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http://www.tandfonline.com/10.1080/02723638.2018.1524653

Platform Real Estate: theory and practice of new urban real estate markets

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Abstract

Recent years have witnessed a surge in the development of digital real estate technologies. Often referred to as PropTech (property technology), these innovations might variously promise more efficient portfolio management (e.g. VTS), new ways to rent accommodation (e.g. Airbnb), or hassle-free maintenance (e.g. FixFlo). Whilst commentators have debated their novelty as either highly disruptive or a temporary fad, few researchers have sought to fully theorize the digital real estate platform. And those that have provided overviews of the so-called PropTech landscape have failed to do so in a sufficiently critical manner, instead opting for a raft of essentialist and categorical terms. Borrowing the lenses of Science and Technology Studies (STS) and platform studies, this paper develops a theory of digital real estate platforms to address this conceptual gap. And through a qualitative analysis of some 400 businesses, it provides a series of key observations of Platform Real Estate as an improved theoretical neologism to inform future research. These observations are important to better understand the nature of digital real estate platforms and the manner in which they may reconstruct future urban real estate markets – a subject of great concern to researchers and market participants alike.

1. Introduction: Silicon Roundabout meets Mayfair

> "The property industry has long worked on the basis of deals struck between individuals, oiled by personal connections and good relationships. *Le marché international des professionnels de l'immobilier* (MIPIM) is the grandfather of these property fairs, which include exhibition areas, networking events and conference sessions."
>
> – Anna Minton in *Big Capital* (Minton, 2017)

London's 2016 edition of the international MIPIM property conference was characterized by the usual suspects: dedicated stands for sleekly-branded regions and cities hoping to compete for outside investment (from Wales to Croydon); banks and other capital partners from around the globe (BNP Paribas to UBS); eager sales executives looking to network with the big contractors; an

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array of private developers; and a noticeable police presence.[1] However, the staging of around eighteen company exhibition stands in a new *Innovation Forum* section – as well as a three-day hackathon, *Innovation Pitching* area, and *Innovation Lounge* – marked the beginning of a new era in the event's history. Billed as an exciting new feature of the event, the website boasted that this move towards representing a new wave of *digital* real estate innovation would "present the solutions to optimize the value of property portfolios" (MIPIM UK, 2017). But despite being a first for MIPIM, this small suite of product offerings was also characteristic of a much larger and widespread phenomenon: the recent global explosion of 'PropTech' start-ups over the past few years (Baum, 2017; RICS, 2017), and their promises to help you 'park smarter' (open extra spaces and income from under-utilized office parking garages, e.g. ParkBee); "make faster decisions with real estate's deepest data set" (leverage more market information for faster and better market decisions, e.g. HouseCanary); or be "the clever thing for your everything" (mobilize a range of hardware and devices that enable more efficient and controlled management of buildings, e.g. Nest).

Some of the PropTech companies exhibiting at MIPIM included VTS (View the Space), LandInsight, EnergyDeck and Habiteo. Variously, these technologies (most of which offer some form of 'dashboard' software product) offered real estate market players the following: "transparency of ownership and a level playing field"; "faster and more accurate decisions"; "integrate your entire leasing business into a single powerful platform"; "more deals, more data, less reporting"; "your entire portfolio, centralized for performance"; "transform the way you search for land"; "no more spreadsheets, track everything"; and "a real taste of what the property or development will look like . . . thanks to a 360 degree 3D model which can be viewed at all angles". All of these real estate portfolio 'solutions' were accompanied by other products and companies that claimed to offer the necessary hyper-connectivity for buildings (Hyperoptic); "disruptive" financing plans that could offer "institutional quality real estate globally" to anyone, with low minimum commitment and an investment tracking dashboard (BrickVest); and many other often unspecified "best-of-breed solutions" (TopUp Consultants). In short, the products' marketing oozed with objective-sounding and normatively desirable words like accuracy, transparency, growth, democratization and potential. All of which presented a deterministic or *solutionist* (Morozov, 2013) approach to the real estate market as a series of problems to be fixed through the application of digital technology. For example, problems that some may define as the limitations of real estate as an asset class – like physical deterioration, illiquidity or legal regulations (Baum, 2015).

1 In the past, the event has attracted unwanted attention from protesting housing activists due to its reputation as a "champagne-soaked jamboree where local authority chiefs are wined and dined by investors" (Wainwright, 2014).

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However, despite criticism that these promises might also represent "a temporary fad" in the real estate market (Baum, 2017), a record $12.1bn was invested in this growing sector during 2017 alone (see Figure 1). Furthermore, a cursory glance at the delegates list of events like MIPIM and #PropTech2017 (held in Central London during May of the following year) reveal that serious interest in the technology is far from lacking. For example, the eight-hundred-strong delegate list for #PropTech2017 (representing over five hundred organizations) included twenty-four venture capital funds; six of Europe's top ten real estate funds (representing *at least* $250 billion of European real estate assets under management); and numerous start-ups with registered offices in the vicinity of Shoreditch's infamous creative digital cluster, *Silicon Roundabout* (Foord, 2013). Therefore, it would seem that events like these represent the formation of a new real estate/financial/technology complex: the global 'wall of money' identified by (Aalbers, 2016) provides a backdrop for the material coming-together of real estate's old 'organization men' from the financial offices of Mayfair or the City of London with a newer breed of entrepreneurial technologist-hacker that has yet to historically intervene in real estate's oily personal connections (Baum, 2017; Himanen, 2001). Considering the 'disruption' of other recently-computerized industries – Amazon in logistics, Uber in taxi services, UpWork in outsourcing, etc. – research into how exactly this coming-together will affect future real estate markets is undoubtedly important if we are to understand how future urban real estate markets form and operate. Real estate is, after all, a trillion dollar asset class that affects all and obsesses many as a biological and social necessity (Dorling, 2014; Linklater, 2013; Savills, 2016). Therefore, this paper asks how should such changes be understood: what is the nature of these new digital technologies, what do they offer to market participants, and what related changes and characteristics can be observed so far? And ultimately, what are digital real estate platforms in theory and in practice?

Following research in economic sociology on the social construction of markets (Callon, 1998; Callon, Millo, & Muniesa, 2007), the performative import of economic knowledge (Butler, 2010; MacKenzie, Muniesa, & Siu, 2007), and relevant work in emergent platform studies (Bratton, 2015; Srnicek, 2016), this paper will outline the importance of considering these technologies from a critical socio-technical perspective; and offer a conceptually improved understanding of PropTech as *Platform Real Estate*. This will conclude with a series of observations surrounding digital real estate platforms as technologies which embody certain characteristic logics. These logics are important to better understand the mechanisms behind Platform Real Estate, and how they are both socially and technically crucial to how the reconstruction of urban real estate markets is negotiated in practice.

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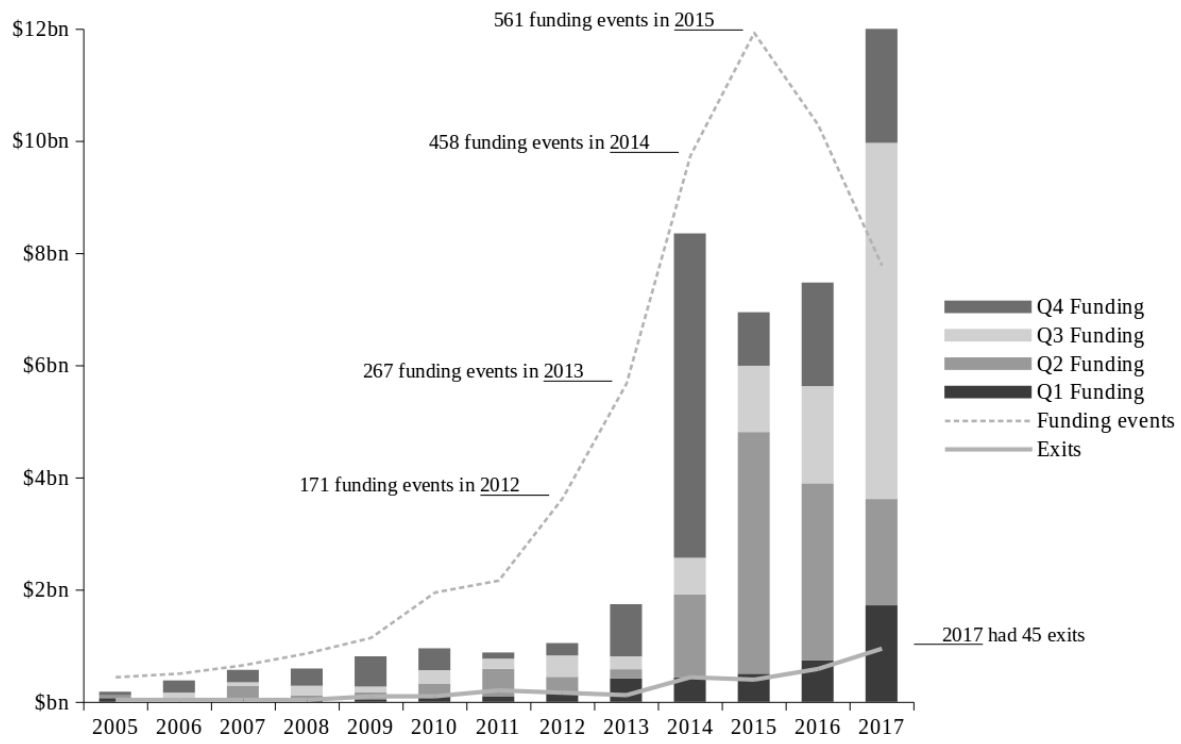

Figure 1. Data from Venture Scanner shows that despite a slight decrease in individual funding events, increasing amounts of venture capital is continuing to pour into what might be roughly demarcated as the PropTech sector (Ivens & Barbiroglio, 2018).

