Lost in translation:

How can real estate make the most of the PropTech revolution?

Contents

On technology and innovation

"This 'telephone' has too many shortcomings to be seriously considered as a means of communication. The device is inherently of no value to us." — Western Union internal memo, 1876

 "Fooling around with alternating current (AC) is just a waste of time. Nobody will use it, ever." — Thomas Edison, 1889

"Television won't be able to hold on to any market it captures after the first six months. People will soon get tired of staring at a plywood box every night." — Darryl Zanuck, 20th Century Fox, 1946

"We don't like their sound, and guitar music is on the way out." — Decca Recording Company on declining to sign the Beatles, 1962

"Remote shopping, while entirely feasible, will flop." — Time Magazine, 1966

"The growth of the Internet will slow drastically, as the flaw in 'Metcalfe's law' – which states that the number of potential connections in a network is proportional to the square of the number of participants – becomes apparent: most people have nothing to say to each other! By 2005 or so, it will become clear that the Internet's impact on the economy has been no greater than the fax machine's." — Paul Krugman, 1998

"The iPhone is nothing more than a luxury bauble that will appeal to a few gadget freaks."—Matthew Lynn, Bloomberg, 2005

"There's just not that many videos I want to watch." — Steve Chen, CTO and co-founder of YouTube expressing concerns about his company's long-term viability, 2005

"The difference between the right word and the almost right word is really a large matter – it's the difference between lightning and a lightning bug", Mark Twain, 1890

"Translation is not a matter of words only: it is a matter of making intelligible a whole culture", Anthony Burgess, 1974

Executive summary

The property sector is traditionally seen as a safe and steady investment. Many players have endured for decades, sometimes for centuries. However, rapid technological change – in particular digital innovation – and new business models are making the market think again about value and risk in the sector. It is clear that the sector needs to modernise.

The Government's Industrial Strategy White Paper[1] challenges all sectors of the economy to improve productivity and deliver growth. The strategy is based on 5 foundations. They all have relevance for a property sector with potential to help in transforming the economy through new ideas for property and its functions; better buildings for people to work, live and play in and for businesses to thrive in; improved infrastructure; and more prosperous communities.

There is a strong correlation between the level and depth of digitisation and productivity. Real estate is not the least digitised economic sector, but it is clear that many opportunities remain. Change is already being driven by digital technology and includes trends towards:

- more flexible use of space in buildings

- a more service-based approach to property

- use of sensors to provide information on building use and provide feedback to developers and architects

- virtual replicas of buildings as a tool to improve design and operation

- more adaptable buildings that can cater for uncertain future uses

This report aims to understand the barriers to and opportunities for improving the productivity of the real estate sector through the application of property technology (PropTech) and to provide practical recommendations for industry and government.

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1   https://www.gov.uk/government/publications/industrial-strategy-building-a-britain-fit-for-the-future

Our research

We used a variety of methods to help us understand the barriers and opportunities:

- an online survey with 10 key questions completed by 54 participants
- 2 project boards led by the British Property Federation
- 2 roundtables involving 13 participants from across the property sector
- 11 interviews with industry experts

Respondents included directors, chief executives, management and practitioners, and they were split between traditional real estate and PropTech.

There were clear structural, technical and cultural barriers to be overcome for the property sector to both reap the full benefits of digital transformation and to build resilience to withstand potential digital disruption.

Three key themes emerged from our research. They were the need to:

- improve on a dearth of market information about the type of technology on offer to the property sector and the needs of users

- create a cohesive approach to championing innovation to counter a disconnected and unclear response to shared challenges across all the different actors

- embed digital knowledge and foster innovative behaviours in an industry lacking the skills and a business innovation mindset

Recommendations

Our recommendations are directed at how the sector as a whole should respond, particularly through umbrella bodies, central government and government agencies. They are grouped under the 3 key themes.

Improve market information

- Develop a PropTech library of all current and emerging PropTech innovation, classified in line with the property lifecycle, user needs and technological drivers

- Develop a property innovation index to assess a company's capacity and preparedness for innovation/tech

- Create a PropTech maturity index to give the market a clearer understanding of which innovations they should be adopting now

- The British Property Federation should undertake regular research on the priority technology needs of members and their occupiers

Create a cohesive approach to championing innovation across the property sector

- Create a plain-language shared vision of the future property sector

- The property industry, government and other key strategic organisations to set up a property sector regulatory sandbox

- The property industry and government to work together to set up a property passport with common data standards for core information

- Centre for Digital Britain to work with industry, architects and innovators to improve consideration of productivity and wellbeing at the earliest stages of a building's design

Embed digital knowledge and foster innovative behaviours

- Develop a programme to place early career software developers, digital designers and innovators in influential roles in property companies

- British Property Federation to develop a leadership development course including a comprehensive overview of the technologies driving digital innovation and the business models changing industries

- British Property Federation to develop a programme of open and challenge-based procurements

Introduction

The British Property Federation (BPF) has approximately 450 members including the largest property developers and owners in the country. The sector has traditionally been a safe and steady investment, populated by players that endure for decades or even centuries. Yet the average lifetime of a company may be shrinking, with implications for both owners and occupiers. The average lifespan of a company on the S&P 500 index of leading US companies has decreased by more than 50 years in the last century from 67 years in the 1920s to 15 years today[2]. New technologies and associated business models are making the market think again about the value and risk of the sector and the companies in it. Whether the latest wave of property technology (PropTech) companies are here to stay for the long term or not, it is increasingly clear that the sector needs to modernise.

The Government's Industrial Strategy White Paper challenges all sectors to improve productivity and deliver growth across the country. The strategy is based on 5 foundations:

- ideas: the world's most innovative economy

- people: good jobs and greater earning power for all

- infrastructure: a major upgrade to the UK's infrastructure

- business environment: the best place to start and grow a business

- places: prosperous communities across the UK

The property sector can play a part in delivering a transformed economy across all these areas – new ideas for property and its functions; better buildings for people to work, live and play in and for businesses to thrive in; improved infrastructure; and more prosperous communities.

The strategy also outlines a series of grand challenges based around global trends of artificial intelligence and data; ageing society; clean growth; and future of mobility. There are many specific challenges relevant to real estate including transforming construction to make buildings more affordable, efficient, safer and healthier; prospering from the smart energy revolution; and using artificial intelligence and data to power the next generation of services.

2   Foster, Richard and Kaplan, Sarah (2003), Creative Destruction: Why Companies That Are Built to Last Underperform the Market – And How to Successfully Transform Them, Crown Business

The property sector and productivity

Researchers at McKinsey in 2016[3] looked at the level and depth of digitisation of different processes across a range of different industries in the US (see Figure 1). They found a strong correlation between digitisation and productivity. While real estate is not the least digitised sector, further opportunities remain. This report aims to understand the barriers to and opportunities for improving the productivity of the real estate sector through the application of technology and to provide practical recommendations for industry and government.

Simply put, productivity is the rate of output per unit of input, used especially in assessing the effective use of labour, materials or capital in economic terms.

The Government considers increased productivity to be the only sustainable way of improving living standards in the long term and to do so not at the expense of providing more inputs, but simply utilising those inputs better to generate more output in terms of either or both of quality and amount.

Figure 1
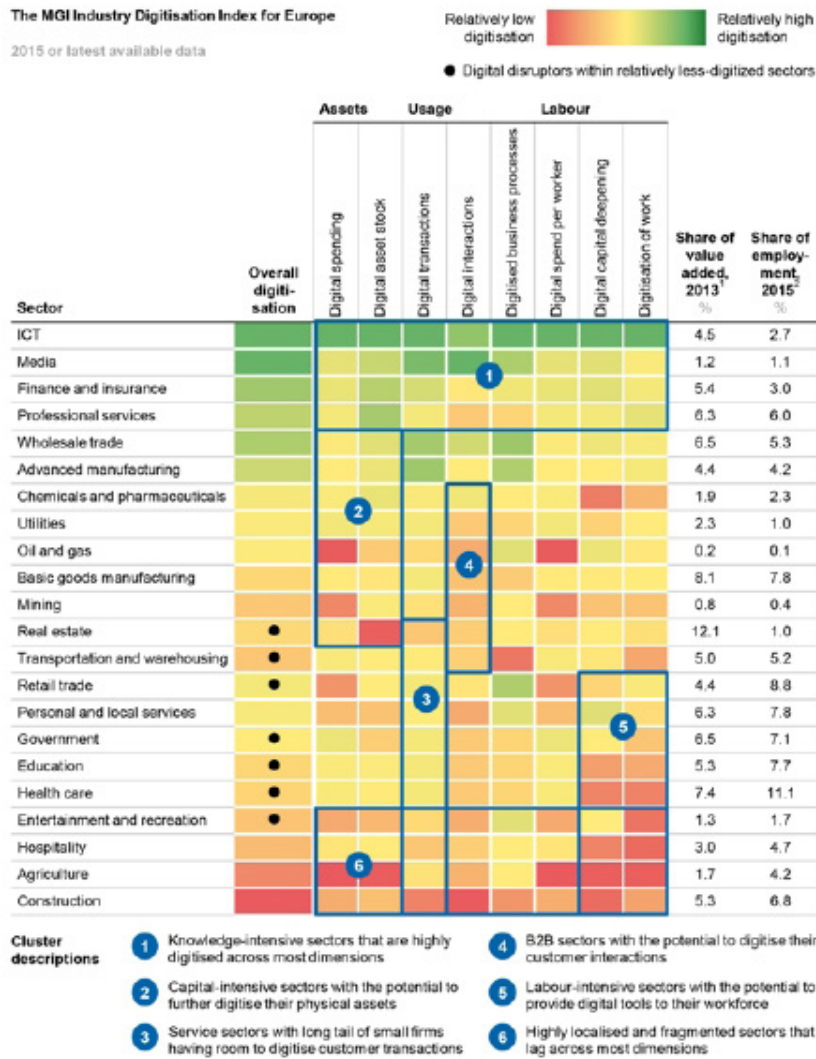
3   https://www.mckinsey.com/~/media/mckinsey/business%20functions/mckinsey%20digital/our%20insights/digital%20europe%20pushing%20the%20frontier%20capturing%20the%20benefits/digital-europe-full-report-june-2016.ashx

