a systematic transformation into a three-dimensional model, which not only enables efficient spatial allocation of property rights, but also sets up an institutional mechanism for a long-term governance of multi-layered interests and stakeholders. Similar steps should be taken to enable the virtual and legal pooling of non-adjacent assets, such as for creating cross-asset security interests, to promote land markets and real-estate financing.

3 Condominiums (Strata Title) as an Institutional Exception

This part identifies the most important exception to the above-surveyed systematic deficiency in multi-layered property rights. In the context of residential land use, basically all legal systems have introduced over the past few decades common interest developments (CIDs). The term CID refers here to various types of shared-interest residential developments, such as condominiums, planned unit developments, stock cooperatives (co-ops), and community apartment projects. Not all forms exist in all countries, and the organizational and legal structure of each type of CID, as well as the terminology used, somewhat diverge among different legal systems (Lehavi, 2016).

Thus, for example, the vertical (but also horizontal) division of property rights in apartment buildings, which is typically governed by the legal institution of condominiums in the United States, is referred to as strata title in Australia. It is the most prevalent form of CID in the world.

Horizontal subdivisions—under which a real estate development comprises detached homes or housing units, with other areas serving as common facilities—are generally known as "planned unit developments" in the United States and as "community title" in Australia (Sherry, 2017).

This part focuses on condominiums or strata title as legal institutions for multi-layered property rights. It shows how such a volumetric allocation of space—while still relying on paper-based or static techniques for 3D allocation—is effectively intertwined with mechanisms for collective governance of both the common amenities and at least some aspects of the individual units. This part then presents the emergence of the "stratum subdivision" in Australia, which governs mixed-use developments, including structures having diverse types of commercial uses.

The condominium consists of an "undivided interest in common in a portion of real property with a separate interest in [a] space called a unit" (California Civil Code, 2014). The basic legal structure is one by which the housing units are individually owned, whereas the hallways, staircases, elevators, etc. of the structure (or complex of structures), alongside exterior spaces and amenities, such as yards, lawns, inner streets, or sports facilities, are owned in common by the group of unit owners. Condominiums developed at different stages and a diverging pace across the world. In Western Europe, early forms of condominiums have been in existence for a few hundred years, but the major push toward comprehensive legislation came in the aftermath of the world wars, which caused an acute housing shortage alongside growing popular demand for homeownership (van der Merwe, 2015). Emerging economies in Southeast Asia followed mostly Australian legislation during the 1960s and 1970s to meet growing local and foreign demand for condominium-type dense developments (Rabenhorst & Ignatova, 2009). Condominiums were introduced in the United States only during the later 1950s and early 1960s, but have since been burgeoning rapidly (McKenzie, 1994; Schill, Voicu, & Miller, 2007). Transitional economies have more recently seen the need for the legal design of condominiums mostly in their urban cores, as demonstrated in the case of China or that of Russia (Chen & Kielsgard, 2014; Lehavi, 2015).

As suggested above, the key institutional feature allowing condominiums to function effectively over time in governing multi-owned, multi-layered properties is the establishment of decision-making bodies with broad powers. Thus, for example, under the Australian model (introduced in New South Wales in 1961 and essentially followed in all other Australian states), a body corporate, constituted by all owners, is automatically created by the registration of the subdivision plan of the strata title. This body corporate is granted by statute the power to raise levies for maintenance, insurance, and administration, as well as the power to enforce bylaws.

While the statute provides for default bylaws, the body corporate can alter such bylaws (for some provisions unanimously, for others by special majority), and subsequently engage in creating new bylaws, typically by special, non-unanimous reso-

lution. Importantly, such bylaws may govern not only the use and enjoyment of the shared property, but also the physical features and use of the privately owned apartments. Such bespoke bylaws, particularly for large schemes, can include provisions about paint colors, mailbox style, plant type, pet type and weight, etc. There are some limits imposed by statute on the power of the body corporate, such that most Australian states ban bylaws that restrict transferring, leasing, or mortgaging lots (Sherry, 2017).

The organization and scope of power of internal bodies that govern multi-owned properties are similar in other countries, such as in the United States. The core of the collective action among homeowners in condominiums lies in the governing documents, composed of "declarations" containing a set of conditions, covenants, and restrictions (CC&Rs), which are recorded with the land registrar. Though based on contractual provisions, the governing documents and subsequent amendments, rules, and regulations adopted by the association go well beyond the law of contracts, awarding these rules a more credible and reciprocal nature. This is so because under enabling legislation, individually owned lots or units are "burdened by a servitude that imposes an obligation that cannot be avoided by nonuse or withdrawal" (Restatement, 2000).

As the California Supreme Court reasoned in its decision in Pinnacle Museum Tower Association v. Pinnacle Market Development (2012), having a single set of recorded covenants and restrictions that applies to an entire residential association "protects the intent, expectations, and wishes of those buying into the development and the community as a whole by ensuring that promises concerning the character and operation of the development are kept" (p. 524). The fact that such provisions are enforced as servitudes and not merely as contractual provisions—which might otherwise allow an infringing homeowner to avoid specific performance and instead pay compensatory damages—secures the endurance of collective action.