2. Gunter's chain: the performativity of market devices

> "Survayers have cause to make muche of me.
> And so have all Lordes that landes do possesse:
> But Tennauntes I feare will like me the lesse.
> Yet I do no wrong, but measure all truly,
> And yelde the full right to everye man justely
> Proportion Geometricall hath no man opprest,
> Yf anye bee wronged, I wishe it redrest."
>
> – Robert Recorde in *Pathway to Knowledge* (Recorde, 1551)

Economic sociologists have emphasized the importance of studying market*places* over markets. In other words, there is an advantage in understanding markets *not* as abstract, ethereal, technical and natural free-floating entities that objectively exist *out there* (and which we can know as such); but rather more as material, corporeal, messy and *socially constructed* phenomena (Callon, 1998; MacKenzie, 2009). As such, and following the broader trajectory of science and technology studies (STS), the role of both human and non-human actors in the market should be considered in relation to the overall *assemblage* of agencies that defines it as such (De Landa, 2006). This especially

includes those *market devices* that constitute "the material and social assemblages that intervene in the construction of markets" (Muniesa, 2007): ticker tapes, calculating machines, gifts, and even the discourses by which we understand these artefacts (Callon et al., 2007; Karl, 2013; Knight, 2013). All provide the material means by which markets and their commodities or assets can be socially framed and practically understood. To understand the applied value of this theoretical framework to real estate's contemporary digital innovations, we need only consider one historical example: Gunter's chain (see Figure 2).

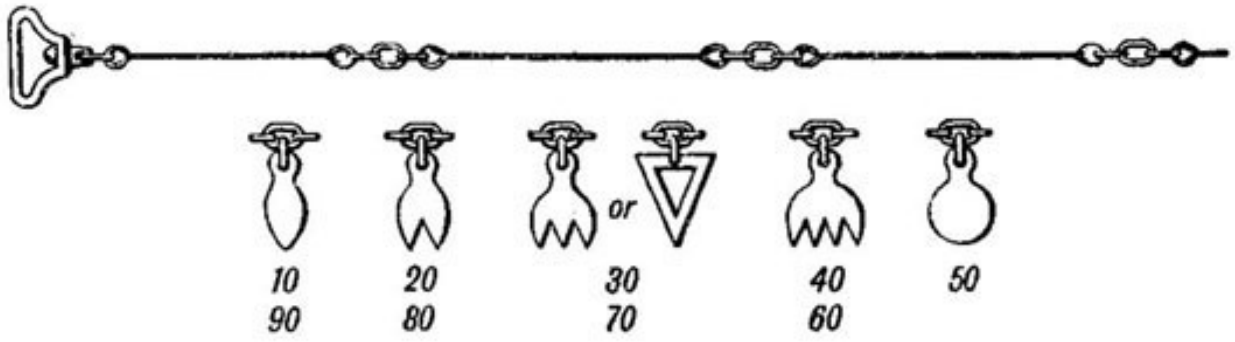

Figure 2. A diagram of Gunter's chain from Weathers (1913).

Gunter's chain was invented by the mathematician Edmund Gunter around the year 1620, and was the first land surveying tool of its type (Weaver, 2003, p. 227). As one of the first reliable, rationalized and standardized units of land measurement it would ultimately supplant many pre-existing, locally-embedded and highly variable units like the *seterée* or *yardland*.[2] In this respect, the adoption of Gunter's chain in the 17th century was arguably revolutionary (Linklater, 2002), and a straightforward economic reading of this history might say that it provided an essential (but previously lacking) aspect of market practice: reliable measurement and commensuration between commodities (Mankiw, 1998). But beyond allowing the market (and the state) to *see* land in a new way, it also enabled land to become a new *thing*. At first this might seem like a benign observation, but following Donald MacKenzie's research on derivatives pricing models (MacKenzie, 2006), a great deal of insight can be drawn from considering Gunter's chain as a *performative* market device. In other words, beyond the technical accuracy of Gunter's invention, it is important to ask what its

2 The French seterée (how much land could be sown with half a bushel of seed) and English yardland (area to grow enough food to feed one family) were dependent upon often incommensurable local interpretations of factors like soil quality.

widespread adoption did or *performed* in the world. Or, just like the paper index books mediating between the mathematics of an abstract pricing model and the "shouting, sweating, gesticulating, jostling human bodies on the trading floors" (MacKenzie et al., 2007, p. 61), how did the chain also produce new market dynamics, trading practices, knowledges and therefore markets along the way?

Here there are two performative aspects of Gunter's chain that should be kept in mind with consideration of new digital technologies in real estate markets. First, the notion of a market device requiring or producing new discourses and knowledges is important, since research shows that economic knowledge is not just used as a representational 'camera' of a market, but more often as an engine that can somehow *drive* it (MacKenzie, 2006). This means that Gunter's chain had a capacity to contribute to new understandings of *owning the earth* (Linklater, 2013), and would have done so in an era where land became newly knowable as *capital*, or the "fat of the body politik" (Petty, 1690).[3] This was also a profound epistemological matter: Gunter's chain was taken up by a new breed of surveyors at a time where new practices of 'ritualized representation' by estate owners were accompanied by a new and initially controversial discourse of 'perfect knowledge' (McRae, 1993, p. 339). These foundational Enlightenment ideals then subsequently informed an entire epoch of land measurement, and reinforced strong beliefs that mind could yet mirror the world (Rorty, 1980). This situates Gunter's chain at the start of a series of historical developments in economics, geography and land measurement; and where subsequent essentialist thinking often became problematically grounded in naturalistic metaphors searching for a social and economic world as an objective reality ripe for rational quantification (Barnes, 1996; Barnes & Wilson, 2014). Therefore, not only is this performative capacity of such market devices often deeply political, but the particular manner in which measurement processes have *framed* land as a market commodity throughout history has usually carried with it some deep assumptions about how we *know* and *see* land as a *thing* to which we can socially relate and commensurate (Espeland & Stevens, 1998, p. 327). This relation could be in terms of territory (Elden, 2013), resources (Scott, 1998) or capital credit (McCormick, 2009). It is therefore right to ask whether new digital real estate market devices also embody discourses that might assume Big Data can yet mirror the world; and if so, then what will the resulting knowledge of real estate *do* to the marketplace and who will benefit from its performance?

Second, it is also important to appreciate that the market's adoption of Gunter's chain was never a foregone conclusion. Rather than assuming that technology simply *diffuses* into adoption (Rogers,

3 William Petty's (1690) political theory provided the basis for treating land as capital at the national scale, and also contributed to discourses that resulted in the establishment of the Bank of England and similar institutions in other countries (Valeri, 2010). Interestingly, he also made his fortune from the first chain surveys of Ireland, as both a harbinger of colonialism and the original real estate data analytics entrepreneur of his day.

1962), work by Michael Callon and others has explained the manner in which adoption of new innovation is better understood as a contested and laborious process of *translation* (Callon, 1984). Historical accounts of surveying as a profession (Thompson, 1968) and the distinctly political resistance to geometry as a discipline in general (by surveyor and peasant classes alike) provide some accounts of this contest (Linklater, 2013, 2002; McRae, 1993). This means that Gunter's chain required a great deal of (non-surveying) work to be undertaken to reconstruct market assemblages of often very powerful actors – landowners, surveyors, peasants and monarchs alike. In Callon's words, Gunter's chain had to be *problematized* and theorized by different actors, and only once suitable *conditions of felicity* (Austin, 1962) or *habitus* (Bourdieu, 1991) were in place could it be widely used in the manner it was – though no doubt there were also important *infelicitous* or unhappy instances of this performance as well (Zelezny, 2014). This analysis cannot be expanded much here, but important aspects of this translation process might have included: the manner in which Edmund Gunter had to (literally) translate his chain's instruction manual from Latin to English (surveyors were not from his educated social class of Latin-speaking clergy); the fact his chain could be more easily carried than the rod; and the device's black-boxing of mathematical conversion between old-English base-four units and the new decimal system (Linklater, 2002). In particular, the latter point is possibly one reason Gunter's chain did not vary in use like other rival chains[4] – since the original relatively non-mathematical surveyor would have been less able or inclined to socially shape its operation, and this would have afforded Gunter's chain an element of technological obduracy and measurement authority (Thompson, 1968, p. 5; Latour, 1991; MacKenzie & Wajcman, 1999; Beer, 2016). In short, this means that no technological innovation is ever truly destined for the market by claims of its objective virtues or technical capacity alone.