In 2007, the Office for National Statistics (ONS) produced a productivity handbook[4] with an expanded range of productivity statistics for use by policy makers, which it continues to maintain. This data, although not perfect, acknowledges the UK real estate sector to be a substantial contributor to UK productivity (third in terms of output per hour in 2015, for example) but among the smallest sectors in terms of percentage of overall hours worked. Its raw contribution is also among the highest overall contributions, as the bar chart below shows.

Chart 1
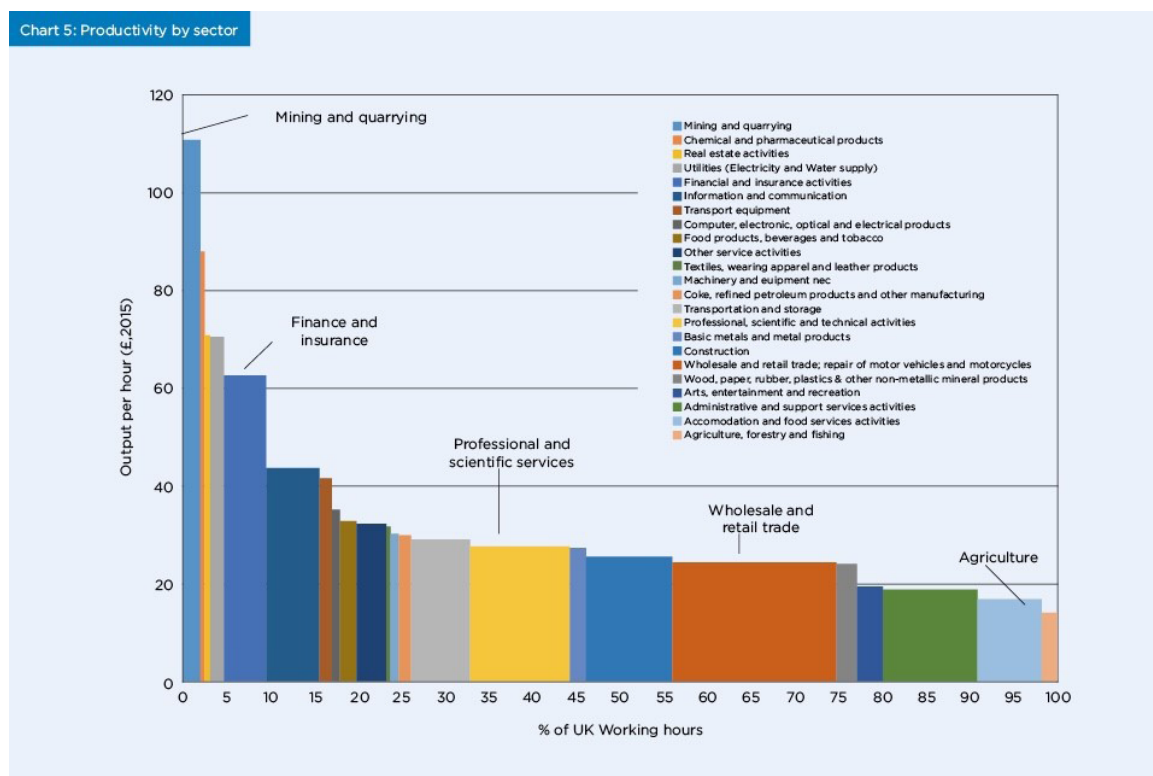
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Yet, if we chart historical data in today's prices across UK regions, we see that the UK real estate sector's contribution to overall productivity is shrinking in some regions, albeit not at a very sharp rate. We also see that the relative contribution of real estate to a number of regional economies is shrinking. In the former case, it is important to stress that it is still a substantial contributor and, in the latter case, that this is likely bound up in general shifts in the economy. Nevertheless, in the face of such trends, it seems wise for the UK real estate sector to be considering how it can examine its productivity and see if there are ways to improve it.

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4   https://www.ons.gov.uk/economy/economicoutputandproductivity/productivitymeasures/methodologies/ productivityhandbook

5   Reproduced from: https://quarterly.blog.gov.uk/2017/07/13/charting-productivity-in-the-uk-economy/

Future Cities Catapult has been working alongside the BPF, its members and leaders in the real estate and PropTech worlds to explore the barriers and opportunities for technology to drive change and productivity across the sector. Whilst there is no single recognised definition for the term PropTech, the first accepted definition for it was provided by Professor Andrew Baum and PropTech influencer James Dearsley and it still holds today -

"PropTech is one small part of the wider digital transformation of the property industry. It describes a movement driving a mentality change within the real estate industry and its consumers regarding technology-driven innovation in the data assembly, transaction and design of buildings and cities"

Existing PropTech literature

A lot of research has been done in recent years into property and technology to try to understand this new emerging market. Many of the reports have sought to establish a categorisation that helps to better organise and make sense of what is happening in the sector.

However, the inconsistent and self-selecting approaches taken by different reports (see table 1 below) have the potential to create more confusion than clarity. Nevertheless, there are some common themes across the main reports we reviewed by CB Insights[6] , JLL[7], Saïd Business School[8] and KPMG[9]. As we suggest in our recommendations, a more standardised and industry-wide taxonomy that builds on this work is an important way forward.

Table 1

COMMON THEMES	JLL CATEGORIES	SBS CATEGORIES	KPMG CATEGORIES
Planning			Urban Planning
Design	Property development		
Construction			Design / Construction
Management	Property Management	Smart Real Estate	Leasing/Management
Sales/Leasing	Brokerage/Leasing	Shared Economy	Search/Sale/Acquisition
Investment/Financing	Investment/Financing	Real Estate FinTech	

6   https://www.cbinsights.com/reports/CB-Insights_Real-Estate-Webinar.pdf
7   http://www.joneslanglasalle.com.cn/china/en-gb/Research/proptech-clicks-mortar-apac.pdf
8   https://www.sbs.ox.ac.uk/sites/default/files/2018-07/PropTech3.0.pdf
9   https://home.kpmg.com/content/dam/kpmg/nz/pdf/November/proptech-bridging-the-gap.pdf

The emerging literature also seeks to understand attitudes towards technology and innovations within the sector. The KPMG[10] report is especially helpful in identifying the 'language gap' between those in need of technology solutions (including whether they are aware of this or not) and those supplying them, which inhibits better and deeper collaboration and coordination. This issue is confirmed by our interviews and is one where we seek to develop practical recommendations.

The literature consistently finds that PropTech is no passing fad. CB Insights[11] (and other reports not considered as part of our work) take a quantitative approach to valuing investment in PropTech companies, products and services. Whilst some of the analysis is for the Asia Pacific region, the volume and frequency of investment suggests that, whilst there is not yet a 'killer app', people are voting with their wallets and their feet. Whilst you might expect that the authors of these reports have an interest in promoting a new sector where new work can be obtained, our interviews have confirmed that the sector is moving from 'hype' to the plateau of productivity, to use the Gartner Hype Cycle terminology.

Whilst these formal reports are not the sole source of debate on PropTech (with more ephemeral content such as the PropTech subreddit, WhatsApp groups and Twitter debates providing different insight but outside the scope of this review), it is still worth noting gaps in the existing literature including:

- no comprehensive way to categorise all technology innovation in the real estate sector, as each report is heavily biased to a specific part of the sector, with little attention paid to the overall picture

- the current list of PropTech solutions are either too vague on real-world application or limited in scope to present overall PropTech activities

- interview-based reports target mainly executive level, without touching the real issues on the ground. Survey reports focus primarily on the innovation side, with little attention paid to user needs and challenges to implementing innovation in the traditional sector

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10   ibid
11   ibid

Property lifecycle model

We have mapped out the major segments/sub-sectors across the lifecycle of a property to better understand how technology might impact the different stages (see Figure 2 below).