As is the case in Australia, rule-making powers of condominium associations extend beyond the establishment and management of common facilities, and may also control cross-apartment externalities resulting from the use of privately owned units, with such types of private ordering coming in addition to—and not in lieu of—public regulation, such as zoning or nuisance law.

Elected directors and officers of the association have broad authority to "exercise all the powers of the community except those reserved to the members." This authority also regularly includes the power to adopt "reasonable" rules that govern the use of the common property and the use of individually owned property when this is required to protect the common property. In reviewing the board's actions, courts regularly adopt either a "reasonableness rule" or corporate law's "business judgment rule"—both bearing a similar deferential content (Restatement, 2000). As for decisions taken by the general body corporate of homeowners, unless expressly limited by law or the association's declarations, simple majority is effective to amend the declarations or to otherwise adopt rules. Unanimous consent is required for restrictions on individual uses that cannot be grounded in common interest; changes made to the basis for allocating voting rights or assessments among homeowners; or rules that do not apply uniformly to similar units/lots.

In practice, however, US courts tend to broadly construe enabling legislation and declarations so as to settle for simple majority to amend the declaration or to promulgate new rules in nearly all instances. In Villa De Las Palmas Homeowners Association v. Terifaj (2004), the California Supreme Court upheld a majority-approved amendment to the condominium's declarations imposing a no-pet restriction, by viewing such a use restriction as "crucial to the stable, planned environment of any shared ownership arrangement" and holding that all homeowners, including those who purchased their units prior to the amendment, are bound by it. The court read Section 1355(b) of California's Civil Code on declaration amendments as settling for simple majority, reasoning that it is designed to prevent a "small number of holdouts from blocking changes regarded by the majority to be necessary to adapt to changing circumstances and thereby permit the community to retain its vitality over time" (p. 1228). Amendments made by simple majority thus generally enjoy a presumption of reasonableness, shifting the burden to the challenging party, who must show that these restrictions are "wholly arbitrary, violate a fundamental public policy, or impose a burden on the use of affected land that far outweighs any benefit" (p. 1231).

While these broad powers may at times seem controversial, especially when they have a practical effect of singling out certain homeowners, or when they otherwise infringe on what may be considered to be fundamental individual rights, there is no doubt that, generally speaking, the governance mechanism that is attached to the proprietary setup of condominiums or strata title is essential for the effective allocation and control of multi-owner, multi-layered properties. As such, it allows for a more intensive use of urban land in an age of increasing density and demand.

A recent development in Australia, which seeks to offer an institutional solution to multi-owned, multi-layered properties beyond residential buildings, is that of 'stratum' or 'volumetric' subdivisions. Realizing that strata title legislation was not adequate for mixed-use developments with residential and commercial owners, or with diverse commercial owners, such that a single body corporate may find it difficult to make decisions, Australian legislation was amended to allow for the subdivision of a building by a deposited plan into separate stratum lots, limited by height or depth by reference to the Australian Height Datum. Such stratum lots can be further divided by a strata plan, creating a residential or commercial strata scheme within that stratum lot, which becomes a 'stratum parcel.' Each such stratum lot or parcel could be then governed by its own set of bylaws. To address the vertical and lateral interdependencies between the different stratum lots, such stratum subdivisions require the introduction of easements intended to grant separate stratum owners access to shared property, which is partly or entirely located in another stratum owner's lot or parcel. Further, in order to deal with maintenance costs and other issues that require ongoing coordination across the different stratum lots or parcels, owners must register Building Management Statements (BMS) and Strata Management Statements (SMS). Such documents must include provisions on insurance, damages, and disputes, but may also and typically do include many other issues. In addition, the BMS must establish a Building Management Committee, which includes all stratum lot or parcel owners (Sherry, 2017). This committee is discussed further in Part 6, by illustrating how it facilitates collective governance.

4 Digital Production of 3D Spatial Data and Move to "Legal Volumes"

Digital technology and other types of innovations are being increasingly employed by both governmental agencies and private entities across the world in the context of land use and land markets. This includes the use of advanced technologies and professional standards, such as interactive graphic visualization, geographic information systems (GIS), building information modelling (BIM), and the land administration domain model (LADM) (Lemmen, van Oosterom, & Bennett, 2015).

The key challenge for efficiently implementing such new technologies lies to a large extent in the ability to integrate them across different professional and governmental platforms that are relevant to land use and land markets, and particularly in land registries and cadastral systems. Optimally, such geographical, technical, and legal tools should be formalized and accessible to all parties concerned, and governed by a unified system of registration (Yu et al., 2017).