Therefore, it is important to understand new real estate market technologies as performative market devices: socio-technical actors that intervene in the social construction of markets. The manner in which a measurement device like Gunter's chain reconfigured (or perhaps even *created*) the real estate market in the past should be ample reason to accept that a theory of emergent digital real estate technology is crucial to understanding how we might practice ownership, exchange and use of the earth in the decades to come. Borrowing this theoretical framework – and the wider outlooks of STS and related anti-essentialist epistemological approaches (Barnes, 1996) – to research new digital real estate technologies is vital to understand that their deterministic marketing claims are absolutely not foregone conclusions, but may nevertheless be doing work to produce the necessary discourses and knowledges of their adoption. Given the immense capital and power at stake in real estate markets, this process will doubtless be acutely contested; and the knowledge

4 Historical research shows that other chains were purposely used in inconsistent units on land with varied forest cover as late as 1796 (Linklater, 2002, p. 15).

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which must be constructed to put new devices into practice will undoubtedly have political import. Therefore, although market devices undeniably associate with particular material capacities and logics, research to understand their role in future real estate markets also has to begin with a critical tracing of their wider social associations (Latour, 2005).[5] This paper will now argue that current assessments of digital real estate technology as PropTech are insufficiently critical to explain the socio-technical mechanisms behind these emergent market devices. A better approach would be to consider them as platforms; and as emergent technologies which pose theoretical and practical transformations of urban real estate markets in a manner comparable to the 17th century developments described above.

3. What is PropTech anyway?!

The enormous variety of digital technologies emerging in the real estate sector now goes far beyond the first wave of multiple listing systems (MLS) and market advertising websites. And those few surviving services and websites that did emerge during the earlier period of Internet-adoption (in the UK from the late 1990s) have now evolved into much more complex operations. For example, the British real estate listings website Zoopla is now more than just a place to buy, sell and rent housing – it also boasts an API, integrated historical sales data from the UK Land Registry, and a number of other metrics and visualizations at the level of individual properties, streets, neighbourhoods and regions. Since 2011, one of its US-based equivalents (Zillow) has offered the *Zestimate*, a proprietary automated valuation model based on a range of historical and locational data.

Along with the range of technologies described in Section 1 above, there is now a complementary cohort of tech-gurus and marketeers currently attempting to provide expert accounts of this emergent field of innovation as PropTech. One example of this might be James Dearsley's weekly UK PropTech Review newsletters, for which a word frequency analysis of technology terms used during 2016 reveals a top-ten that can be instantly transposed to the annual Gartner Hype Cycle™ graph (see Figure 3). But whilst Dearsley might be a regular host and commentator at events like MIPIM and #PropTech2017, it could be argued that a list of buzzwords curated by someone who is also the Founder of the *Digital Marketing Bureau* and a Partner in *PropTech Consult* might not provide the most objective answer to the question "What is PropTech?"[6] However, the one extensive academic report on the subject – authored by Andrew Baum (2017) of

5 To look at these technologies and techniques as they emerge historically is also important, since other researchers in this domain have often failed to adequately examine the early origins of that which is later "thought to be without history" (Elden, 2013, p. 328; Foucault, 1977, p. 139).

6 Dearsley is also a co-founder of the UK PropTech Association (established 2017), along with a Director from the Royal Institute of Chartered Surveyors and a number of other real estate market professionals.

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the Saïd Business School – also adopts Dearsley's terms and infographics as a concrete point of departure for its research. This section will now briefly explain why Baum's (2017) report also fails to define the term PropTech in a way that is useful for academic research into digital real estate technology, but why it is nevertheless an interesting research object and point of departure in its own right. The next section will then build upon this critique to offer an alternative account of PropTech as *Platform Real Estate*.

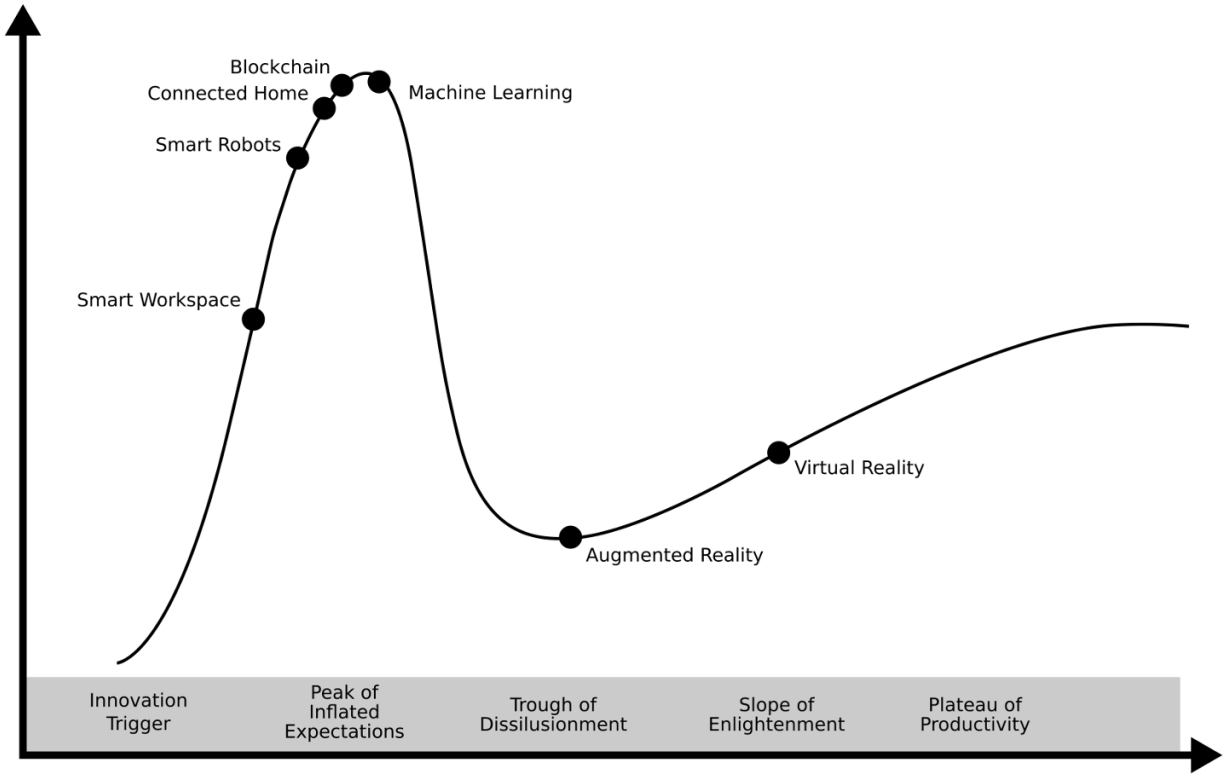

Figure 3. A basic frequency analysis of technology terms for a year of James Dearsley's PropTech email newsletters reveals a series of common terms that also appeared (either directly or as synonyms) on Gartner Consulting's infamous Hype CycleTM of the same period (2015–2016), and have been transposed accordingly here.

The most immediate problem with the market's own characterizations of this technology, including Baum's 95-page report (2017), is that they fall foul of what the theoretical framework above might term *technological essentialism* (Feenberg, 1991). This means that Baum's attempt to provide an account of PropTech by discretely categorizing a range of businesses and their products is flawed from the start due to its reliance on naturalized and essentialist categories (part-borrowed

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from marketeer Dearsley) such as *FinTech* (financial technology), the *sharing economy*, *smart buildings* and *ConTech* (construction technology). The results of this be seen in Table 1, extracted from the report.[7]

	Real Estate FinTech	Sharing Economy	Smart Buildings	ConTech	Total
Information	12.9%	0.6%	0.9%	3.1%	17.5%
Transactions	38.3%	16.6%	3.4%	3.4%	61.7%
Control / Management	0.0%	2.5%	15.0%	2.1%	19.7%
Total	51.2%	19.6%	19.3%	8.6%	98.8%

Table 1. Analysis of 600 start-up applications to Pi Labs venture capital accelerator program for PropTech taken directly from Baum (2017). Each company was categorized according to criteria around the technology's use in certain business sectors and activities (Baum, 2017, p. 27).