Land appraisal, acquisition and permissions: This may include land searching and assessment, design and planning of a property, applying for and receiving planning permission.

Construction: The majority of work is completed on site and design vision is turned into physical assets.

Sales/leasing: Depending on their business model, real estate owners may develop and/or own real estate and that may temper for how long and under what circumstances they hold assets.

Property management: Preparation for occupancy also marks the start of property management. This includes the asset maintenance and tenancy management. A property may be re-sold and re-let many times, and the property management may be handed over to the new occupants. It means there could be lots of back and forth between the sales/leasing and the property management areas of the lifecycle.

Demolition and remediation: When a property is too old or needs to be replaced, it will be demolished, and the land may be remediated, marking the end of a property lifecycle. The land will be available for acquisition and enters a new property lifecycle.

Fit-out and refurbishment: When the fabric of a property decays or its original designed function becomes obsolete, it may then need to be refurbished and fitted out again to extend its life.

Investment and financing: All stages of the lifecycle are dependent on investment and financing.

The diagram below illustrates the property lifecycle model, with a mini reuse cycle embedded within the major new development cycle, and the investment/financing segment surrounding all the other segments.
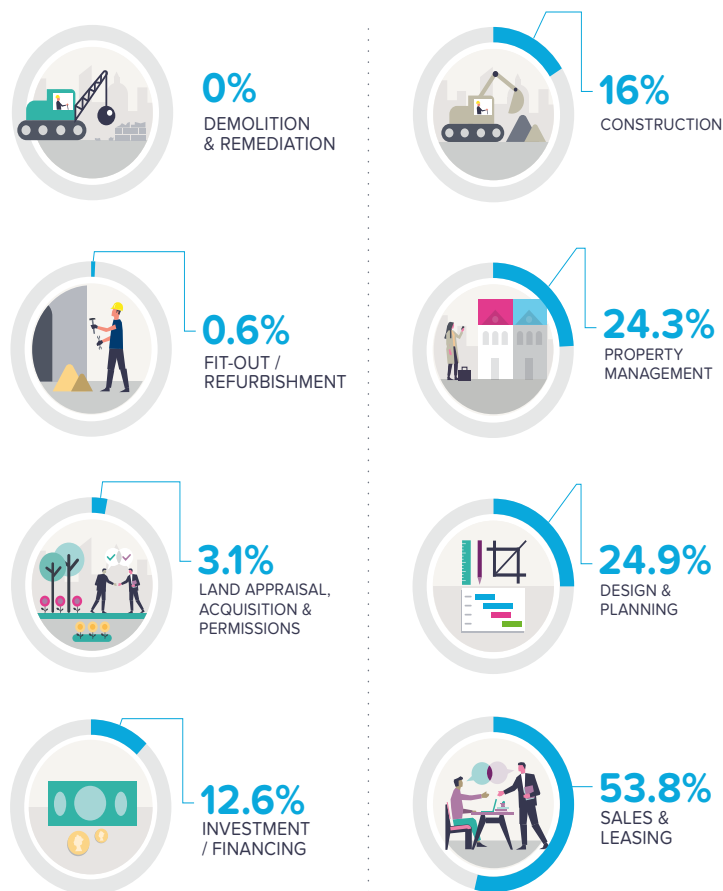
Figure 2
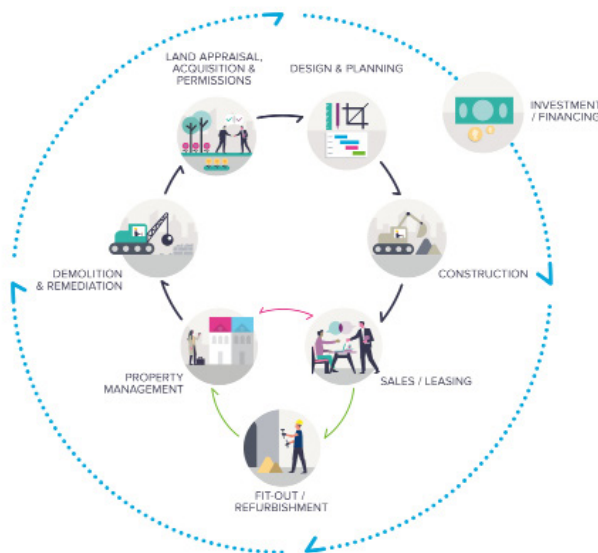
Distribution of technology across the property lifecycle

We mapped out what type of technology applications are available in the UK market and how they are distributed across the property lifecycle (see chart). We included companies from the PropTech UK Map drawn up by the property technology marketing agency TDMB, companies that exhibited at the 2018 Future PropTech Event in London and at the 2018 Digital Construction Week, and companies in the Future Cities Catapult's PlanTech database[12]. We removed non-PropTech and non-UK businesses and narrowed the list down to 326 companies.

We categorised the companies in line with the property lifecycle model. A lot fell into more than one segment, so the figures add up to over 100%. The analysis shows that more than 50% of PropTech companies focus on sales/leasing, whilst only half as many companies focus on design/planning and property management. Only 16% and 12% of PropTech companies apply themselves in construction and investment/financing respectively. Land acquisition and refurbishment have less than 5% of active PropTech companies. No companies from the data sources fell into the category for demolition/remediation (see Figure 3 below).

For a full analysis of the different PropTech companies working across the property lifecycle, see Appendix 1.

Figure 3

0%
DEMOLITION & REMEDIATION

16%
CONSTRUCTION

0.6%
FIT-OUT / REFURBISHMENT

24.3%
PROPERTY MANAGEMENT

3.1%
LAND APPRAISAL, ACQUISITION & PERMISSIONS

24.9%
DESIGN & PLANNING

12.6%
INVESTMENT / FINANCING

53.8%
SALES & LEASING

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12   https://airtable.com/tblMY7mzLOPEwtK40/viwdkvq8QCisC2TsU

Trends in property and technology

Digital technology is already shaping the real estate sector. This section looks at the main ways this is happening and at where we can draw lessons from other sectors that have experienced digital transformation.

Flexible space

Digital technology has quickened the rate of change in many industries. The built environment is not immune. The seminal work of Frank Duffy and Stewart Brand [13]exploring the speed at which different 'layers' of the built environment change is still a useful reference.

The 'stuff' and 'space plan' of a building have always changed more quickly than the rest of a building, but digital technology is bringing even faster change. A building used as a clothes shop one week will transform into a cafe, a gallery or a cinema the next. No-go and under-utilised areas are transformed into desirable locations within months. The use of data to analyse, plan and optimise the use of space has created a fluidity in the way that we use buildings, a trend we see continuing to dominate the built environment in the 21st century (see Figure 4).

The demand for this short-term access to property has spawned companies such as Appear Here, who provide short-term space to over 150,000 businesses and have access to over 10,000,000 sq ft of space across the globe. This same trend of easy and flexible access to space is what underlies the success of co-living businesses such as WeLive, Common and The Collective and of co-working companies such as Second Home, Work.Life, Club Workspace and WeWork.

Figure 4

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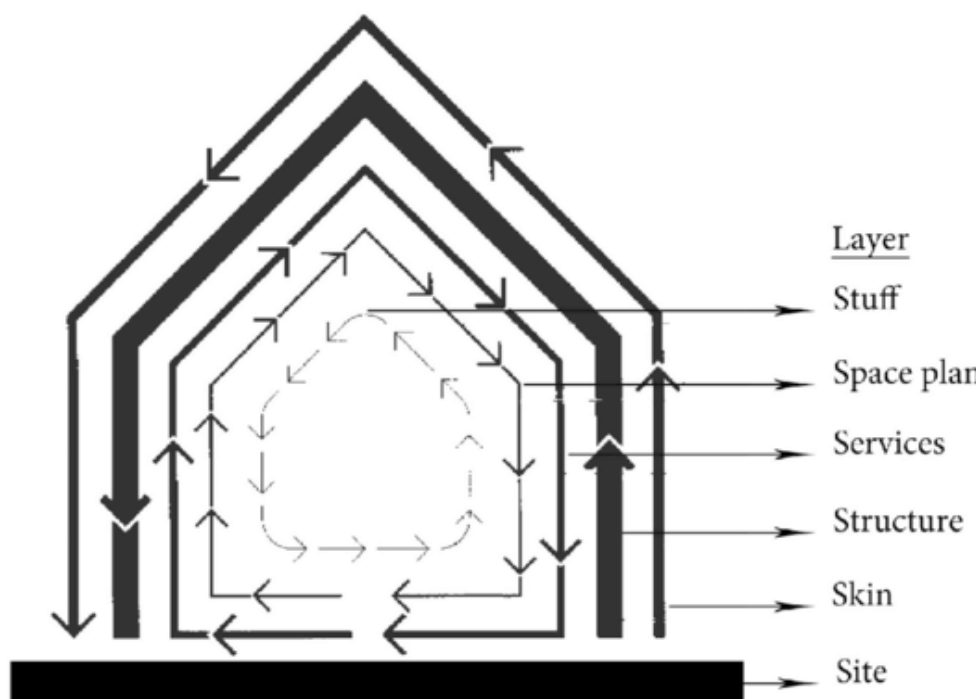
13   Brand, Stewart (1995), How Buildings Learn: What Happens After They're Built, Penguin (London)

Space as a service

Real estate can be viewed as a traditional hardware/product business where you build or acquire an asset and then sweat it – often based on a bond that delivers stable income, from rental payments, over a number of years. This is changing fundamentally as companies demonstrate the added value of the service delivered or the value in having a combined asset and service offer. This transformation is already well established in companies in other industries, from Apple to Rolls Royce, who have realised that the provision of hardware will only get you so far. Embracing the service industry is critical to growth, hence Apple worked to provide the software as well as the hardware for computers and Rolls Royce started selling their jet engines on an hourly rate.

