UNIVERSITY OF OXFORD

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Oxford Future of Real Estate Initiative

University of Oxford Research

The future of real estate occupation: Issues

THE FUTURE OF REAL ESTATE OCCUPATION: ISSUES

This report is intended as a thought piece to precede future empirical research. It has been compiled using solely external sources (see references), and does not contain any original research. We thank those whose research has contributed to this report; any stated opinions and any remaining errors are our own.

The Oxford Future of Real Estate Initiative at the Saïd Business School is led by Professor Andrew Baum and is a collaboration between Oxford academics and industry-leading organisations: Arcadis, BCLP, CBRE, EY, Grosvenor, Nuveen, Redevco, The Crown Estate and UBS. Our research is grounded in real-world business questions. To find out more about the Initiative, or to read our other research, please visit our website at: https://www.sbs.ox.ac.uk/research/oxford-future-real-estate-initiative.

Any reference to specific companies or organisations does not constitute a recommendation and is included solely for illustrative or case study purposes. We welcome reader feedback and comments, which can be sent to us via e-mail at realestate.reports@sbs.ox.ac.uk

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1. Introduction

The average human adult will spend a third of their life at work, more than any other activity, including sleeping. Research within the built environment appears to have ignored this fact, largely ignoring the end user of a space and focussing more on the environmental and financial impacts of any project, policy or investment.

Meanwhile, key studies sourced outside the built environment community have concentrated on the impact of job satisfaction on an individual's wellbeing. For years science has catalogued what we should put in our bodies; now interest has turned to what we are putting our bodies in.

Why, when we book a short holiday, do we scour numerous comparison websites, enabling us to select the features of the hotel we require, read through numerous reviews, and browse photos and nearby attractions, before ultimately relying on customer satisfaction scores and comparative costs to determine in which specific room, in which specific property, we would like to reside for a long weekend, when the buildings we work in every day, sometimes for decades on end, go without such scrutiny?

This tide may be about to change. Thanks to the rise of *space as a service* models of real estate occupation, which put user experience at the core of their operations, far more is being written about the end users of space, or customers and what, if anything, landlords can do to enhance the productivity or social sustainability of any given asset.

In the digitally connected society we live in, increasing attention needs to be paid to the changing nature of work, the changing demands of individuals and the changing requirements of occupiers. "Location, location, location" is now challenged by "location, experience, analytics". This report will explore why this new mantra will begin to hold increasingly true.

Through gathering together much of the thought leadership written about this current 'workplace revolution' we aim to present an overview of the impact the office environment can have on an individual employee's satisfaction, wellbeing and productivity, and how that is likely to forever change the market for commercial real estate. In doing so we will raise questions which remain to be answered.

In an attempt to begin to answer some of the major questions we present in this paper, we develop a framework through which we can analyse the connection between buildings and occupier satisfaction. This will be of value to investors, as these buildings are expected to deliver a premium as the market begins to reflect the importance of workplace wellbeing in rents and prices. It will also offer invaluable insights for heads of real estate at occupier firms, to help identify which offices will best suit their corporate strategy.

2. A market in transition

There are four major drivers changing in the way we will use business space. These are climate change and carbon management; co-working; digital data, worker performance and smart buildings; and transport technology.