First, the very notion of dividing these companies into discrete market 'verticals' seems muddled and ontologically problematic. For example, Airbnb has been coded under 'FinTech – Transactions/Marketplace' (Baum, 2017, p. 28) despite simultaneously referring to Airbnb as a 'poster-child of the sharing economy' (Baum, 2017, p. 40). More importantly, the definitions of the categories themselves seem nebulous. For example, the definition of sharing economy used by the report seems ill-defined and pays little attention to recent research on the ambiguity of the term (Davies, Donald, Gray, & Knox-Hayes, 2017). Such consideration would ideally recognize that the sharing economy encompasses a great range of technologies that reflect a larger matrix of sharing (Davies et al., 2017, p. 215) and that "the distinction between market and non-market or capitalist and non-capitalist should be considered not as a thin line but as a broad terrain" (Mitchell, 2007, p. 247). Instead, the sharing economy is merely referred to as being about (somehow) "sharing the use of real estate assets or space" (Baum, 2017, p. 41), and yet the sharing economy companies sampled are almost entirely for-profit sales-oriented businesses that push the meaningful boundaries of sharing to the limit. For example, WeWork is surely little more than a commercial landlord with more flexible leases, a few ping-pong tables and some free lager?

Second, Baum's (2017) 'horizontals' also have some problematic foundations. Since although it is acknowledged that overlap may occur (which seemingly defeats the main purpose in discrete categorization), the degree to which these three market processes (information, transactions,

7 Using Baum's coding criteria (Baum, 2017, p. 27), this table was largely reproducible using a sample of 393 PropTech companies encountered in the field by the researcher during the twelve-month period of this research, with slightly more FinTech companies encountered (61.1%) and slightly less sharing economy companies (10.7%).

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control) could ever be observed to exist independently seems inherently problematic. What is control without information? How could a technology ever be concerned with only one of these market processes alone? A wide range of literature concerning these topics provides accounts that either deny the possibility of such discrete distinctions to begin with, or the value in such discretion when trying to holistically assess markets, information communications technology, or both: from von Hayek's (1988) price signals, to cybernetics (Wiener, 1948) and other more recent work on similar topics (Fourcade & Healy, 2016; Tiqqun, 2010). None of these accounts would discretely separate process of control from process of information; or accept the notion of a transaction, marketplace or price without an indissoluble informational signal.

Figure 4. An illustration from William Leybourn's The Compleat Surveyor (1653) indicates the divine reverence with which Edmund Gunter's chain was held at the time.

In short, Baum's schema of verticals and horizontals raises far more questions about PropTech than it resolves, and the percentages in the boxes are hazy at best – and at worst little more than market research eye-candy. The report usefully tells us that many billions of dollars are being invested in companies that claim to operate around some types of real estate market processes (and

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provides a useful flavour of what technology might currently exist), but it tells us very little about what socio-technical mechanisms or logics PropTech actually embodies as a group of market devices. Because of this, it is a good example of where new terms can sometimes lead us to confuse the language of marketplace participants with our own analytic endeavors (Beer, 2008). And Baum's (2017) report perhaps sits better in the category of the phenomena-to-be-researched, not in the category of foundational research literature: it is an interesting and provocative research object that is very much a part of the field in question in terms of how it is discursively contributing towards framing, legitimizing and *translating* the technology and market (Preda, 2009).[8] All of which are processes that Baum's notion of 'exogenous' and 'endogenous' real estate technologies seem to deny in favour of a vision of their technological *diffusion*; much as the surveyors of the 17th century may have seen the chain as divinely exogenous, perhaps diffusing via cherub (e.g. Figure 4). These short-comings now form a good departure for considering a better approach.

4. Platform Real Estate

This paper now suggests that one better approach to understanding digital real estate technology would begin by considering these technologies as *platforms*. Few researchers have begun to apply this lens to real estate, perhaps due to real estate's hitherto analogue sensibilities, and those that have made the strongest starts are only just beginning to explore the definition of platforms as digital real estate technologies (Rogers, 2016; Rogers & Fields, 2017). Overall this approach to understanding new digital innovation in real estate markets aims to expand on a theory of these technologies whilst also avoiding the technological essentialism described above by expanding upon the much simpler, broader and less discrete analogy of the platform. This will provide a more accurate and useful assessment of the key mechanisms and logics at play in digital real estate technologies.

Despite its present ubiquity, the term platform is relatively new in application to digital technology or economics. As such, it is often employed without much by way of context, critical consideration or clear definition. One basic and functional description might be that platforms are "digital infrastructures that enable two or more groups to interact", and where *network effects*[9] are crucial to a platform's success and value as such (Srnicek, 2016, p. 43). Another definition might be "a business based on enabling value-creating interactions between external producers and consumers" (Parker, Van Alstyne, & Choudary, 2016). Both definitions seem to draw from, and

8 To this end, Baum also appeared for interview on Dearsley's *PropTech Podcast* – and the report was shared and re-Tweeted by a number of London's best-known PropTech personalities, including other co-founders of the UK PropTech Association and those who sought to legally protect its intellectual value as an industry term (Holmes, 2017).

9 Roughly speaking, this means the more users a platform has, the more valuable it is to everyone using it.

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align with, the few more complex definitions which are available, mostly from the disciplines of software studies and economics, where platforms might be technically understood as: “A foundation technology or set of components used beyond a single firm and that brings multiple parties together for a common purpose or to solve a common problem”, where the platform’s value increases exponentially as it offers more complementary products and services and gains new users (Gawer & Cusumano, 2002).

To complement this, economic studies of platforms similarly focus on their practical connection of users as a component or site of a market (Nocke, Martin, & Konrad, 2006), or on the economic operation of the platform itself as such (Täuscher & Laudien, 2017). And bridging both technical and economic domains, platforms are often theorized in terms of their effective impact on business processes and institutional forms in terms of efficiencies and information exchange (Sundararajan, 2016). This body of work often revolves around a relative distinction between markets and hierarchies as different organizational forms that can be mediated or reconfigured through processes of computerization and information technologies – with much debate as to which direction platforms might shift this distinction (Chandler, 1977; Gurbaxani & Whang, 1991). Finally, rather than resolving these debates in their own terms, Benjamin Bratton (2015) has instead followed similar lines of discussion to point to the complex nature of platforms as hybrid organizational-technical forms with an institutional logic that is not reducible to either markets, hierarchies (e.g. states) or machines (Bratton, 2015, p. 41). This account provides a more nuanced view of the platform that is simultaneously highly developed as a theory and also usefully simplistic in its core assessment of the platform: platforms pull things together into temporary higher-order aggregations, adding value to both the things and the platform in the process.

By defining a platform as something connecting users (Srnicek, 2016), and pulling things together into new aggregations and somehow relating to value (Bratton, 2015), we can now revisit PropTech as *Platform Real Estate* (PRE) with some simple questions: which market participants are these new real estate platforms connecting? How are they pulling them together? By attending to observations from the wider theoretical framework it is suggested that we can now answer these questions – since “entities take their form and acquire their attributes as a result of their relations with other entities . . . In this scheme of things entities have no inherent qualities: essentialist divisions are thrown on the bonfire of the dualisms” (Law, 1999, p. 3).

In light of John Law’s bonfire, Figure 5 displays the most commonly implied user connections (the top 75%) of the 393 real estate platforms mentioned above, who were encountered during twelve months of participant observation in the market*place* whilst working for a real estate data analytics company (see Figure 6). Each platform has been qualitatively coded in a manner that

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draws upon their self-identification in marketing literature (websites, trade show pamphlets, discussions with employees) in order to work towards allowing them to 'code themselves' in terms of which users they connect (or implicitly claim to connect). By *connect* it is understood that the platform has, and draws its power upon, a shared user base where each group of user somehow takes on an actionable meaning in relation to the others (where reasons for action might include communications, transactions, data analysis, and more). For example, the analysis revealed that 76