Such techniques are being increasingly used in an attempt to gradually switch cadasters and land registries from two-dimensional systems to three-dimensional ones, with diverging degrees of success in introducing 3D systems and in synchronizing industry and governmental platforms. Accordingly, there is a growing body of literature on the recent experiences with 3D cadasters and/or land registries worldwide (Paasch et al., 2016), with numerous works focusing on case studies in countries such as Australia (Atazadeh et al., 2017), Croatia (Vučić et al., 2017), Korea (Kim & Hoe, 2019), India (Hamid et al., 2016), and Slovenia (Drobež et al., 2017).

In 2016, The Netherlands experimented with the first registration of an interactive 3D visualization of "legal volumes"—i.e., 3D physical spaces identified each as a distinctive unit—in the cadaster and the land registry (Stoter et al., 2017). As shown below, by legally validating and providing access to such a new type of physical identification and registration of rights in regard thereto, this regulatory and legal innovation seeks to serve not only current stakeholders, but even more so future transferees and other stakeholders of these multi-level property rights. As such, the introduction of legal volumes not only facilitates a more flexible approach to the division or aggregation of space over time in the face of social, economic, and technological changes, but may also enable the development of new types of property rights, outside of the current closed list (*numerus clausus*)—thus better serving future organizational and legal design.

The program was run for the Delft Railway Zone Project. The project covers an area of 24 hectares, but the 3D cadaster was introduced for a smaller part, consisting of the combined new Railway Station and City Hall, together with the underground platforms and railway tunnel, several technical installations, and underground bicycle parking (Stoter et al., 2017). This multi-layered construction combined the property rights of three parties: Municipality of Delft, which is the owner of the land and the City Hall; the Dutch railroad company for passenger transportation ("NS Real Estate" or "NS Vastgoed"), which is the owner of the Station Hall, shops,

and technical installations; and the Dutch railroad infrastructure company ("ProRail" or "Railinfratrust B.V."), which owns the travelers' area, the tunnel, and the platforms. To address this multi-level setup, six legal volumes and property rights thereto have been established:

1. Residual legal volume, not covered by the other five legal volumes (represented as "Index 1" in Fig. 1 below)—under a right of ownership of the Municipality of Delft.
2. Tunnels ("Index 2" in Fig. 1)—right of superficies, Railinfratrust B.V.
3. Travelers' area ("Index 3" in Fig. 1)—right of superficies, Railinfratrust B.V.
4. Station Hall ("Index 4" in Fig. 1)—right of superficies, NS Vastgoed.
5. Elevators and stairs ("Index 5" in Fig. 1)—right of superficies, NS Vastgoed.
6. Technical installations ("Index 6" in Fig. 1)—right of superficies, NS Vastgoed.

Because of the experimental nature of the 3D registration process, in order to avoid the economic risks of delay in doing so, the property rights were initially recorded in the land registry through traditional 2D registration. In the deed, the six legal volumes were described textually, and were accompanied by 2D maps, illustrating the various cross sections. For this initial registration process, new ground parcels were formed by the cadaster—such that the original parcels were consolidated and subsequently subdivided to specify the different accumulation of rights of the new complex (Stoter et al., 2017).

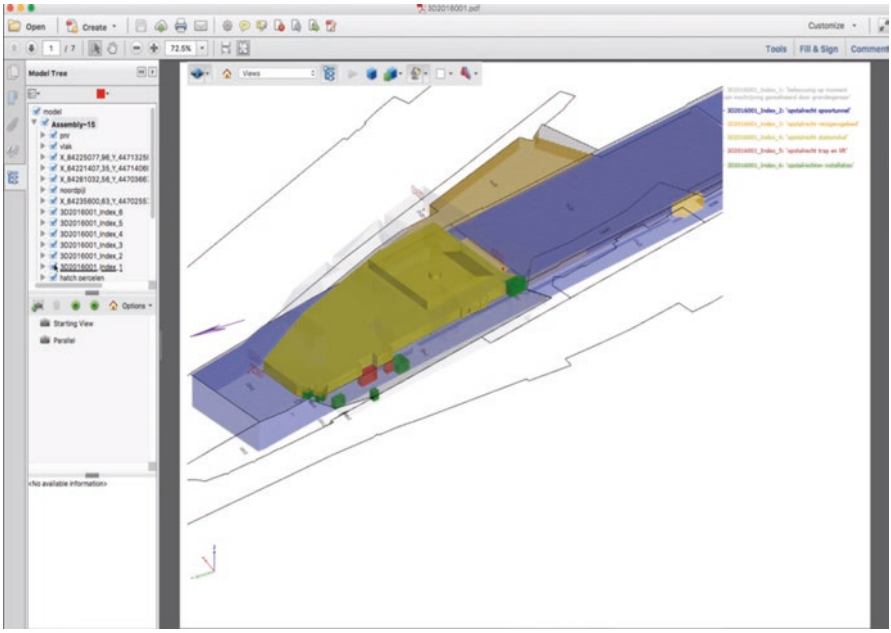

Fig. 1 Frame taken from the interactive 3D PDF of the Delft Railway Zone Project, as deposited in The Netherlands' national cadaster and the land registry (Source: Kadaster, 2016)

Then, for the 3D registration, the architect of the building complex converted the 3D data of the construction itself, using BIM technology, into 3D geometries representing the six legal volumes, based on the design data of the complex, the already registered deed with 2D maps of the complex, and the input of all stakeholders collected via four work sessions. Next, the 3D representations of the property rights were converted into a 3D PDF. This also included a legend of the rights, the 2D cadastral map in which the parcels were identified, and the x, y, and z coordinates of the national reference system. Subsequently, a notary firm issued a certificate for the deposit of the 3D PDF in the land registry as an official deed (Stoter et al., 2017).