Occupiers want a lot more from buildings than an empty 'dumb' shell, be this ease of fit-out, the levels of digital connectivity, the facility management tools available, the data generation capabilities of the building or the overall impact on productivity and well-being. In other words, the services provided by the property industry are as important as the space. SMEs, such as District Technologies, are homing in on this, offering a digital layer to property owners that manages and augments the occupier's experience of the property itself.

Space for outcomes

The huge range of sensors embedded in our buildings means it is increasingly possible to measure the impact a building is having on health, wellbeing and productivity of its occupiers. High-definition cameras with image recognition give insight into the emotional impact of different spaces. Eye-tracking allows us to study attention, memory and language; mobile electroencephalography machines potentially allow us to study in situ how environments are perceived in real time.
With access to this data, developers and architects are increasingly able to simulate and design buildings around the needs and aspirations of tenants.

Buildings account for just under half of all UK carbon emissions, and the threats posed to our economic competitiveness and society because of human induced climate change are well documented and understood by academics, politicians and business leaders. There has been increasing focus in recent years around understanding building performance, both industry[14] and Government driven[15] seeking to interrogate the barriers to improving building resource efficiency. Obtaining better data[16] to improve policy and practice around building resource efficiency and lowering emissions has been a prevalent theme of historic reports and initiatives in this space. While buildings are built to perform to an anticipated specification, buildings fail to perform to this specification often in operation. The advent of better sensor technology (e.g. technologies that are quicker and easier to install than some traditional metering technologies) can help to both improve insights into building performance and to routinise such concerns.

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14   http://greenfinanceinitiative.org/workstreams/green-finance-taskforce/
15   https://www.greenconstructionboard.org/
16   https://www.bpf.org.uk/sites/default/files/resources/GPA-Carbon-Penalties-Incentives-MAIN-REPORT-with-foreword.pdf

Similarly, the use of digital twins in the construction process can lead to better coordination of works, and a reduction in construction waste and use of materials. A built environment that provides accommodation and business space at lower rates of resource consumption, and with fewer negative externalities, is more productive.

Digital space

The emergence of digital twins is already well established in many other industries. Virtual replicas of assets, processes and services are created to better understand and optimise design, manufacturing and operation.

The amount of data we can harvest about the built environment, together with new frameworks for their collection and coordination have the potential to change the way we plan buildings and cities, and design, manage and operate buildings – a cultural shift as much as a technological one. Data from sensors will be combined with data from the property's original BIM, planning application, energy performance certificates, previous sales, previous tenants, maintenance schedules to become a comprehensive record of the building and its history – a digital twin. This digital twin will be part of the overall service that the property owner provides its occupants and will add value to the building.

The continued emergence of data-driven and digitally-enabled approaches to land use planning, potentially as part of City Information Models, will allow for radical efficiencies in how the sector appraises land, designs buildings and receive planning permission.

The precision and collaboration offered by digital twins of buildings permit, too, the use of prefabricated components and parts of buildings for assembly on-site. Asset classes such as build-to-rent are already making extensive use of off-site manufacturing and this is only likely to increase.

Adaptable space

Many of the above trends increase the levels of uncertainty about the future occupiers of a property and their requirements. This uncertainty could be further magnified by disruption to working patterns and space requirements brought about by autonomous vehicles and alternative and virtual reality, which may further disrupt working patterns and space requirements. These trends will increase that need for buildings to be designed and built to allow for quick and easy adaptation, refitting and repurposing.

Advances in offsite manufacturing and construction technology may stabilise or reduce the costs of development, as the costs related to the unpredictability of occupiers increases, we may see a move towards buildings tailored to the widest range of occupiers, rather than bespoke designs. With a typical lifespan of well over 50 years, if the original design is too bespoke to one type of occupier, the building will inevitably require significant investment in its lifetime to be able to adapt. However, if this is considered in its early days the building can be designed to be quickly fitted and refitted, responding to changing demand.

Research

Our core research involved an online survey, two project boards, two roundtables and 11 in-depth interviews with senior industry representatives from PropTech and traditional real estate organisations.

Online survey

The online survey consisted of 10 key questions to help gather insights and views on technology uses, barriers to improving efficiency in the property sector today and who should be responsible for addressing barriers. Fifty four participants completed the survey. Respondents were mainly directors, chief executives, management and practitioners split evenly between traditional real estate and PropTech.

Project board and round tables

There was a total of 18 participants from across the sector in the four project board and roundtables that we held. The objective of these engagements was to test the findings of our research and interviews, identify priority areas for further exploration and help shape and critique our recommendations.

Interviews

We conducted 11 interviews with industry experts, from directors to chief executives, managers and practitioners across the lifecycle model. They were split evenly between traditional real estate and PropTech.

The goal was to gain their views on culture and behaviour in the sector, where they thought innovation was thriving the most, and areas innovation was most urgently needed. We also asked what they thought were the key barriers to preventing adoption of innovation and what were the short to long-term solutions that could help to drive efficiency across the sector.

Research insights

We have grouped the insights from our research into areas where practical action from industry and government can be achieved. These are not direct quotes from participants, unless otherwise stated, but reflect themes drawn from the online survey and from the comments provided by interview, roundtable and project board participants.

Market information

Quantitative and qualitative market information is essential for more efficient use of capital, quicker decisions and greater liquidity. Market information includes not only the environmental performance of assets, the value of companies, the value of transactions, but critically the needs and challenges of real estate companies that could be met by technology and the range, maturity and quality of technology available to address them. Understanding where the application of technology has failed is of equal importance to making investment decisions as what technologies have worked.

Information about the outputs and outcomes from real estate activity is likely to be increasingly important in a world where the value of property may be influenced by the wellbeing and productivity of tenants, as well as the rent they are paying.

Understanding user needs

There was widespread agreement that the sector needs a step change in who it views as the customer and how it responds to that customer. There was a concern that the conventional owner and occupier relationship could not persist. Too few companies have realised that by treating tenants as customers, you receive and retain their loyalty, let alone that the value of an asset may increasingly be determined by the tenant, as the value of rent is determined by the quality of space that delivers a productive workforce.

Whilst the majority of the larger transactions in the sector are and will remain business-to-business, the sector needs to consider its end-users and their future needs much more closely. Disruption in other industries has been led by those with a laser-like focus on the needs of the customer. Whilst opinions varied amongst participants of the likely long-term sustainability of WeWork within the real estate sector, there was near unified agreement that their customer focus would continue to drive innovation.

Valuation

Traditionally, companies have tended to believe their buildings must be in a good location and the cost driven down to achieve high valuations. However, in recent years organisations have been viewing their workspaces differently. Buildings should be hubs for productivity and wellbeing to attract and retain staff. Whilst many queried the robustness of WeWork's sky-high valuation, there was agreement among participants that it marks a shift in the way properties are valued and, increasingly, the sector needs to think outside traditional property valuations.

There is a trend towards tenants valuing the wellbeing and productivity of their workforce, and government and society being interested in the broader economic, social and environmental impacts of real estate. Yet, valuation still focuses almost solely on the economic impact of the building itself. There is a need for incentives and metrics to better understand the narrow and broad social impact of real estate, and for the sector to follow a similar journey of discovery to that which it has already experienced concerning environmental sustainability.

Data transparency

There is a lack of transparent market data, especially relating to transactions. This is understandable when it is perceived as the most commercially sensitive information. Yet there was disagreement among participants about where to draw the line between making data more transparent so as to improve decisions and liquidity and the need to protect intellectual property/commercial confidentiality.

More standardised and open data (about transactions but also about the sector more widely) was seen by many participants as benefiting the sector as a whole, but it would be a challenge to the competitive advantage of incumbents. The fact that this data is partially available through (proprietary and limited) platforms such as CoStar and IPD does not negate the need for a wider debate about the potential for more open data across the sector to allow for more efficient use of capital, quicker decisions and greater liquidity.

Sourcing innovation

To improve productivity, it is necessary to understand that there are, or may be, new and more efficient solutions on the market. However, participants felt that there was poor market information available about the range, nature and quality of technology and startups, with a small number of companies getting the majority of the publicity and funding, to the detriment of other potentially more useful companies and solutions. There was also a perception that many of the more valuable technology solutions may come from non-UK companies, but there was an excessive focus on UK technologies.