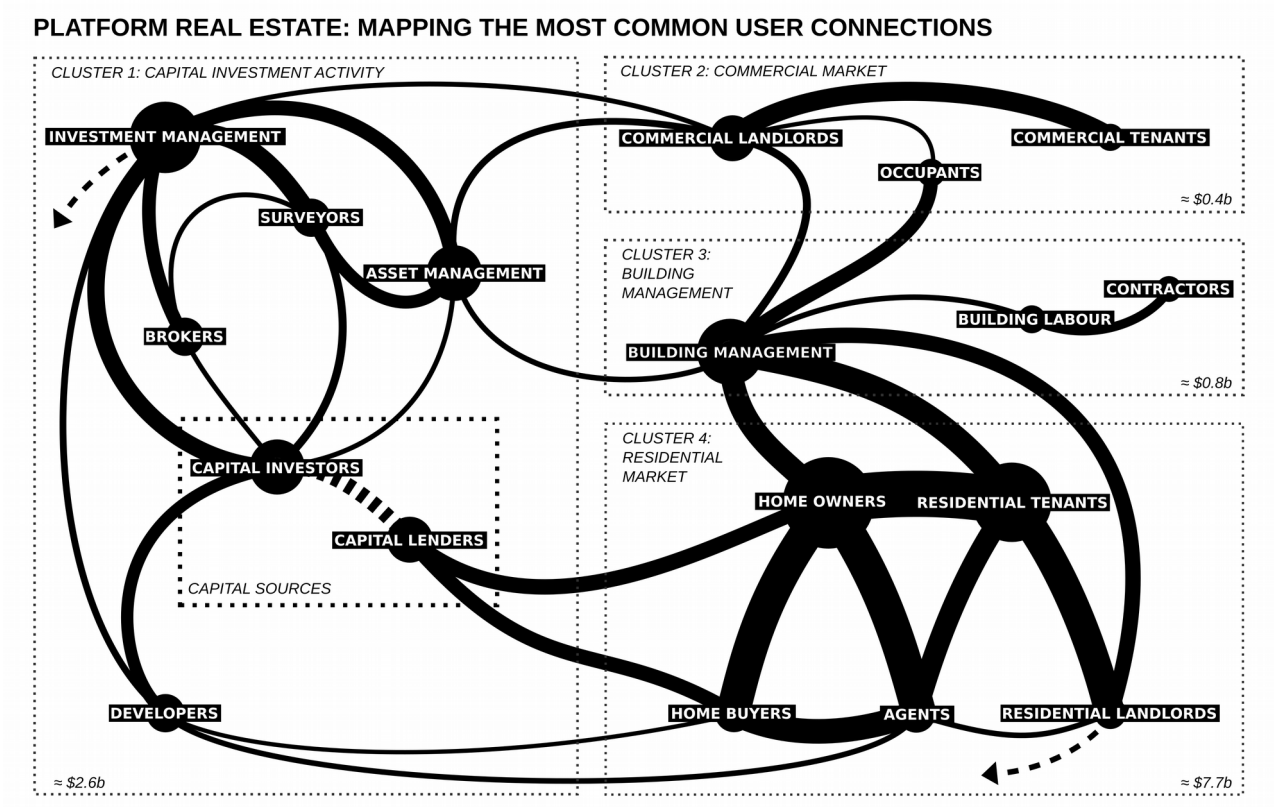

Figure 5. The most common implied connections between real estate market participants according to the advertised operations of 393 self-identified PropTech companies, snowball sampled from 12 months of participant observation in the field of digital real estate technologies (primarily in London, but where 69% of the companies encountered were known to have non-UK headquarters – with 27% in New York or California). A thicker node and edge size implies more user connections and therefore more platforms operating these particular connections. The minimum estimated amount of venture capital investment in the companies is indicated per cluster in billions of dollars, according to data cross-referenced from the start-up tracking website CrunchBase.

of the companies sampled claimed to connect homeowners directly with tenants (e.g. Airbnb), whereas only 35 claimed to connect agencies with tenants (e.g. homie.rent). In some instances, larger or more complex platforms were broken out into two or more records (for example, if they

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separately connect user A to user B, and B to C, but do not yet connect A to C); and in a few cases (including Airbnb) it is conceded that additional platforms, intermediaries and users may also be at work in a less advertised manner and this will be discussed later (e.g. HostMaker, AirSorted).

Figure 6. Business cards from one day of discussions with delegates at the real estate conference MIPIM in 2016. Much of the reflection in this paper is based on a year of participant observation in the field of digital real estate technology, and the snowball sampling of 393 companies encountered during this period (either directly, through conversation, or in marketing materials).

Overall, this attempt to survey the current field of digital real estate platforms is designed to avoid many of the pitfalls outlined previously – instead of uncritically imposing categories in a top-down manner, it tries to meet the companies in the middle, allowing them to define themselves relationally as a part of the real estate market. In other words, it begins by tracing the associations of the matter in question (Latour, 2005). In doing so, we can observe a structure emerging that reflects a more open representation of what digital real estate platforms themselves claim to be about; and this representation can serve as a useful critical tool to draw out some important observations around PRE as a theory and a practice.

A summary of Figure 5 is useful here to paint a picture of Platform Real Estate. In Cluster 1, the type of platforms available typically offer a range of information and data analytics products that promise to help investment managers, asset managers, surveyors and those with capital to make

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better market decisions – in terms of managing their existing assets and investing in the best market opportunities. This includes a raft of data science and financial management products that have been aggregated and connected in online dashboards or data services like APIs and 'data warehouses', as well as crowd-investing platforms that connect capital sources to the physical ownership of real estate. Hence, these platforms connect market participants with information that enables prescient decisions around capital investment and the pursuit of profit; or they might offer a source of that profit through marketplaces open only to large funds or 'Sophisticated' and/or high-net-worth investors (FCA, 2017). Judging from the marketing literature, these platforms are typically aimed at larger investors (investment funds, REITs, etc.), but the aggregation of open data sources is also enabling tools to emerge that might be affordable to smaller developers, investors and agents who are looking for smaller market opportunities. This could include small off-market plots, up-and-coming neighbourhoods, home auctions, and proprietary algorithms to anticipate which houses will come to market, etc. Cluster 2 represents the commercial real estate market – the point at which investors or funds have become commercial landlords with a need to connect to their tenants, users, building management, and asset managers. Cluster 4 is the equivalent residential market, and the thickness of the edges in this cluster represents the relatively large amount of platforms operating in this market – home sales, vacation rental, tenant verification and screening services, estate agents, developers, and their connection to capital through mortgage lenders. Cluster 2 and 4 both contain a great many rental platforms, which make a variety of claims as to how innovative and 'sharing' they are. Cluster 3 is the area of building management and maintenance platforms that operate between both residential and commercial markets. Finally, the manner in which these clusters connect between each other is also representative of further platform typologies – mostly in connecting investment capital to commercial or residential real estate markets, or connecting building labour and construction to buildings and developments of all types.

Neither Figure 5 or the sampled companies are supposed to provide a complete or perfect quantitative representation of all real estate platforms (the coding process was iterative and ad-hoc), but rather to provide the beginning of an enquiry that is based on a socio-technical theory of PRE. It shows us a picture of the real estate platform landscape encountered *in situ*, and forms a departure for understanding PRE as a wider phenomenon. Figure 5 also immediately shows us two important things about PRE: first, that the market structure and activity implied by PRE does not seem especially new (yet). There are four significant clusters implied by PRE's most common user connections: finance/capital investment activities, the residential market, the commercial market, and the management of buildings as physical-material assets. PRE arranges itself (via its marketing discourse and operational claims) nicely around these areas of activity: connecting users as they

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turn from home buyers to home owners, the wall of capital identified by Aalbers (2016) to the big investment or asset managers, tenants to estate agents, shopping mall owners to the analysis of shopper footfalls, and so on. Nothing here, in terms of market structure, business sectors, objectives or activities is immediately new – there is no need whatsoever to use terms like the *sharing economy* or *FinTech* to explain the positioning of the vertices in Figure 5. They are, by and large, in a position that one might expect to find them given any mainstream understanding of the real estate market (Baum, 2015; Eldred, 2016; Sayce, 2006); or even more complex social accounts of it as a performative 'asset assembly line' (Weber, 2015).

Second, Figure 5 also demonstrates one aspect of what is new about PRE: the nature of the edges in Figure 5. Or, in other words, the connections between the users; and therefore the very nature of their activity as part of PRE. As indicated by the tables above and broader description of PRE, what is new is the connection of users in a manner that is reliant upon digital technology and dependent upon the accumulation, storage and processing of digital information in a manner that is previously unprecedented either in scale or in its application to (and around, and through) the real estate market. How can these connections – which are also market connections – be thought of? How relevant is their thickness (other than to tell us how popular or prevalent a connection is) and what is the nature or mode of these connections? What lies behind the edges of Figure 5? What relations do they imply for the user and which connections are becoming more or less prevalent?

Here it is suggested that thinking of PRE – and the nature of its user connections – as having a *stack* ontology is useful (Bratton, 2015). Or, that the market participants of PRE are connected by platforms that operate through a stack of digital hardware and software layers that are structured around two basic key market activities and concerns: first, the ownership or social occupancy of buildings (and land, or space generally), and second their exchange as part of a capitalist economic system that operates with the objective of profit according to certain users' registers of value. Both of which are concerns identified by most researchers in this field, and which are widely accepted as uncontroversial realities (Baum, 2017, p. 1). Around these activities, layers of users, interfaces, software and hardware define the operation of PRE through their various protocols and material-cultural particularities (all of which were originally exogenous to all markets before translation). Therefore, what is new here to real estate markets is the presence of this digital stack of technologies – since previously existing platform technologies of real estate like the screw-driver, Gunter's chain, a vellum property deed, talking on the telephone or meeting in a bar did not connect users through any such stack, and did not rely on the same interoperable protocols of digital information. In the case of Bratton (2015), these layers are seen as comprising six connected layers of activity – earth, cloud, city, address, interface and user – each operating with core logics of

interoperability and standardization as part of a giant accidental megastructure that comprises *planetary computation* (Bratton, 2015, p. 5). Of this megastructure, the real estate market is incidental perhaps only inasmuch as it has not been incorporated into this overall stack as much as many other industries. Or in simpler terms, it is not as computerized as much as most other industries (technically, socially, culturally).