In the cadastral registration, a 3D complex ID was generated and the different rights were assigned unique indices (numbered 1 to 6, as shown in Fig. 1). Additionally, a reference was made in the cadastral registration to the interactive 3D visualization of property rights. The 3D data itself was stored by the cadaster to accommodate future needs, which may require the adjustment of the legal situation. The 3D data is stored and maintained by the public registries.

The 3D PDF is publicly viewable not only from the public registries, but also from the cadaster, and can be viewed in any PDF viewer that supports 3D. In the viewer, the 3D setup can be interactively viewed, such that one sees the relationship between the different legal volumes. Each volume is visible for further inspection, such that by clicking on each one of the objects, one sees the 3D indices and identity of the property owner of the legal volume (Kadaster, 2016).

Without going into further technical details and addressing other intricacies that may be the result of the transition from a 2D registration system of property rights to a 3D system, a few comments are in order about the prospects—but also the limits—of this technological and legal innovation.

First, the transition into 3D interactive registration has clear benefits for facilitating more efficient land use and land markets. The inefficiency of relying on 2D maps and accompanying textual descriptions is especially significant in cases of multi-level property rights, wherever boundaries are not exactly on top of each other when projected on a 2D plane (Stoter et al., 2017). Under 2D systems, there is often a need to artificially create tiny parcels to accommodate potential mismatches between the location of 2D cadastral boundaries and the projection of the 3D construction. Moreover, future division or aggregation of current legal volumes may also not conform to purely vertical or horizontal divisions. It may employ geometrically irregular—but economically efficient—3D shapes. A system of 3D surveying of the land for cadastral purposes, followed by a system of 3D land-use regulation and the 3D creation of legal volumes allows for more flexibility for both the initial stage of developing the project and any future redevelopment.

Second, while the benefits are clear, the regulatory and technical challenges in synchronizing the different industry and governmental platforms are still prevalent and not merely the result of conservatism or other path-dependency. Thus, for example, BIM systems and cadastral surveying methods often have a different level of accuracy, which may result in physically small but important implications for questions of property rights, use, and future development of lands. As shown in the case of the Delft Railway Zone Project, this may also call for an active input by all stakeholders in setting up the multi-layered property scheme to resolve any such ambiguities.

Third, and relatedly, the potential for dynamic reconfiguration of legal volumes and property rights thereto, embedded in an interactive 3D system, may require that the relevant stakeholders be involved in any processes of change in real time to mitigate the potential for disputes or ambiguities for any such future reconfigurations. This may strengthen the need for intertwining the development of systems for the 3D planning, allocation, and registration of property rights, with the establishment of institutional governance mechanisms for the various stakeholders that hold multi-layered property rights. This point is discussed further in Part 6 below.

Finally, the switch to a more flexible, transparent, and dynamic system of allocating and reallocating property rights across subsurface, surface, or above-surface spaces may provide an opportunity for creating new types of property rights—ones that may better accommodate up-to-date needs coming from developers, financiers, tenants, and so forth, and that may be supported by digital technology and legal innovation.

As noted, in the case of the Delft Railway Zone Project, the Dutch railroad company for passenger transportation and the Dutch railroad infrastructure company, which together own five out of the six legal volumes, were granted a superficies right—and not an ownership right—in view of traditional legal constraints, whereas the Municipality of Delft retains its ownership of the complex and rights to the residual legal volume. While such a division may make sense, there is no reason to a-priori rule out a different type of allocation of rights, including by setting up a new kind of property right that may be particularly appropriate for complex settings of multi-layered property rights. This could have implications not only for increasing legal certainty, but also for the ability to finance the acquisition and development of a certain legal volume by pledging such a new type of right, in light of current constraints that often apply to limited proprietary rights, such as the superficie. In considering the list of recognized property rights as embedding "optimal standardization" that balances between increasing the efficiency of land use and land markets and the social costs of introducing new types of rights (Merill & Smith, 2001), the innovation of 3D registration and legal volumes might create a new optimal standard in determining the number and variety of property rights in land.