Property sector purchasers tend to use products and services from established brands with strong marketing drive, making it more difficult for new entrants to get a foothold. This barrier to new entrants is further exacerbated when companies try to generate their own innovation, when others outside their organisation might be better placed to do so. Even if companies know what the problem is, they struggle to source solutions and to differentiate between the many different and competing products and services. On the other side, PropTech companies have difficulty identifying which traditional real estate companies are serious about innovation.

Another key barrier to the identification and scaling of technology innovation, cited by a number of participants, is the siloed attitudes and approaches between and within segments of the property lifecycle, and different asset classes. This may in part be due to the highly competitive nature of the sector but also the fact that narrow specialisms have been the focus of income and innovation to date. This may become less relevant as more and more innovation within the property sector involves companies looking across traditional boundaries, from WeWork leading fit-out and management to Katerra looking to digitise land, planning and construction of residential homes.

Real estate stakeholders are often not willing to share their barriers and challenges (due to not wishing to admit failures and/or give away privileged information/insight). Where there is a willingness to share challenges or user needs, it is mainly around operational issues (HR, IT etc) and not in areas where there is or is perceived to be a competitive advantage.

Sector cohesion

There are a number of trade bodies, ministries and regulators that cover the property sector. This is in part due to the many different activities that take place over the property life cycle, the different asset classes in play and so on. However, to the outside world "property" is a homogenous sector, and innovators are increasingly exploiting the gaps between segments of the property lifecycle. Many of our participants felt it was both necessary and imperative for government and industry to start talking and thinking in a more unified fashion, to face up to and respond to the shared challenges and opportunities that technology brings.

Government: Many participants felt that government should be flying the flag more broadly for the sector and helping to drive innovation and productivity through incentives, standardisation and communication. This has happened in other industries (FinTech, building information modelling, digital technology). Championing technology within the whole property sector was considered to be a useful way of promoting productivity.

Participants noted that there were a lot of government departments and regulatory initiatives such as the National Infrastructure Commission, the Government Property Agency, and the Industrial Strategy, which should be better connected and aligned to the real estate sector so as to deliver greater efficiency and productivity for government and industry.

The government could help to create a more stable platform for investment in innovation in real estate by doing more to communicate and forecast its plans for investment in property and infrastructure. A number of participants suggested government could play a key role in public and market data standardisation and transparency. There were differences of opinion regarding the types of data that should be made more open and transparent to deliver productivity benefits and whether this should extend to having a role in standardising market data.

Industry: Almost all industry participants pointed out the complexity that is hidden within our property lifecycle diagram. There are many different stakeholders and asset classes across the property lifecycle, with conflicting ideas around the needs of buildings and how the sector could improve.

However, participants still came back to the point that the industry is "fragmented", "siloed" and "not innovative" and would benefit from greater cohesion and perhaps learning and taking inspiration from other sectors. The expression "that's how we've always done things" simply cannot exist anymore, nor is it as simple as telling a sector to change. The industry needs support in communicating and establishing "new norms" with curious partners.

A number of participants referenced sectors not bogged down in traditional ways of working and with a strong innovative approach to innovation, such as manufacturing, aerospace and automotive.

More cohesion across the property lifecycle was seen by some participants as essential in fostering more innovation. This does not necessarily require harmonious communication across the entire lifecycle, but it is important that the right data is being shared.

The power of an industry-wide language to serve as a shorthand to what the future will hold, would be valuable. The automotive industry uses "ACES" (autonomous, connected, electric, shared) which reminds them of their shared future, and, if they are not developing innovations with these themes in mind, they need to shift their direction. The property sector should consider adopting a similar common acronym to unify the sector.

Digital knowledge and skills

There is no shortage of opportunities for technology to improve the productivity of the real estate sector but one of the strongest themes from our interviews and roundtables was the patchy knowledge and skills in the sector of the fundamentals of digital technology and digitally-enabled business models.

Knowledge and culture: Participants were near universal in their assessment of the shallow level of understanding of the technical functionality of different technologies and their maturity. There is a need to educate the traditional real estate sector about what digital/technology can do but also about the new business models that technology is enabling.

Underpinning this may be a poor understanding of what data is and its potential uses across the sector. There is poor data capture by many real estate companies, and much of the data that does exist is unstructured and difficult to analyse without specialist skills. Too many hoard what data they have and seek to immediately monetise (even if it has little or no value when not connected to other data), with little evidence of good data-sharing within organisations let alone between them.

Sensor technologies are not new, but when deployed in a workplace to research and understand the current use and space efficiency, they can provide effective information on which to base future decisions. Yet there is still a common disparity between how users think buildings are being used and how they are actually being used. Whilst organisations such as Carbon Buzz and the Better Buildings Partnership are addressing this gap for sustainability performance, there are few examples of companies systematically understanding occupancy, performance and productivity.

It was evident that, whilst many of our participants were aware of BIM, there was scepticism about how knowledgeable people were and whether they were aware of the potential of BIM not only in construction but also in management and operation.

Skills: Most participants felt that across the sector there was a dearth of skills that would better enable the selection, development and deployment of digital technologies and business models to enhance productivity. There were diverse views on what the response should be, with some arguing for chief digital officers to become the new norm. Others felt this approach was insufficient and 'digital' needed to be mainstreamed within an organisation, much like the sustainability agenda has over the last 15 years.

Organisations should be seeking a wider set of skills and experience outside the traditional cohorts of surveyors and accountants, so that there is a broader understanding of the opportunities and challenges of digital through all levels of the property industry. Universities should be including more about the functionality and impact of digital technologies. By embedding a basic understanding of the functionalities of key technologies and digital business models early in someone's career, the sector as a whole could improve its productive adoption of new technology.

Conclusions and recommendations

There are structural, technical and cultural barriers to be overcome for the property sector to both reap the full benefits of digital transformation and to build resilience to withstand potential digital disruption.

Critically, there is no 'one size fits all' solution to digital transformation across a sector containing very different asset classes, legal and financial drivers. Many of our interviewees had diametrically opposed views about the actions that property companies should be taking.

There were, however, some clear trends that need addressing, specifically how might the property sector:

- **improve market information**
- **create a cohesive approach to championing innovation**
- **embed digital knowledge and foster innovative behaviours**

One way of addressing these challenge areas would be to ask companies in the 'traditional' property sector to adopt certain strategic initiatives and change their structures and behaviours; and for PropTech companies to better address user needs. This approach is well covered by other academic and consultancy-led reports into how individual actors in the property sector need to respond to the challenges and opportunities afforded by digital technologies.

Our recommendations are directed at how the sector as a whole should respond, particularly through umbrella bodies, central government and government agencies.

Improve market information

There is a dearth of clear, quantitative and authoritative information, from the needs of different users across the property lifecycle to the nature and type of technologies on offer to property professionals. It means that investment, buying and selling decisions are not optimised.

PropTech Library

The many different PropTech infographics, PropTech categorisations and media-driven awards are all an important part of raising awareness of the opportunities of technology in property. However, as the sector matures, there needs to be a more authoritative source for property sector buyers seeking innovation. A PropTech library of all current and emerging PropTech innovation, classified in line with the property lifecycle, user needs and technological drivers would be data-driven rather than self-selecting. It could potentially mirror what the Open Data Institute Leeds has done to map and understand the Internet of Things sector[17] by bringing together multiple different data sources, such as SIC codes, registration at meet-ups and patents, and then applying machine learning to structure the resulting information.

The data and structure generated from this work could be communicated in a number of ways, such as through best practice/peer learning websites similar to UKGBC pinpoint, but also embedded into platforms such as Built-ID, where property technologies employed in a building are communicated alongside the building architects, engineers and others. Having an open, complete database with current PropTech information will help developers adopt technologies applicable to their needs and apply industry best practice. Further, it will help PropTech entrepreneurs to market their offerings to a focused, targeted audience, lowering the marketing costs and improving their business development.
Recommendation: Develop a PropTech library of all current and emerging PropTech innovation, classified in line with the property lifecycle, user needs and technological drivers.

Property innovation index

The diverse nature of the property sector makes it possible for organisations to dismiss innovation going on in a different part of the sector as irrelevant to them. Equally, commercial sensitivities, real or imagined, make it difficult to accurately benchmark how innovative your company is. A property innovation index that assesses a company's capacity and preparedness for innovation/tech could overcome this. Assessment categories could include procurement, digitisation of assets/processes, digital skills and representation in governance/strategy. The index could allow for comparisons across different asset classes. This could mirror the approach of GRESB (The Global ESG Benchmark for Real Assets) in terms of environmental, social and governance benchmarking but for digital transformation.
Recommendation: Develop a property innovation index to assess a company's capacity and preparedness for innovation/tech.

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17   https://odileeds.org/projects/iot/

PropTech maturity index

Our research demonstrated that the hype naturally associated with the creation of a new market such as PropTech, combined with low levels of technical digital knowledge amongst many purchasing organisations, leads to an unclear understanding of which technologies might be implementable today and which are unlikely to deliver efficiency for a number of years.