Through employing this stack ontology (and Figure 5), digital real estate platforms can now be roughly demarcated and differentiated from each another in the sense that they represent particular social arrangements of technology – those interdependencies, protocols, other standards and intellectual property that are often the components of individual businesses. And importantly, each platform offers users a certain connection or 'path of action' to its users – where *path* is similar to Bratton's *column* (Bratton, 2015, p. 67). Each path of action consequentially depends upon and will bring about activation across every layer of the PRE stack. This now provides an alternative and relatively non-essentialist method to recognize digital real estate platform technologies – through the shapes or arrangements of user connections they offer between market participants (users) as outlined in Figure 7. Here each platform can be understood as defined by the particular socio-technical assemblage that constitutes the path they offer to a user through the stack of technology within which they operate. Paths which currently concern the central real estate market concerns of land and capital.

However, although Figure 7 is a useful way to start thinking about real estate platforms (albeit using examples that could disappear or change beyond recognition in the years to come), it also omits some aspects of Bratton's theory that are important to how PRE is understood. In particular, the representation of user connections in Figure 7 should not be read in a finite or static manner, since these 'sessions' would more often be fleeting, rapid and vast in number (Bratton, 2015, p. 67). In any given day, a market participant of PRE might be the user of thousands upon thousands of devices (applications, sensors, etc.) within a larger planetary stack of computational technologies; in various combinations and at various scales; and almost none of which they or the platform's legal owner hold any possession over. Consequently this enrols myriad new and unknown objects, actors, relationships, opportunities and fragilities into new real estate markets, many of which would have previously been unaddressed externalities (see Section 5.5 for further discussion).

So although each platform can be associated with a market program or plan in its own right, the overall characteristics of PRE markets will ultimately depend upon a complex and currently unforeseeable planetary combination of technologies and their users. Hence the platforms in Figure 7 are also much less detached from each other than any such diagram might imply. Much as discussed in relation to Figure 5, PRE is already messy and overlapping, where many of the larger

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platforms may in fact play host to a range of other unintended users and platforms; perhaps as parasites, impending requisites, or as-yet unseen opportunists. Furthermore, to argue the toss between an ultimate form of PRE as a dystopian algorithmic capitalism or a more utopian eventuality with more emancipatory programs is still too early to call, since PRE contains "the seed of both outcomes" (Bratton, 2015, p. 192). But despite these uncertainties, this is not to say we shouldn't try to pick out certain characteristics and looming concerns around how PRE is currently being designed and performed in the present.

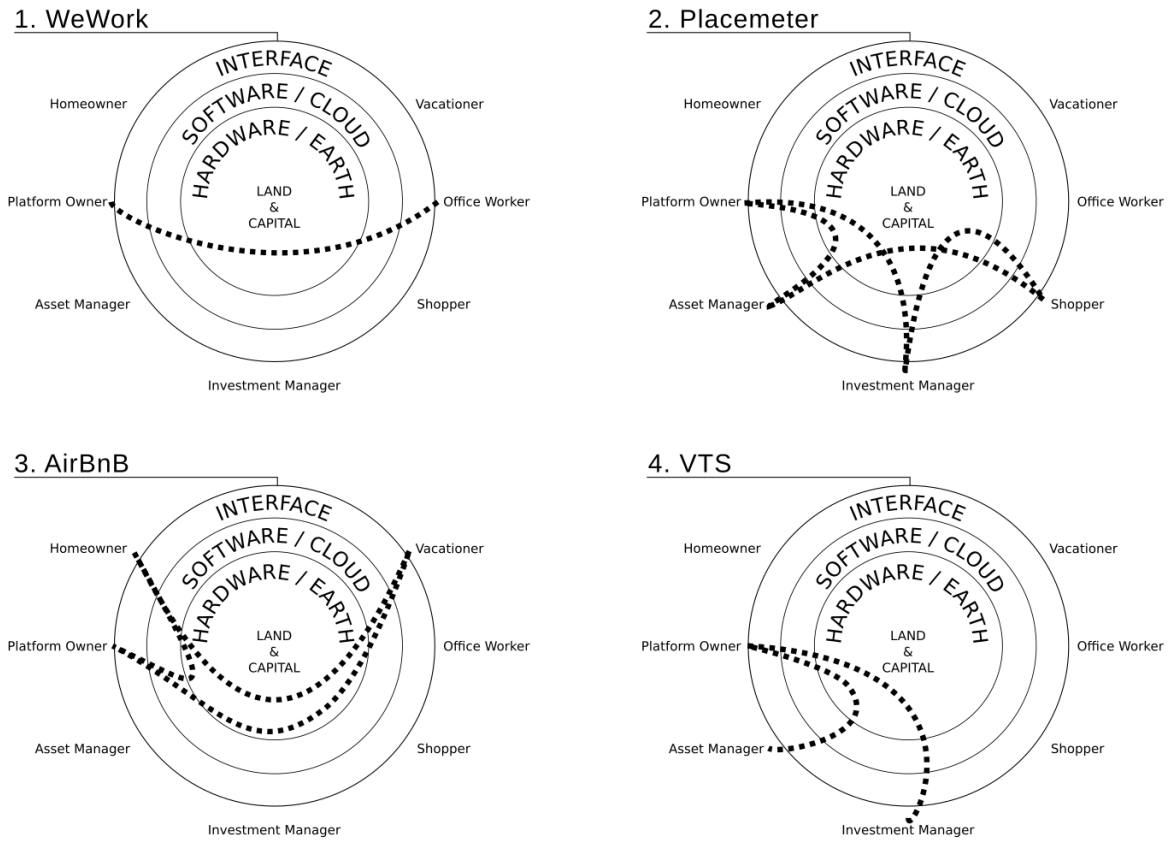

Figure 7. An example of four digital real estate platforms as characterized by some of the paths or columns of action they might offer their users; through a stack of digital technology surrounding central concerns of land and capital.

The examples in Figure 7 are, again, not designed to offer quantitative insight, but instead to offer an improved ontology towards an understanding of PRE: digital real estate platforms can be better understood as particular arrangements of user agencies within interoperable layers of digital

technologies that produce and offer certain paths of action to real estate market participants. And in the case of the currently-existing real estate market they offer paths that engage with concerns of land/building ownership, land/building use, and the exchange of these as part of a capitalist economy. Whilst this might sound like a simple definition of what a real estate platform is, it is a stronger and less-essentialist foundation to using terms like PropTech or sharing economy since it makes far less discrete or categorical claims about the technologies as they actually exist. Finally, it also enables us to make a number of useful observations surrounding PRE in terms of its nature and how it can lead to the practice of new urban real estate markets.

5. Observations

The following five interrelated observations draw upon the theoretical framework above, the work of Bratton (2015) and Srnicek (2016), and the insight into Platform Real Estate's current form, as suggested by Figure 5. They both explain aspects to PRE's various functions and logics, as well as raise questions as to how they can transform future real estate markets in practice. Each observation is limited in scope, but provides the beginning of a series of deeper questions about digital real estate platforms that future research should seek to address.

5.1. Platform Real Estate depends on data from the user layer

The nature of PRE user connections also represent a technology of data collection. The thickness of the edges in Figure 5, as well as the shape in which they connect users around market concerns, implies a significant and particular opportunity to capture data around market processes that include both price information as well as information concerning the social and material occupation of buildings (by office workers, by consumers, by thieves, by families, and by other non-human actors). This is especially noted in Bratton's (2015) work through a description of the user layer as the most culturally complex layer, since PRE can thus offer new ways to see previously un-seeable market processes and actors (Bratton, 2015, p. 71). Also identified by Desiree Fields (Fields, 2017) as the *datafication* (Mayer-Schönberger & Cukier, 2013) of real estate market processes and practices, this process of collecting data from market participants is both politically complicated but also a matter of basic PRE economic necessity (Srnicek, 2016). Therefore, the platforms must operate on this data as their 'raw material' and thus the thickness of the lines represents not just a site for the analysis of data between two market participants at the PRE interface level, but also the site of accumulation for a particular platform; and perhaps as well as other (relatively disconnected) platforms and users.

Following this, the edges of Figure 5 tell us that the residential market is currently a major site for the collection of PRE data (and investment in PRE). But in terms of where this information then

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flows – or is ultimately stored, and owned – we cannot tell from the diagram. The nature of information as a commodity and PRE as a complex stacked assemblage makes this a massively complicated and overdetermined problem with multiple answers. It is both a technical and economic problem. For example, information accumulated in the thick connection between home owners and home buyers (Zoopla, the Land Registry, VillageDefense, Nested, WalkScore, etc.) might then be appropriated for use in another platform between asset managers and investors. Ultimately, this (other) platform might even buy the rights to data collected elsewhere, and the information could change hands over and over again (albeit as it becomes relatively more obsolete). To fully understand the emergence of new real estate markets as part of Platform Real Estate, research needs to follow these flows of data collection, accumulation and circulation.