5 Interactive Pooling of Non-adjacent Assets and Portfolio Financing

Digital technology, big data analytics, interactive graphic visualization, and other innovative tools can push forward land use and land markets in various other ways. Thus, alongside the ability to more effectively slice tracts through the integration of three-dimensional visualization, land use, and land registration systems, new technologies can also be utilized to pool together non-adjacent assets. Such interactive pooling, which could also carry legal consequences in bundling property rights to non-adjacent assets, could serve current and future economic needs, especially in the context of real-estate financing and real-estate-backed investment securities.

To understand why current forms of real-estate financing challenge traditional boundaries (literally speaking), consider the observation by which "loans secured on real estate today are amended, redeemed, subjected to both initial and subsequent syndication, assigned, certified, secured by charges against more than one property, divided up and sold in part" (Stöcker, 2012).

What this new reality means is that individuals, business corporations, and financial institutions increasingly engage in practices that move away from the single loan/single asset model for a secured transaction in real estate. These practices include securitization of real-estate-based credit, which includes both pooling of multiple loans and the reslicing of such agglomerated debts into different tranches of bonds, and their consequent trade in stock-exchange markets (Basel Committee on Banking Supervision, 2014). Modern credit instruments may also involve portfolio financing, by which multiple real-estate properties collectively serve as security for large-scale financing schemes. Portfolio financing is currently more prevalent for movable goods and intangible assets, especially in the context of receivables financing, by which a financial institution that extends credit to a business corporation acquires a proprietary interest in the monetary claims (receivables) that the corporation has vis-à-vis its own debtors (Lehavi, 2019).

In fact, the ability to increase the usage of portfolio financing for real estate may hinge to a large extent on improving the ability to consolidate information and to link proprietary rights—and particularly security interests—in non-adjacent assets in a flexible and efficient manner.

In the case of movable goods or intangible assets, the constant replacement of assets that serve as part of the package of the collateralized assets can be generally done in a flexible way. This is so because the financier and/or debtor do not need to register a distinct security interest in each specific movable or intangible asset, but can generally rely on a "floating lien" and related legal instruments to provide general priority to the financier over other, non-secured creditors. The floating lien is thus premised on placing a "charge on assets both present and future," with such assets "expected to change in the normal course of business," thus allowing the corporation to sell such assets—including its commercial inventory—to buyers in the ordinary course of business, while subjecting new/future assets to the floating charge, and so forth (Sheehan, 2017).

Differently, under the current dominant approach across various legal systems, placing a security interest over a tract of land or a standalone unit in a subdivision (such as a condominium unit) requires the registration of a specific security interest on each tract/unit. Accordingly, any change in the security interest or its termination requires a specific process of registration. When security interests are placed on various tracts/units for the purpose of portfolio financing, the different tracts/units are neither visually nor legally interrelated. Current land registries do not agglomerate the different locations of the charged assets in a single map, registration deed, or other instrument. Unlike the floating lien, a legal action taken in regard to one tract/unit does not have direct effect on other assets that are allegedly under the same portfolio- financing scheme. This means that bundling, slicing, or otherwise updating such a scheme requires a relatively cumbersome analogical process, and that the

overall picture of the composition and status of the securitized assets is not readily and digitally accessible to right-holders and other stakeholders.

Enabling portfolio financing for real estate thus requires, first, the employment of digital technology that would identify in real time the various assets placed under a security interest—thus pooling visual and textual information on such multiple, non-adjacent properties. In so doing, this technology can rely, at least to some extent, on existing platforms related to security interests, such as information made available for mortgages under the US Home Mortgage Disclosure Act (HMDA) of 1975, which grants access to much of the raw data—modified to protect applicant and borrower privacy—and accordingly enables cross-asset visual and textual analysis (Consumer Financial Protection Bureau, 2019). Thus, in 2016, almost 7000 institutions released over 16 million records, making HMDA an invaluable administrative dataset on housing and homeownership for policymakers, regulators, and researchers, and this data is increasingly used for digital, publicly available cross-asset analysis, such as interactive boom and bust maps (Urban Institute, 2019). Presenting such pooled information on non-adjacent assets could prove essential for land use and land markets in many other contexts. One could think, for example—especially considering the gloomy history of the 2007 subprime crisis—about requiring issuers of real-estate-based securitized bonds to make available to investors real-time cross-asset visual and textual data. This would allow investors to better understand the tranches of securitized loans, including local and regional risks of default, foreclosure, and realization of real-estate assets. The degree of diversification of the bond portfolio could be better understood by the use of digital technology.

In addition to employing digital technology to link together non-adjacent assets through the provision and dissemination of cross-asset information, portfolio financing or real-estate-backed security investments could be further facilitated by legal innovation. One could think about a new type of security interest in land, located somewhere between the traditional fixed mortgage and the floating lien (for movables and intangible assets), which would allow for a swift replacement of real-estate assets that are used as a collective collateral by a certain borrower.