A PropTech maturity index would give the market a clearer understanding of which innovations they should be adopting now, which to keep an eye on for the near future and which to dismiss today. The index could draw on the approach most famously demonstrated in the Gartner Hype Cycle or a more technical approach as exemplified by the EU-driven Smart Readiness Indicator.

Together, the property innovation index and the prop tech maturity index would help PropTech buyers identify the right companies to work with, based on their needs and situations. They would also help PropTech entrepreneurs find potential partners to improve their offerings, which will further benefit the development of the entire PropTech industry. **Recommendation: Create a PropTech maturity index to give the market a clearer understanding of which innovations they should be adopting now.**

Research priority technology needs

Many interviewees suggested that a lot of PropTech innovations were solutions in search of a problem and that technology was being developed without an understanding of who the customer was. Whilst this is a natural part of a market economy, with those companies displaying these characteristics likely to go out of business, the 'noise' created by these firms is not helpful in creating a more stable market. Regular user-needs research by the BPF with members and their occupiers would provide better information on priority needs. This would help PropTech entrepreneurs develop solutions that are responsive to the needs of the potential buyers, lower the risks and increase the commercial sustainability of the PropTech businesses, which will in turn help further the development of the industry. **Recommendation: The British Property Federation should undertake regular research on the priority technology needs of members and their occupiers.**

Create a cohesive approach to championing innovation

The different asset classes, actors, innovators and regulators across different segments of the property lifecycle lead to a disconnected and unclear response to the many shared challenges and future vision.

Shared language for property sector

A plain-language shared vision for the future property sector in the same vein as the McKinsey-coined ACES (autonomous, connected, electric, and shared)[18] framework for the future of the automobile industry could improve debate across the sector. The property sector needs a coherent way to talk about and champion change. One suggested framework might be SOAR (shared, outcome-focused, AI-driven, responsive). This would help bring key trends to prominence and provide a focus for professional development and lobbying efforts.**Recommendation: Create a plain-language shared vision of the future property sector.**

A regulatory sandbox

There was low-level and widespread reference to the thicket of different regulations and regulators as you move around the property lifecycle. A property sector regulatory sandbox could be set up, broadly following the model of the Financial Conduct Authority approach. It could involve the BPF, Royal Institute of Chartered Surveyors (RICS), Ministry of Housing, Communities and Local Government, UK PropTech Association and other key strategic organisations in initially mapping out the regulation and regulators across the property cycle. This could be combined with a short piece of research to understand the key perceived regulatory barriers for new and established property businesses. Should these activities create a case for regulatory innovation to support technological innovation, then government help could be requested. **Recommendation. The property industry, government and other key strategic organisations to set up a property sector regulatory sandbox.**

Establish a property passport

Data and information about built assets will play an increasingly important role in enabling innovation and creating more frictionless transactions across the property lifecycle. Whilst initiatives such as BIM will create more consistent asset information in the future, data about the mass of existing property will continue to be unstructured. Organisations such as RICS, the Centre for Digital Built Britain, BPF and BEIS should work together and with industry to develop a property passport. This would be a data standard for core information to be generated and maintained throughout the property lifecycle and for different users. This might include core asset, financial and building performance information, and could build on recent BEIS consultation on standards for smart systems and a flexible energy system. **Recommendation: The property industry and government to work together to set up a property passport with common data standards for core information.**

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18   https://www.mckinsey.com/~/media/mckinsey/industries/automotive%20and%20assembly/our%20insights/ electrifying%20insights%20how%20automakers%20can%20drive%20electrified%20vehicle%20sales%20and%20profitability/ how%20automakers%20can%20drive%20electrified%20vehicle%20sales%20and%20profitabilitymck.ashx

Consider productivity and wellbeing early

Much of our research revealed the challenge of fixed and immoveable property confronting technological and social innovation that was changing views about the function of the built environment. Designing and refurbishing for productivity and adaptability at the earliest stages of a project is an essential activity. However, data-driven digital innovation is focused on the later stages of the Royal Institute of British Architects (RIBA) Plan of Work[19] – a process followed by every architect and most construction professionals. BIM has a role to play in the future, but it is still seen as something for design and construction, not operation and management. The Centre for Digital Built Britain should work with the property industry, RIBA, the UK PropTech association and innovators in the field to enable architects to better consider productivity and wellbeing at the earliest stages of a building's design. **Recommendation: Centre for Digital Built Britain to work with industry, architects and innovators to improve consideration of productivity and wellbeing at the earliest stages of a building's design.**

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19   https://www.ribaplanofwork.com/

Embed digital knowledge and foster innovative behaviours

Our research uncovered scarce and unevenly distributed technical digital skills and a lack of a business innovation mindset across the property sector.

Put people with digital skills in influential roles

Whilst some property companies are beginning to recruit those with digital skills to board and entry-level positions, surveying and accountancy dominate middle and senior manager roles. We should develop a programme to place early career software developers, digital designers and innovators in roles in property companies, where they have an opportunity to influence strategy, procurement and delivery. These early career digital professionals will have the benefit of already having been immersed in digitally driven businesses with innovative business models, and none of the disbenefits of being schooled in the challenges and constraints of the property industry. **Recommendation: Develop a programme to place early career software developers, digital designers and innovators in influential roles in property companies.**

Leadership development course

The property sector needs to work together to ensure that the leaders of tomorrow are being schooled in technologically-driven change and business model innovation. The British Property Federation could create a leadership development course for emerging leaders, with modules including a comprehensive overview of the technologies driving digital innovation and the business models changing industries. **Recommendation: British Property Federation to create a leadership development course including a comprehensive overview of the technologies driving digital innovation and the business models changing industries.**

Open and challenge-based procurement

Procurement of new solutions varies across the sector according to asset class, type of solution required and so on. The lack of transparency in these processes is consistent. This closed approach to innovation, allied with the natural risk aversion and commercial sensitivity of much of the sector, means companies are not being exposed to the full range of solutions, and providers have limited access to their target customers. The BPF should work with its members to develop a programme of open and challenge-based procurements. There are plenty of models that could be emulated; CityMart, which helps to unlock opportunities for city authorities through procurement; Driven Data, which seeks data science solutions for social problems; and Kaggle, which hosts competitions on behalf of companies and charities to elicit insights from data. It will be important to select the right challenge areas where the potential technology solution is not related to any one company's unique selling point, where there are shared needs and ideally where no one company can afford to innovate on their own. A challenging but not impossible task. **Recommendation: British Property Federation to develop a programme of open and challenge-based procurements.**

Summary of recommendations

Improve market information

- Develop a PropTech library of all current and emerging PropTech innovation, classified in line with the property lifecycle, user needs and technological drivers

- Develop a property innovation index to assess a company's capacity and preparedness for innovation/tech

- Create a PropTech maturity index to give the market a clearer understanding of which innovations they should be adopting now

- The British Property Federation should undertake regular research on the priority technology needs of members and their occupiers

Create a cohesive approach to championing innovation across the property sector

- Create a plain-language shared vision of the future property sector

- The property industry, government and other key strategic organisations to set up a property sector regulatory sandbox

- The property industry and government to work together to set up a property passport with common data standards for core information

- Centre for Digital Built Britain to work with industry, architects and innovators to improve consideration of productivity and wellbeing at the earliest stages of a building's design

Embed digital knowledge and foster innovative behaviours

- Develop a programme to place early career software developers, digital designers and innovators in influential roles in property companies

- British Property Federation to develop a leadership development course including a comprehensive overview of the technologies driving digital innovation and the business models changing industries

- British Property Federation to develop a programme of open and challenge-based procurements

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Future Cities Catapult accelerates urban ideas to market, to grow the British economy and make cities better. It brings together businesses, universities and city leaders so that they can work with each other to solve the problems that cities face, now and in the future.

British Property Federation (BPF) is a not-for-profit membership organisation representing companies involved in property ownership and investment. The BPF works with Government and regulatory bodies to help the real estate industry grow and thrive, to the benefit of its members and the economy as a whole.

Appendix 1 – Technology across the property lifecycle

We analysed PropTech solutions within each segment. This does not cover applications being developed by traditional real estate companies themselves.

1. **Investment/financing:** Some popular FinTech concepts such as crowdfunding and P2P lending have been introduced to the real estate sector. New investment and financing instruments such as crowdfunding, P2P lending, market valuation tools, and online mortgage brokers have been developed to improve efficiency.

 - **Crowdfunding/peer-to-peer (P2P) lending platform:** Crowdfunding/P2P lending platforms create a channel for borrowers, whether they are property developers or buy-to-let investors, to borrow money from a wide range of investors, and meanwhile allow lenders to earn returns. There are already many players applying this new model in the UK property sector, such as BrickVest, Property Partner and Landbay.

 - **Market Valuation Tools:** Companies such as Propcision, RElalyse, and CoStar have collated different property datasets and developed analytical engines that could automatically value property, compute key fundamentals, and forecast potential capital and yield growth.

 - **Online mortgage broker:** Companies such as Trussle and Habito provide more efficient and responsive online mortgage broker services. Whether you are a first-time homebuyer, moving home or looking for remortgaging, these digital platforms instantly analyse mortgage offers from across a wide range of lenders in the market, and quickly match you with the most suitable mortgage and manage the application.