5.2. Platform Real Estate offers a new way of seeing the market

From the perspective of the user, the PRE stack offers a new 'way of seeing' for market participants (Fourcade & Healy, 2016) as they navigate user pathways between the outer interfaces of the PRE stack and the central market concerns. This is clear from the prominent position of data analytics products at the interface layer, which can draw upon the accumulation and scoring of new data in informational drag-nets (Fourcade & Healy, 2016, p. 12). The accumulation of data around the edges of Figure 5 is completed for the purpose of converting and standardizing the material market concerns into interfacial products that generate the revenue for platform owners through a process of user data surpluses and data brokerage or sale. This has significant consequences for future real estate markets. At the very least, it means that the 'informational surprises' on which all markets run (Mankiw, 1998) are to be gradually deferred in authority to the domain of PRE in practice (both the technologies themselves and the individuals that own them) – or, that PRE will come to replace, substitute or maintain (to some extent) the tacit and distributed cognition upon which the real estate market currently depends to function (Preda, 2009, p. 7).

This raises issues of power and agency in the marketplace, so future research must ask questions like: to what extent can this occur, and how will market participants negotiate this power shift in practice? Just as the surveyors of Edmund Gunter's day were attuned to the controversy of geometry as a new way to see the land (see above), PRE will be no less significant to the long-established professions of current real estate markets. For example, is the position of a commercial broker secure in the PRE represented by Figure 5? Why are connections we would expect (or hope!) to see relatively lacking in PRE, such as between agencies, landlords and building labour (i.e. providing adequate building maintenance for tenants)? Therefore, if this information processing is to be increasingly deferred to machines, then the particular way in which these machines intelligently read (and write) the market will also privilege (or ignore) a great deal of other non-

human agents in new ways (Mattern, 2017). Bricks, train stations, database endpoints (or even the earth's rare metal resources) will all attain new agency in this particular mode of seeing – and the owners of the platforms with the greatest network effects will also come to control those indexing and symbolizing systems that are most crucial to new real estate markets, their financialization, and the reproduction (or crises) of capitalism (Lazzarato, 2014).

5.3. Platform Real Estate obscures social relationships

The term platform draws on an etymology that simultaneously points towards a plan of action, scheme and design (Bratton, 2015) – all metaphors which can obscure the politics of their operation (Gillespie, 2010). Following this, the design and operation of PRE through an increasingly connected software stack hints at the potential for PRE to represent a new governing technique and its political potential as a phenomenon which doesn't just represent a politics, but will actually physically in itself *be* a politics (Bratton, 2015, p. 44). This means that the practices of new real estate markets as PRE can obscure at least three types of social relation. First, as services they are unlikely to be 'flat' platforms (Gillespie, 2010, p. 350): instead they will be characterized by a range of both new and pre-existing structural power imbalances. And any rhetoric that they might provide a level playing field to market participants will only serve to obscure the diverse communities of new real estate market participants that use them; instead concealing them as an amorphous apparition of an abstract market rather than an unevenly contoured marketplace reality. For example, the extremely gendered and unequal socio-economic contours of real estate markets will not disappear (Allen & Williams, 2018; Hatcher, 2016); they will only be masked in new ways by PRE. Second, they will also hide a great deal of labour that goes into their production and maintenance as a human endeavor – especially those which utilize outsourced labour or concern building maintenance. This hidden labour is not merely a matter of exploitation and commodification, but also concerns the ways in which mistakes, values and political relationships become wrapped up in the platforms at the point of design and calculation. So just as it would be a mistake to equate any designs of interoperability with platform neutrality (Shilton, 2015), it should be remembered that (contrary to their marketing claims) market participants will never simply 'calculate' with the devices of PRE in future real estate markets (Callon, 1998, p. 133).

Therefore, PRE as a market device will both be deeply structured by accounts of what can be of value, and (vice versa) the social process of coming to commensurate and know this value will also be obscured by the design and practice of PRE. And those social relations that were once *overflowing* (and perhaps desirably incommensurable to some) will become newly framed and unified by PRE as disentangled objects (Espeland & Stevens, 1998; Preda, 2009); but this framing process will be largely opaque to all but the most savvy platform users and owners as PRE's

machinetic operations increasingly come to arbitrate in the valuation of new real estate assets. Valuations and measurements which, though stripped of relational narrative and meaning (Espeland, 1997), will become increasingly obdurate, authoritative and *real* under PRE. Conversely, this places all the more importance on understanding those *unhappy performances* and processes of PRE that will continue to overflow in future real estate markets, and perhaps where we least expect (Callon, 1998, p. 40): the board rooms of global investment funds, Silicon Roundabout's co-working spaces, Mayfair's venture capital firms, a server farm in Iceland, and so on. Therefore, these observations raise questions for future research around the design and construction of digital real estate platforms, because PRE is a political phenomenon and necessarily designed as such.

5.4. Platform Real Estate is geopolitical

Investment tracking data from the website CrunchBase suggests that at least $11.5b has been invested in the companies sampled for Figure 5 alone. This is indicative both of the intense competition between such platforms as they attempt to establish themselves as part of new real estate markets, and also the manner in which there is already a presence of multiple conflicting platform *sovereignties* (Srnicek, 2016). This conflict of platform sovereignty is not just important with reference to the observations above, but also in relation to the broader emergence of an overall condition of PRE as a stack of many interoperable platforms that might constitute a larger phenomenon of *planetary computation* – where multiple layers of PRE might also co-occupy the same territorial location, gathering and subdividing their processes vertically into discrete machinetic jurisdictions (Bratton, 2015, p. 66). This understanding of PRE as a stack also allows us to theoretically expand on other accounts of the relationship between geopolitics and real estate (Rogers, 2017), and is potentially the most consequential aspect of PRE: it represents a potential for new real estate markets to be practised in a setting with entirely new geopolitical rules. For example, whereas the historical era of Gunter's chain was represented by the horizontal *nomos* of Carl Schmitt's 'loops' (Bratton, 2015, p. 19) – lines on the earth representing territory and sovereignty – the coming historical era of PRE will be characterized by a vertical stacking of digital real estate platforms.

This is the most profound manner – but hardest to foresee – in which PRE represents a theoretical and practical spectre for new real estate markets. It means that the way in which PRE will subject land (and its occupants) to new practices of knowing, valuation and trading will also include new processes and understandings of sovereignty and territory as part of an emergent geopolitical project. Whether this will come under the jurisdiction of a *Google Grossraum* (Bratton, 2015, p. 34), or not, is yet to be fully ascertained; but whoever wins the 'Platform Wars' for new real estate markets is sure to wield the strongest hand in deciding this. Fully understanding the

nature and consequences of this observation represents the biggest challenge for future research into the markets of Platform Real Estate, and also the biggest challenge for those who dwell in its presence.

5.5. Platform Real Estate is urban

Based on the abundance of cityscape imagery in real estate platform marketing alone – replete with graphs, maps and dashboards that offer users a generic view of highly urbanized real estate assets – there is reason to suspect that PRE will be both prototyped *in* the city and *for* the city as a primary site of experimentation. Added to its material connection of spaces like Silicon Roundabout, New York City, the Bay Area and the City of London, it could also be theorized that PRE is reconstructing a new global real estate marketplace that will be increasingly defined by an assemblage of definitively urban spaces and actors. However, there are also other more concrete reasons to argue that PRE is a distinctively urban phenomena – which may even be *of* the city (Bratton, 2015, p. 147) – and this will now be discussed with reference to preceding observations.

To begin with, the present global production and accumulation of data is most voraciously observable in the urban context (Kitchin, 2014; Rabari & Storper, 2014). This means that there is a great density of *infinitely recursive* addressable connections that can be enrolled into platforms of all types (Bratton, 2015, p. 206). For PRE, such newly enrolled phenomena could include anything from a city's flows of pedestrians (e.g. Placemeter Inc.) to FourSquare check-ins (Hristova, Williams, & Panzarasa, 2016; Rodionova, 2016) or even restaurant reviews (Payne, 2018). All of which (and more) can be recursively addressed, connected and measured as the means to construct and observe new urban real estate markets, values and units. And with reference to Gunter's chain, the accelerated circulation of new PRE metrics can therefore enable urban space to become a newly knowable *thing*,with new historical possibilities and market opportunities.