To facilitate a streamlined legal process of replacing charged assets, parties holding a security interest, other creditors, and additional stakeholders would have access to a digital platform, which presents at any given time the current assets placed under security interests and the overall value of the security vis-à-vis the debt—based also on third-party evaluations of the land in question, such as those done for purposes of property taxation. To accommodate potential conflicts in the transition of security interests across different real-estate assets, such a new type of charge should set rules on the date that would apply as the starting date of the charge on a replacement asset (such as the filing date of the charge on the original/previous asset) and any other rules that would establish the priority of such a replacement charge vis-à-vis other rights. While the details of such a legal reform should be tailored more specifically to meet the changing needs of real-estate finance, there is no doubt that such legal innovation would prove effective only if it relies on interactive digital visualization and registration platforms that link non-adjacent lands.

6 Multiplicity of Property Rights: Digital Information and Collective Action

As the previous parts have shown, digital technology and other innovations can provide better information to all parties about the spatial features of tracts of land. A corresponding reform in zoning regulation and the composition of property rights can potentially give them more flexibility in exploiting physical space. That said, the potential for coming up with new or more sophisticated forms of multi-layered property rights or the pooling of non-adjacent assets does not in itself create a mechanism for resolving potential frictions and deadlocks among multiple holders of property rights and other legal interests. In fact, any such type of digital or legal innovation intended to facilitate more intense land use or more sophisticated land markets may also generate new types of collective action problems.

Such coordination challenges can implicate the 'tragic' dynamics of commons (Hardin, 1968), in which multiple stakeholders that simultaneously occupy and use the same physical space might tend to over-exploit it and under-invest in it. Correspondingly, the allocation of a certain physical space among multiple parties can implicate the mirror-image problem of anticommons (Contreras, 2018; Heller, 1998), under which over-fragmentation of private property rights in legally separate but practically interdependent spaces can lead to inefficient results or outright deadlocks, by preventing coordination or integrative use of such assets. These collective action problems can result from either strategic behavior, such as holdouts or free riding, information asymmetries, or genuine heterogeneity among stakeholders about their preferences and priorities.

Examples for collective action problems resulting from multi-layered, multi-party uses of lands abound. One such instance, prevalent in the United States, concerns conflicts among landowners and utility companies, when the latter are granted the power of eminent domain to create involuntary easements in their favor for the construction and the laying-out of power lines, pipelines, communication lines, and other utilities in and across privately owned lands. Unlike cases of eminent domain in which the fee simple estate (ownership) is condemned, such that the utility company becomes the owner of the entire land, the creation of an involuntary easement results in the division of property rights and use of space. Also, unlike the case of a voluntary easement, where parties not only negotiate the initial allocation of rights, but also address future contingencies to alleviate frictions resulting from the existence of simultaneous rights, the parties in the case of such involuntary easements find themselves entangled in long-term governance problems with basically no tools to address them efficiently and fairly (Morriss et al., 2014).

In particular, despite the fact that the creation of multi-layered, multi-party property rights embedded in such infrastructure projects requires repeated interactions on a variety of issues, there is no institutional arrangement that accompanies such projects and practically no default legal rules against which parties would be able to act collaboratively over time. This is a type of problem that no digital technology can solve. As a pure governance problem, it requires a legal solution that sets up a mechanism for long-term institutional governance of such assets.

What is therefore required to facilitate new forms of land uses and land markets, which are otherwise made possible by digital technology and other innovations, is a systematic legal reform that establishes dynamic decision-making frameworks tailored to accommodate such innovations. Just as condominiums and other forms of residential strata title have been able to develop and create real innovation in land use and land markets, so do other new forms of multi-layered, multi-party interests in land depend on the ability of property owners and other stakeholders to engage in long-term institutional governance. To ensure coordination, order, and a reasonable balance between predictability and flexibility in the on-going governance of such new types of land uses and markets, such institutions should be supported by default legal rules that establish the various issues that are relevant for such types of real-estate schemes. Such rules should address issues such as voting rights, required majorities for decisions, mechanisms for assessment of fees, maintenance and improvement, or rights-of-way and other easements.

To illustrate how the future of land use and land markets can and should be complemented by setting up rules and institutions for long-term collective governance, tailored to the specific intricacies of such innovations, consider again 'stratum' or 'volumetric' subdivisions, which seek to offer an institutional solution to multi-owned, multi-layered properties beyond residential buildings, as mentioned in Part 4 above. In order to deal with various issues relating to the vertical and lateral interdependencies between the different stratum lots, such as establishing easements intended to grant separate stratum owners access to shared property that is partly or entirely located in another stratum owner's lot or parcel, or dealing with maintenance costs, lot owners must register Building Management Statements (BMS) and Strata Management Statements (SMS) that address such issues. Beyond the initial rule-setting for the allocation of rights and responsibilities to private and common spaces, the BMS must establish a Building Management Committee, which includes all stratum lot or parcel owners, although owners may be excluded from the Building Management Committee with their consent (Sherry, 2017). The Committee is intended to deal with the ongoing governance of the 'stratum' subdivision, considering also the unique features of each type of stakeholder in such mixed-use projects.