2. **Land Appraisal, Acquisition and Permissions:** Land acquisition is normally the very first task for new development, which marks the beginning of a property lifecycle. Generally, developers can purchase land from the open market or through any off-market contacts. Now developers can search and buy land from online marketplaces, or use land identification tools to discover land that meets specific criteria. To inform decision-making for land acquisition, there are now digital site appraisal tools available for land seekers to do land assessment more efficiently.

 - **Online land marketplace:** Compared to the variety in the online property marketplace, there are far fewer listing and searching platforms focused specifically on land. Plotfinder is one of the few online marketplaces targeted mainly on land. It allows landowners to post their land and developers and real estate developers to find and purchase it.

 - **Land identification tool:** The amount of on-market land available on publicised official or commercial channels, namely SHLAA or online marketplace, is insufficient to meet the need of the UK's housing target. To facilitate the exploration of new land opportunities, companies such as LandInsight, Nimbus Maps, and Datscha have developed efficient solutions for land identification. By collating a variety of property related datasets into a single platform, they enable land seekers to source ownership details and other land specific information instantly, and to contact owners of off-market land more easily.

- Site appraisal tool: Early appraisals of potential sites for a development is normally conducted by surveyors or consultants in a manual and time-consuming way. Envirocheck – part of Landmark Information Group – provides a digital solution to accelerate site appraisal by aggregating different sources of environmental and geospatial data into a single platform delivering more enhanced environmental site assessment reports to their client faster.

3. Planning/design: Planning and design are creative activities that decide what a property will look like and how it will be used in the future. From the collected list of UK PropTech companies, planning and design makes up the second largest group of PropTech solutions. There are a variety of solutions focusing on addressing different user needs in planning and design, which range from applications such as consultant searching platforms, 3D visualisation and management tools, 3D model and geospatial database, to planning application and public consultation tools.

- Consultant searching platforms: Built-ID was introduced in 2017 as an online platform and professional community that connects real estate developers with consultants. It allows different consultants to showcase their work online, and meanwhile enables potential clients to search and compare across different offers based on their needs and preferences.

- 3D modelling/interactive 3D visualisation tools: 3D modelling, particularly large-scale, has been a very important service for the urban planning and design industry. Virtual and augmented reality technologies are making traditional 3D design more immersive and interactive. Zmapping, Accucities and Vu.City are all large-scale 3D model suppliers in the UK. SenSat uses autonomous mapping drones to produce engineering grade real-world data in the context of a 3D map. Companies such as Lucid and Seeable visualise 3D designs with augmented and virtual reality and interactive 3D apps. For instance, they produce interactive 3D models of a building or an entire area that allow people to spin around, zoom in and click on the model to understand the design and access key information.

- City information modelling (CIM) platforms: Some companies have already started to apply the principle of building information modelling (BIM) to wider urban context and thus developed city information modelling platforms. Cityzenith has developed Smart World Pro, which allows users to consolidate BIM, computer aided design, construction and real estate, and geographic information system tools, documents, sensor feeds, and social media posts into one 3D data platform. Similarly, CIM Toolkit provides a platform that enables the input, management, and analysis of information-rich 3D urban models.

- Geospatial data/mapping tools: To do spatial analysis, planning consultants normally need to collect site-specific information from across various sectors and agencies. Esri's ArcGIS is the most comprehensive mapping and geospatial analysis software, which enables the development of other location intelligence tools. Online tools such as Magic Map and Landmark Information collate different geospatial datasets on a cloud platform, which enables planning professionals to access site-specific data instantly from a single platform online. And the mapping tools on those platforms allow users to layer and visualise different datasets intuitively. In this way, spatial analysis becomes easier and more efficient.

- Planning application platforms: Traditional planning application processes used to be paper-based and cumbersome. The introduction of solutions such as Planning Portal and iApply means most planning applications are now submitted online.

- Public consultation tools: A common issue for traditional public consultation approaches is the time and geographic constraints, which may easily result in low engagement and light-touch feedback. Now companies such as Common Place, Participatr, and Stickyworld have developed online consultation tools that allow for participation at any time from any location, allowing engagement of a wider range of audiences, covering even those hard-to-reach ones.

4. Construction: Construction is a costly, complex and labour-intensive element of the property lifecycle, which historically has been driven by very analogue approaches. Having been promoted by the UK government, building information management (BIM) has become the major source of innovation within the construction sector. A variety of project management tools and innovations have been developed for streamlining project management, facilitating collaboration, calculating costs and promoting modular construction.

- Project management tools: With various players involved, either on-site or in office, the management of a construction project can be cumbersome and inefficient. To reduce unnecessary administration and improve the efficiency of communication, companies such as Basestone and Keepsite have provided new solutions to streamline the management of construction projects.

- Building information modelling (BIM) platforms: BIM platforms integrate project information with 3D models and enable collaborative management across different stages of the property lifecycle. Since the UK government promoted the adoption of BIM from 2011, there are now a variety of BIM solutions in the market include 3D Repo and Dalux. These solutions normally combine project information and files with 3D BIM models, allowing information to be shared and viewed intuitively.

- Cost Estimation Tools: Cost estimation is at the core of development projects, which is important for contractors to win more profitable work and for developers to get more return on investment. In response to this demand, Nomitech has developed CostOS to provide more efficient and accurate cost estimation for development projects. Elecosoft provides Bidcon, which allows users to extract information instantly from a 3D model and import information from a wide range of sources.

- Modular/off-site construction solutions: Traditional on-site construction tends to be rigid, time-consuming and generating a lot of waste. Modular construction has thus been introduced as a new solution – buildings are pre-produced in "modules" under controlled plant conditions and put together on site, which is more flexible, efficient and eco-friendly. Nu Build's modular home-building solution allows clients to customise the building design and shape building materials into modules that will be fully fitted out and delivered to site for final assembly and construction. Wiki House initiates a modular building system designed for open digital manufacturing, which can be written as code and customised to its size and users.

5. Sales/leasing: Sales and leasing together have the biggest market value in the UK real estate industry. More than 50% of PropTech companies fall into this segment. Here are a variety of solutions, including online property marketplaces, online agents/brokers, as well as agency services such as agent matching platforms, digital marketing and remote viewing tools. There are also digital identity tools for tracking rental history, platforms for location information research, as well as new business models such as co-working and co-living space.

- Online property marketplace: Online property listing and searching platforms started to emerge in the UK in the early 2000s and have now become a dominant force in the property market. Zoopla and Rightmove are currently the most comprehensive and largest property portals in the UK. Other players include Realla, the UK's most complete commercial property sales and letting platform, Hubble, a commercial property letting platform focused on co-working and shared offices, Rentr, a one-stop letting platform for residential property, and Investorist, a B2B off-the-plan property sales platform.

- Online agent/broker: Most online agents have their own listing and searching website, but they may also make use of online marketplaces. Purple Bricks is an international online agent that uses its own listing and searching platform. YourMove is the UK's biggest single branded online estate agent, with the biggest network of local experts, and Instant Offices is the world's largest online office broking service. Housepedia created an artificial intelligence engine that enables searching through millions of property listings.

- Agent matching platforms: There are tens of thousands letting agents in the market, thus it is difficult for inexperienced landlords to find the right agents. In response to such demand, companies such as Houzen, Getagent and Go-offMarket have developed solutions to match landlords with ideal agents.

- Digital marketing tools: Unlike other categories that focus on specific types of solutions, digital marketing tools include various approaches that could generate more leads and help property agents grow their business. For instance, Valpal has developed technology that can capture and convert agents' website traffic into vendor and landlord leads, while Vaboo provides a service that gives renters access to perks/savings in exchange for feedback about their renting experience. Yomdel provides a fully managed 24/7 live chat service for estate agents, while Humley provides embedded 24/7 automated chat assistant service powered by artificial intelligence.

- Remote viewing tools: Property viewing used to be a very time-consuming activity for letting agents and landlords. 360-degree camera and virtual reality technology now make remote viewing possible. Eye SPY 360 and Vieweet have introduced easy-to-create virtual tour viewing services to the property sector, which enable tenants to view properties remotely at any time, saving agents and landlords a lot of time while allowing them to generate more leads. Eye SPY 360 provides an additional remote engagement function alongside its remote viewing service, which allows viewers to invite people to join the virtual tour and the online communication with the agent at the same time.

- Rental passports: Competition for good rental homes could be fierce, and it's not easy for agents and landlords to distinguish which tenant has a better rental history. Companies such as Canopy and Good2Rent allow tenants to create a digital rental passport to speed up the rental process.

- Location research platforms: Before moving homes, tenants and homebuyers would normally do some research about the location, on issues such as transport coverage, social infrastructure and safety, to inform their decision-making. To meet such demand, Property Detective and One Dome allow home-movers to get a complete picture of a property, street or neighbourhood instantly. Online property marketplaces such as Realla also provide property and market information search services.