However, despite the fact that this newly addressable topology of perpetual urban interaction is increasingly crucial to the generation of a city's economic sustenance (Bratton, 2015, p. 159); it also poses new real estate market *fragilities* through the design of this new market information and the economy of its exchange as part of PRE. Or, just as 2008 could be said to have witnessed a global 'crisis of addressability' due to the "kaleidoscopic nesting [and addressing] of asset debt inside collateralized futures inside options and so on. . ." (Bratton, 2015, p. 335), the specific and particular manner in which PRE is currently being designed to construe and *know* the urban world as an addressable surface is important to the future economic performance of urban real estate markets, and to those exposed to them. This is especially the case as new addressing means, models and units by which to commensurate future urban real estate values become established and

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obdurate within PRE over time, because they can give rise to both a performative and *counter-performative* potential for the production of economic crises (MacKenzie, 2006; MacKenzie & Spears, 2014).

By extension of this point, there is also a looming political question around which urban subjects get addressed by PRE, and how. This is because the very right to exist within PRE depends upon being addressed in the first instance, and thus also rendered calculable in the second. Beyond this, the precise calculative positioning of each addressed user within PRE matters too, since this will function to open up and close off urban spaces to different users in different ways (Bratton, 2015, p. 148); and means we should also consider PRE with a critical lens akin to the right to the city (Lefebvre, 1968). This is already evident in some platforms today, including the racial contours of Airbnb (Kakar, Voelz, Wu, & Franco, 2018) or 'gig economy' building maintenance platforms like TaskRabbit or Handy (Graham & Shaw, 2017; Schor, 2017; Thebault-Spieker, Terveen, & Hecht, 2017). This suggests that the most visceral and consequential experiences of PRE will occur within the city, and where current states of alegality (neither within or outside of present regulatory legislation) mean that "even if the state can see it, it can't name it properly" (Bratton, 2015, p. 176). Therefore, just as a powerful platform-based company like Google can occupy the right to the city (Shaw & Graham, 2017), a descriptive theory of PRE as part of urban real estate markets raises similar concerns for the manner in which these observations will play out in practice. In new urban real estate markets of PRE, it should be asked: "What gets to count and to whom, and who profits from merely counting?" (Bratton, 2015, p. 199); and what new forms of political subject might be able to arise from a shared urban condition in relation to PRE and its geography of address? Overall, there is therefore both an economic and political concern attached to the urban dimension of PRE.

5.6. Platform Real Estate's adoption is not a foregone conclusion

Digital real estate platforms are offering new paths of action to market participants. That some of them also *profess* to offer paths which provide solutions to the tricky nature of real estate as an asset class is undoubted; but there are a great many uncertainties that emerge from the analysis of PRE above. For example, theories of the platform explain why characteristics like network effects and data capture are important to PRE, but they also explain why PRE's adoption depends on more complicated factors: a model neither reducible to market or hierarchy; a condition where multiple overlapping platform sovereignties make tracing associations a difficult task; and where market actors have strong and diverse motives at stake. Therefore, linear paths of pre-determined progress are highly unlikely and it is not certain that any current market participant will ultimately take the paths offered by PRE. In other words, these technologies will not simply diffuse into the market,

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since the process of translation "is at first an endeavor . . . later it may [or may not] be achieved" (Callon, Law, & Rip, 1986, p. 25).

For this reason, there is a need for new research into both the current and longitudinal emergence of PRE; ranging from its relation to the broader construction of new real estate markets to the specifics around individual platforms like those considered above. In particular, questions have emerged from this discussion as to whether the paths provided by PRE are actually being used by market participants at present and how? And if they are, then how are other non-human actors (or users) – like homes, bank accounts, electricity prices – supposed to pull in line with the logic of a PRE stack? What discursive formations, grand narratives, problems and solutions are being constructed at events like MIPIM; and how do they contribute to the translation of new market assemblages? What other work is being done to prepare for the wider PRE assemblage and its new real estate markets?

In addition, given that there is room for new real estate markets to be negotiated as something entirely different altogether, such questions around the precise situation, definition and performance of PRE also have important normative dimensions. There are also significant ontological choices to be made in adopting the new technologies (and metrics) of PRE because they have the capacity to both create and limit future crises and political possibilities (Amoore, 2013; Beer, 2016; Mol, 1999) – and that means that PRE's most powerful actors also have a growing capacity to map and act upon various uncertain futures of real estate. This raises questions like: how could PRE-to-come be designed in different and perhaps more equitable ways; like re-framing the relationship between capital and the PRE stack (Terranova, 2014)? How will such changes be politically negotiated or resisted by those exposed to future real estate markets, or those newly *addressed* by PRE? Such actors could include newly-disempowered brokers fearing redundancy, or entire families of long-disempowered urban rentiers. Forms of resistance could include more subtle workplace practices of behavioural *reactivity* against PRE (Espeland & Sauder, 2007), or more direct interventions for collective gains: hacking smart meters; campaigns to regulate algorithmic redlining; or the development of alternative platforms designed to aid and improve the enforcement of housing regulations like rent control (e.g. AmIRentStablized.com). Therefore, despite the tangled uncertainties that presently characterize PRE in theory and practice, there is a pressing need to continue the task of mapping and evaluating the actors, networks and (perhaps infelicitous) performativities which are currently emerging in order to answer some of the questions posed above.

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6. Conclusions

> "Surveyors were forward agents of capitalism and the state, and, when soldiers were not close at hand, they often had to negotiate temporary relationships with first peoples, who understood the power symbolized by chains and stakes."
>
> – John Weaver in *The Great Land Rush and the Making of the Modern World* (Weaver, 2003)

> "We see our opportunity as capturing more market share among global real estate investors, landlords and brokers, so we can become the single platform upon which the entire industry is managed. A side effect of that is that we generate a ton of data for our clients to harness and use to improve performance."
>
> – CEO of VTS, one of several commercial leasing and asset management platforms (TechCrunch, 2016)

This paper has argued that recent innovation in digital technology means that real estate markets are theoretically and practically faced with transformations that are comparable to those of the 17th century. This includes the emergence of new measurement tools, new discourses in market knowledge and new market devices. All are set to materially intervene in the social construction of future real estate markets; however resorting to technological essentialism and the market's own terminologies (like PropTech) is not useful if we want to best understand how this intervention will occur and what mechanisms are involved.

A better way to understand this shift is through the theory of the platform, and the mass adoption of digital real estate platforms as part of a general phenomenon we might call *Platform Real Estate* (PRE). Following a theoretical framework borrowed from STS and the performative turn in economic sociology, as well as work on platforms by Srnicek (2016) and Bratton (2015), this means that future real estate markets will increasingly be defined by the particular way in which these platforms connect market participants through a digital stack of technology. Therefore, platform logics of network effects, address, interoperability and standardization will also become increasingly important to understanding the construction, performance and practice of new real estate markets.

Some further observations can also be drawn from this theoretical position alongside a basic study of around 400 companies operating as digital real estate platforms. This raises important questions for future research around these technologies as market devices that will intervene in the social re-construction of new real estate markets. Important observations include: (5.1) the dependency of digital real estate platforms on the accumulation of data around user connections as part of market practices (where users might be both human and non-human). This collection, processing and accumulation of data also means that (5.2) digital real estate platforms offer market

participants a new way of seeing (and being) the market. However (5.3) platforms can also obscure the social relations present in the marketplace around their production and use; especially with reference to their role in the measurement of real estate value. Along with their (5.4) geopolitical implications – in terms of their relation to sovereignty and territory – these points all raise questions around the wider political significance and import of PRE.

However, (5.5) it is in the urban context where these processes are most visible and consequential. The complex density of data assemblages already existing in the city provide the greatest potential for PRE to address and re-address previously incommensurable social processes as part of new urban real estate markets. It is also in the city where PRE is being designed and tested with the most energetic capital application. This raises both economic concerns around the precise design of PRE as part of the global real estate market and also further highlights the political points raised in the preceding observations: how PRE addresses users and who owns the most profitable and powerful platforms are political matters that have the capacity to produce crises, cause harm and provoke resistance. Hence, (5.6) the wider market adoption of PRE is also not a given: a theory of these technologies is yet to be fully translated into action, and its adoption is likely to be controversial and contested by present market participants.

Therefore, all of these observations raise questions for future research on how we will come to see, know, value, own and occupy the earth under Platform Real Estate – whether as home, real estate asset, or something entirely different. And with consideration of other economies that have been recently transformed by digital platforms, the current position of Platform Real Estate's most powerful actors, businesses and platform owners should be of particular interest to any researcher concerned with these issues as part of the future of real estate markets.

Acknowledgments

The author would like to thank Sarah Knuth, Dillon Mahmudi and Will Payne for their editorial support in publishing this paper; as well as for organising the Real Estate Technologies sessions at AAG 2017. In addition, the author is very grateful for the helpful comments and input from three anonymous reviewers and editor Susan Moore; as well as earlier feedback from Danny Dorling, Andrew Dwyer, Mark Graham, Ewa Jasiewicz, David Moats and Pip Thornton.

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