While still underdeveloped legislatively and regulatory, and not often analyzed by Australian courts, stratum subdivisions have a significant potential in furthering new types of developments. As such, they can also serve as a source of inspiration for other kinds of multi-layered, multi-use developments, including those involving large surface or subsurface infrastructure utilities. The same can also hold true for the governance of portfolio financing or other proprietary interests that implicate non-adjacent assets, as discussed in Part 5 above. At its core, every type of intensive, interconnected land-use or land-market novelty calls for such collective governance.

7 Conclusion

Digital technology has enormous—but not unlimited—potential to promote efficient land use and land markets. Thus, three-dimensional surveying, visualization, registration, and planning are increasingly being introduced around the world, fos-

tering legal innovation in the form of "legal volumes" and rights thereto, and opportunities for more intensive, sophisticated land uses. In addition, the interactive pooling of non-adjacent real-estate assets through digital technology can push forward current market practices, such as portfolio financing, and in turn encourage legal innovation in the form of new types of property rights, providing a more flexible approach to security interests as a means to broaden financing opportunities and expand land markets.

That said, while digital technology and other innovations open up new opportunities, and allow for broad dissemination of data in real time, they cannot solve in themselves what are largely interpersonal challenges of governance and decision-making. Collective action problems resulting from strategic behavior or genuine heterogeneity require dynamic institutions of governance and a system of substantive and procedural rules that supports collective action.

On a final note, the analysis in this chapter might echo the voluminous discussion about blockchain as an alternative, decentralized, and verified recording system for transfers of asset ownership—one that allows for validating and registering various transactions by bypassing traditional centralized channels such as banks, while alleviating problems of conflicting transactions or unauthorized transfers of rights (Koch & Pieters, 2017). However, to truly replace current systems of market transfers and registration of property rights in the context of land, the blockchain technology must be supported by legal innovation. Thus, blockchain-based transactions should be broadened in scope to include other types of proprietary rights, such as security interests and easements, alongside the right of ownership. Accordingly, blockchain ledgers and protocols should also be governed by priority rules and governance bodies that settle potential conflicts between different types of property rights in the same asset. It is a challenge that can be met, but it cannot rely merely on digital technology. It requires legal innovation and mechanisms for multi-party governance institutions that are based on human judgment.

References

Atazadeh, B., et al. (2017). Building information modelling for high-rise land administration. *Transactions in GIS, 21*(1), 91.

Basel Committee on Banking Supervision. (2014). *Basel III document: Revisions to the securitisation framework*. Retrieved from https://www.bis.org/bcbs/publ/d303.htm

Chadwick, H. (2018). Community land trust solutions to local housing issues. In *AMPS Conference 10: Cities, Communities and Homes: Is the Urban Future Livable?* (p. 164). University of Derby.

Chen, L., & Kielsgard, M. D. (2014). Evolving property rights in China: Patterns and dynamics in condominium governance. *Chinese Journal of Comparative Law, 2*(1), 21.

Consumer Financial Protection Bureau. (2019). *Mortgage data (HDMA)*. Retrieved from https://www.consumerfinance.gov/data-research/hmda/.

Contreras, J. L. (2018). The anticommons at 20: Concerns for research continue. *Science, 361*, 335.

Davis, J. E. (Ed.). (2010). *The community land trust reader*. Cambridge, MA: Lincoln Institute of Land Policy.