- Co-working/co-living spaces: In response to the growing demand of more flexible working and living style, co-working and co-living has been introduced to the property market as a new business model. WeWork is growing its global network of co-working spaces that offer desks, office suites, or an entire headquarters to meet the requests of freelancers and small businesses. The Office Group provides offices of different sizes, co-working spaces and drop-in workspaces. The Cube is a co-working space in London, with a preference for renters who are interested in science, technology and design. The Collective allows residents to rent their own private apartments in London, but also share spaces and events.

6.   Property management

Property management is the most persistent activity throughout the property lifecycle, and most of the technological solutions focus on improving the security and efficiency of buildings, and the services to tenants and homeowners. They also include those focusing on building or tenancy management.

- Building monitoring tools: With the support of technologies such as IoT and data analytics, various companies have developed advanced building management solutions to monitor building performance and human behaviour. Fabriq provides a comprehensive platform that integrates existing building management systems and connects all kinds of data sources – digital equipment, meters and smart sensors – and allows property managers to track and run analysis in real time of all kinds, from energy consumption to air quality, wellbeing and productivity. Asset Mapping enables the integration and monitoring of all new and old data of any asset. OpenSensors uses sensors to track how every desk, floor, or building is used in real time and analyses the data on demand. Pavegen equips the floor tiles of a building with data transmitters to analyse movement patterns and generates energy from each footstep.

- Home management tools: While there are needs for tools to manage a whole building block, there are also demands from occupiers of each single property unit to better manage their homes. For instance, Chimni is developing an online tool that could aggregate all apps, services and online accounts (for example utilities, insurance) into a single, easy-to-use dashboard. Homeshift is a tool that enables households to set up and manage all kinds of bills from energy to internet, council tax and water bills in one place, whilst also offering lower-than-market energy and internet plans for them to save money.

- Tenancy management tools: When a property is rented out, it is normally still within the landlords and letting agents' responsibility to manage the whole tenancy, which could be very trivial but time-consuming. To facilitate and improve the efficiency of tenancy management, a variety of solutions have been developed to help ease the burden of landlords and agents. Sorbet is an all-in-one app for landlords and letting agents that automatically books appointments, chases reports and handles property maintenance requests. Heylandlord is a digital communication tool that simplifies the communication between tenants, property managers and landlords; TAP provides tenants with 24/7 access to property specific information; Inventorybase and Imfuna simplify property inventories and inspections with a mobile app and reports.

- Short-let management services: In response to the growing popularity of short-term letting platforms, typically Airbnb, there are now companies such as GuestReady and Airsorted that provide property management services for those who want to rent out their property for short terms but do not have enough time to handle trivial process.

- Home service marketplaces: [Plentific](), [Homyze](), and [Bizzby]() have developed online marketplaces to connect users with home professionals such as an electrician, handyman or cleaner.

 - Access management tools: For commercial property such as offices and hotels, managing the entry and exit of employees and visitors has always been an important issue. For businesses who still use traditional key or access, [Keyzapp]() has a simple-to-use software with smart fobs for easy issuing and tracking of keys. Kisi provides cloud-based access control systems that replace a traditional key with smart card or cell-phone.

7.   Fit-out/refurbishment: For new-built or rebuilt properties, fit-out work is needed to make interior spaces suitable for the new occupant, whilst refurbishment is necessary for the renewal and reuse of after years or decades of use. Although there are very few technology applications focusing specifically on fit-out/refurbishment, many of the above innovations can and are applied to the fit-out and refurbishment process.

 - Augmented space planning tool: Indoor space planning, such as the layout of desks within offices, encompasses complex decision-making such as functional and experiential considerations, building code requirements, and client expectations. Such activity is normally done manually based on human experience. Now some researchers from WeWork have developed [Augmented Space Planning Tool]() – a suite of procedural algorithms to automate desk layouts in commercial offices. These algorithms were benchmarked against 13,000 actual offices designed by human architects. They will enable indoor space planning tasks to be completed as well as a designer but in a much shorter time.

 - Cost calculation tool: The cost of refurbishment could easily get out of control without an estimated cost plan in advance and comparison of prices across different builders. In response to this, [1Roof]() has developed a cost calculation tool that could provide quick, accurate and affordable cost plans for home improvement. Architects, after uploading floor plans into the system, will receive an itemised breakdown. Invited builders' rates could be added and checked, and finally they will receive clear and comparable prices. Builders could also use the tool to generate detailed cost plans as quotes for potential clients. As they quote, the data feeds back into the system and continually updates the prices to ensure their accuracy.

  - 3D survey service: Before moving into the architectural design phase, it is important to conduct a spatial survey of the property to understand the current use of space. With the support of 3D scanning and modelling technology, [Seeable]() offers a rapid 3D survey service for refurbishment projects that enables surveying of up to 20,000 sq ft a day and pre-architectural design.

8.   Demolition/remediation: We have not found any demolition/remediation specific PropTech solutions.

Appendix 2 – PropTech company list

- 1Roof: https://www.1roof.com/
- 3D Repo: http://3drepo.org/
- Accucities: http://www.accucities.com/
- AcrGIS: http://www.arcgis.com/index.html
- Airsorted: https://www.airsorted.uk/
- Asset Mapping: https://www.assetmapping.com/
- Augmented Space Planning Tool: http://journals.sagepub.com/eprint/KumUk4AE8tsngPnqENDX/full
- Basestone: https://basestone.io/
- Bizzby: https://www.bizzby.com/
- BrickVest: https://brickvest.com/en/
- Built ID: https://www.built-id.com/
- Canopy: https://www.canopy.rent/
- Chimni: https://www.chimni.com/
- CIM toolkit: https://www.cimtoolkit.com/
- Cityzenith: https://cityzenith.com/
- Common Place: https://www.commonplace.is/
- CoStar: http://www.costar.co.uk/
- Dalux: https://www.dalux.com/
- Datscha: http://datscha.co.uk/
- District Technologies: https://www.district-tech.com/
- Elecosoft: https://www.elecosoft.com/
- Envirocheck: http://www.envirocheck.co.uk/
- Eye SPY 360: https://www.eyespy360.com/en-gb/
- Fabriq: https://fabriq.space/
- Getagent: https://www.getagent.co.uk/
- Good2Rent: https://good2rent.co.uk/
- Go-offMarket: https://go-offmarket.com/
- GuestReady: https://www.guestready.com/
- Habito: https://www.habito.com/
- Heylandlord: https://heylandlord.co/
- Homeshift: https://www.homeshift.com/
- Homyze: https://www.homyze.com/
- Housepedia: http://housepedia.net/
- Houzen: https://www.houzen.co/
- Hubble: https://hubblehq.com/
- Humley: http://humley.com/index.html
- iApply: https://iapply.co.uk/
- Imfuna: http://www.imfuna.com/let-uk/
- Instant Offices: https://www.instantoffices.com/en/gb
- Inventorybase: https://inventorybase.co.uk/
- Investorist: https://investorist.com/
- Keepsite: https://www.keepsite.com/
- Keyzapp: http://www.keyzapp.com/
- Kisi: https://www.getkisi.com/

- Land Insight: http://www.landinsight.io/
- Landbay: https://landbay.co.uk/
- Landmark Information: https://www.landmark.co.uk/
- Lucid: http://lucidenvironments.com/
- Magic Map: https://magic.defra.gov.uk/
- Nimbus Maps: http://nimbusmaps.co.uk/
- Nomitech: https://www.nomitech.eu/
- Nu Build: https://www.nubuild.co.uk/
- One Dome: https://www.onedome.com/
- OpenSensors: https://www.opensensors.com/
- Participatr: http://participatr.co.uk/
- Pavegen: http://www.pavegen.com/
- Planning Portal: https://www.planningportal.co.uk/
- Plentific: https://plentific.com/
- Plotfinder.net: https://www.plotfinder.net/
- Propcision: http://propcision.com/index.php
- Property Detective: https://www.propertydetective.com/
- Property Partner: https://www.propertypartner.co/
- Purple Bricks: https://www.purplebricks.co.uk/
- Realla: https://realla.co/
- Realyse: https://realyse.com/
- Rentr: https://www.rentr.co/
- Rightmove: https://www.rightmove.co.uk/
- Seeable: http://seeable.co.uk/
- SenSat: https://www.sensat.co.uk/
- Sorbet: https://www.sorbethq.com/
- Stickyworld: http://info.stickyworld.com/
- Tenant Assistant Program (TAP): https://tap-in.co.uk/
- The Collective: https://www.thecollective.com/
- The Office Group: https://www.theofficegroup.co.uk/
- TheCube: https://www.thecubelondon.com/
- Trussle: https://trussle.com/
- Vaboo: https://vaboo.co.uk/
- Valpal: https://www.valpal.co.uk/
- Vieweet: https://www.vieweet.com/
- Vu.City: https://vu.city/
- WeWork: https://www.wework.com/
- Wiki House: https://wikihouse.cc/
- Yomdel: https://www.yomdel.com/
- YourMove: https://www.your-move.co.uk/
- Zmapping: http://zmapping.com/
- Zoopla: https://www.zoopla.co.uk/

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