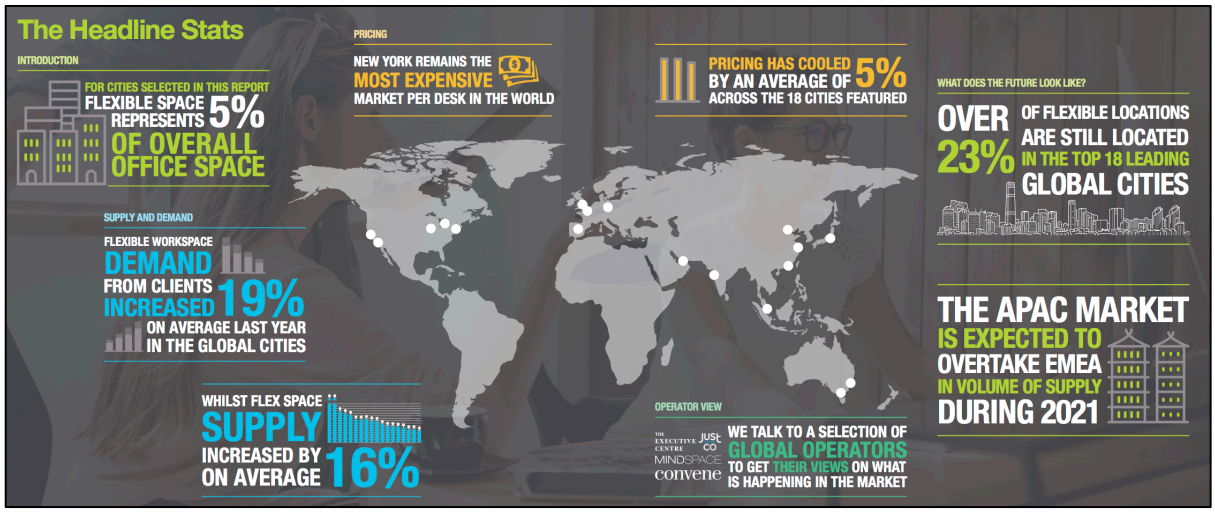
Climate change and carbon management

The World Green Building Council requires all new buildings to achieve net zero carbon by 2030, while all existing buildings will need to meet net zero carbon standards by 2050 (WGBC, 2018). This has prompted a transition phase for the commercial office market. By law, any building falling short of this target will require a significant retrofit and an upgrade to its existing operational systems. Given that it is estimated that in 2050 70-80% of current UK buildings will still be in use (Adams, 2019), and with around 18% of commercial real estate in England and Wales not even meeting current minimum energy efficiency standards (JLL, 2019a), the next thirty years is set to see an overhaul in the demand and subsequent provision of office space.

Co-working

This pressing need for green upgrades of existing offices has coincided with a time of cultural change driven by technology and the changing nature of work, with wellness at work becoming a buzz phrase. The average workstation in Central London costs £17.5k pa, yet the average desk utilization rate is now only 45%. In a typical London office containing 500 workstations, that represents as much as £5m a year wasted on rent alone (Stanton, 2019). Reducing or repurposing this disused space can help to produce enhanced tenant wellbeing through offering amenities such as break out areas, crèches or gyms.

Figure 1: global flexible office market headlines

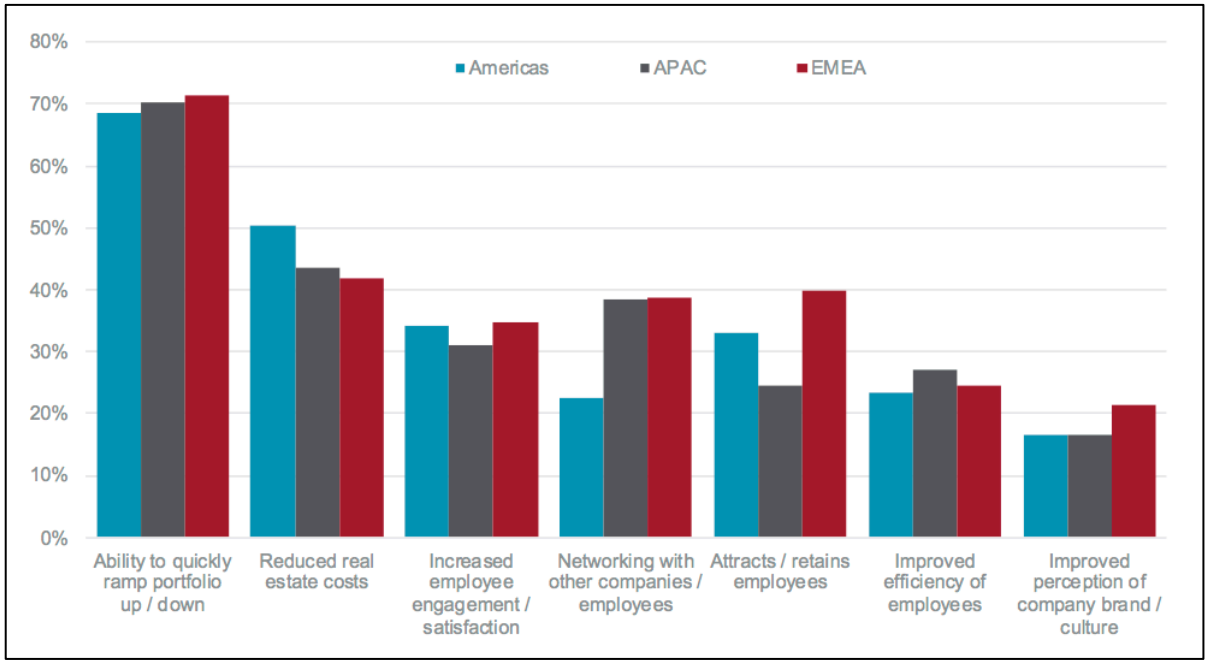


Source: Instant Group, 2019

This model of space arbitrage has been best commercialised by the co-working brand WeWork, whose (albeit now curtailed) growth has been bolstered by the changing requirements of both SMEs and corporates for shorter leases in order to facilitate unpredictable scaling and outsourcing in a time when the very nature of employment itself is uncertain and unpredictable (WEF, 2018). *"Driven primarily by rapid digitalization, the very nature of how, when and where we work is changing. And so too (is) the role that our workplaces and buildings play in that dynamic"* (Curtis, 2019). Such is the scale of this transition that while in 2012 there were an estimated 2,000 co-working spaces globally, by 2019 that figure had grown to about 18,000, with a new co-working facility opening its doors in New York every 7.5 days (Diduch, 2020).