Demsetz, H. (1967). Toward a theory of property rights. *American Economic Review Papers & Proceedings, 57*, 347.
Drobež, P., et al. (2017). Transition from 2D to 3D real property cadaster: The case of the Slovenian cadaster. *Computers, Environment and Urban Systems, 62*, 125.
Dukeminier J., et al. (2018). *Property* (9th ed.). New York: Wolters Kluwer.
Ellickson, R. C., et al. (2013). *Land use controls: Cases and materials* (4th ed.). New York: Wolters Kluwer.
Fennell, L. A. (2019). *Slices and lumps: Division and aggregation in law and life*. Chicago & London: The University of Chicago Press.
Hamid, Q., et al. (2016). Arc GIS and 3D visualization of land records: A case study of urban areas in Punjab. *National Academy of Sciences Letters (India), 39*(4), 277.
Hardin, G. (1968). The tragedy of the commons. *Science, 162*, 1243.
Heller, M. A. (1998). The tragedy of the anticommons: Property in the transition from Marx to markets. *Harvard Law Review, 111*, 621.
Kadaster, The Netherlands. (2016). *3D deeds*. Retrieved from https://3d.bk.tudelft.nl/news/2016/03/21/3DKadaster.html
Kim, S., & Hoe, J. (2019). Registration of 3D underground parcel in Korean cadastral system. *Cities, 89*, 105.
Klass, A. B. (2008). The frontier of eminent domain. *University of Colorado Law Review, 79*, 651.
Koch, C., & Pieters, G. C. (2017). Blockchain technology disrupting records systems. *Financial Insights, (Federal Reserve Bank of Dallas), 6*(2), 1. Retrieved from www.dallasfed.org/outreach/insights/fi1702
Kostrub, D. B., & Christenson, R. S., II. (2012). Canons of construction for the interpretation of mineral conveyances, severances, exceptions, and reservations in producing states. *North Dakota Law Review, 88*, 649.
Lehavi, A. (2013). *The construction of property: Norms, institutions, challenges*. Cambridge: Cambridge University Press.
Lehavi, A. (2015). Law, collective action, and culture: Condominium governance in comparative perspective. *Asia Pacific Law Review, 23*(2), 5.
Lehavi, A. (2016). The culture of private law. *Real Estate Law Journal, 45*(1), 35.
Lehavi, A. (2019). *Property law in a globalizing world*. Cambridge: Cambridge University Press.
Lemmen, C., van Oosterom, P., & Bennett, R. (2015). The land administration domain model. *Land Use Policy, 49*, 535.
McKenzie, E. (1994). *Privatopia: Homeowner association and the rise of the residential private government*. New Haven & London: Yale University Press.
Merill, T. W., & Smith, H. E. (2001). Optimal standardization in the law of property: The numerus clausus principle. *Yale Law Journal, 110*, 1.
Miller, S. (2013). Community land trusts: Why now is the time to integrate this housing activists' tool into local government affordable housing policies. *Zoning and Planning Law Report, 36*(9), 1.
Morriss, A. P., Brandys, R., & Barron, M. M. (2014). Involuntary cotenants: Eminent domain and energy and communications infrastructure growth. *LSU Journal of Energy Law & Resources, 3*, 29.
Paasch, J. M., et al. (2016). Building a modern cadastre: Legal issues in describing real property in 3D. *Geodetski Vestnik, 60*, 256.
Parisi, F. (2002). Entropy in property. *American Journal of Comparative Law, 50*, 595.
Rabenhorst, C. S., & Ignatova, S. I. (2009). *Condominium housing and mortgage lending in emerging markets—Constraints and opportunities*. Urban Institute Center on International Development and Governance. Retrieved from www.urban.org/publications/411921.html
Restatement (Third) of Property (Servitudes). (2000). *American Law Institute*.
Righetti, T. (2016). The private pore space: Condemnation got subsurface ways of necessity. *Wyoming Law Review, 16*, 77.
Rule, T. A. (2011). Airspace in a green economy. *UCLA Law Review, 59*, 270.

Schill, M. H., Voicu, I., & Miller, J. (2007). The condominium versus cooperative puzzle: An empirical analysis of housing in New York City. *The Journal of Legal Studies, 36*, 277.
Sheehan, D. (2017). *The principles of personal property law*. Oxford: Hart Publishing.
Sherry, C. (2017). *Strata title property rights: Private governance of multi-owned properties*. London and New York: Routledge.
Smith, H. E. (2015). The persistence of system in property law. *University of Pennsylvania Law Review, 163*, 2055.
Stöcker, O. (2012). The Eurohypothec. In B. Akkermans, A. F. Salomons, & J. H. M. van Erp (Eds.), *The future of European property law* (pp. 65–77). Munich: Sellier.
Stoter, J., et al. (2017). Registration of multi-level property rights in 3D in The Netherlands: Two cases and next steps in further implementation. *International Journal of Geo-Information, 6*, 158.
Urban Institute. (2019). *Home mortgage disclosure act data*. Retrieved from https://www.urban.org/policy-centers/housing-finance-policy-center/projects/home-mortgage-disclosure-act-data
Van der Merwe, C. G. (2015). Introduction and content. In C. G. van der Merwe (Ed.), *European condominium law* (pp. 1–24). Cambridge: Cambridge University Press.
Van Erp, S., & Akkermans, B. (2012). *Cases, materials and text on property law*. Oxford & Portland, OR: Hart Publishing.
Vučić, N., et al. (2017). Overview of the Croatian land administration system and the possibilities for its upgrade to 3D by existing data. *International Journal of Geo-Information, 6*, 223.
Wainwright, O. (2019, February 5). Super-tall, super-skinny, super-expensive: The 'pencil towers' of New York's Super Rich. The Guardian.
Wilkerson, G. (2015). Rigging rights of passage: Analyzing subsurface easements in horizontal drilling. *Mississippi Law Journal Supra, 84*, 135.
World Economic Forum. (2020). *Fourth industrial revolution*. Retrieved from https://www.weforum.org/focus/fourth-industrial-revolution
Yu, C., et al. (2017). LADM-based modeling of the unified registration of immovable property in China. *Land Use Policy, 64*, 292.

Legislation

California Civil Code (as amended, 2014). West's Annotated California Civil Code, § 4125.

Cases

Pinnacle Museum Tower Association v. Pinnacle Market Development, 145 Cal.Rptr.3d 514 (2012).
United States v. Causby, 328 U.S. 256 (1946).
Villa De Las Palmas Homeowners Association v. Terifaj, 90 P.3d 1223 (Cal. 2004).