Co-working space comprises 5% of all US office space as at 2020, but the number of global co-working spaces is projected to double to 36,000 by 2025 (Diduch, 2020) and JLL (2019b) predicts that 30% of all US office space will be operated under a flexible lease or space-as-a-service model by 2030. Deloitte (2018) suggests that over 50% of surveyed professionals are looking to increase property investments with a flexible lease in the near term.

Figure 2: the benefits of implementing co-working



Source: Cushman and Wakefield, 2019

The major risk facing all space-as-a-service providers is how they will maintain revenue during an economic downturn (Fiorilla, 2018). While tenants value short-term flexibility, long-term leases protect the landlord. Small businesses and start-ups, the most common occupiers of co-working spaces, are the first to fail during recessions, while entrepreneurial workers can opt to work from home. Large corporations would also likely opt to terminate co-working leases when belts need to be tightened, as happened to pioneer Regus in the early 1990s. The industry has grown during the long economic recovery and certainly will be tested the next time the economy dips, with the 2020 COVID-19 pandemic presenting the immediate present challenge.

Much has also been written about the collaboration encouraged within shared office spaces. Collaboration is defined as the share or exchange through peer-to-peer based platforms of such intangible assets as skills, expertise, innovation and user experience. In a 2016 JLL poll, 74% of respondents indicated that "*thinking, talking, and brainstorming create the most value for an organisation. In response, companies are turning to alternative workplace solutions such as co-working to encourage collaboration"* (JLL, 2016). However, a collaborative workplace not only depends upon its tenant mix, but also upon its design. Researchers have shown that people in open offices take nearly two-thirds more sick leave and report greater unhappiness, more stress, and less productivity than those with more privacy. A 2018 study by Harvard Business School found that open offices reduce face-to-face interaction by about 70% and increase email and messaging by roughly 50%, shattering the notion that they make workers collaborative (Schwab, 2019).

The changing cultural demand for shorter leases, smaller spaces and enhanced collaboration has driven the occupier markets closer towards the customer-centric model found in hospitality, where a positive or negative user experience is capable of being publicised by platforms such as Trip Advisor.

With shorter contractual obligations comes increasing choice. The end user of the space is now able to leave without penalty if that space does not meet expectations or requirements. Accordingly, managers of flexible space have begun to compete by offering more amenities, often including a host of unnecessary luxuries as a part of their service offering (free beer at WeWork, for example).

However, very little information exists on which of these 'essential luxuries' increases occupier productivity and rent, and which deliver little or no financial or social benefit. Soon, shared data will begin to reveal which of these offerings are regularly used by employees and have a positive impact on workplace performance, and which are simply window dressing. This distinction will be reflected in price, as the productivity effect of a positive user experience within a space becomes further understood and a return on investment for the (dis)inclusion of each additional service or amenity will be visible through the introduction of 'smart building' technologies.

Digital data, worker performance and smart buildings

Adding to climate change and workspace productivity, the third emerging challenge to the current office market status-quo is the availability of digital data and its use in measuring worker productivity and applying this knowledge to so-called 'smart buildings'. A host of PropTech start-ups, with an ever-increasing capacity to understand the behaviour and preferences of occupants within a smart building environment, is enabling the collection, analysis and actioning of increasingly novel and granular data sets.

Matescu and Nguyen (2019) highlight four broad applications emerging from such exercises. These are:

- Prediction and flagging tools that aim to predict characteristics or behaviours of employees or that are designed to identify or deter perceived rule-breaking or fraud. Touted as useful management tools, they can augment biased and

discriminatory practices in workplace evaluations and segment workforces into risk categories based on patterns of behaviour.

- Apps designed to collect biometric and health data of workers through tools like wearables, fitness tracking apps and biometric timekeeping systems as a part of employer-provided health care and workplace wellness programs.

- Remote monitoring and time-tracking tools used to manage workers and measure performance remotely. Companies may use these tools to decentralise their activities and lower costs by hiring independent contractors, while still being able to exert control over them with the aid of such tools.

- Gamification and algorithmic management of work activities through continuous data collection. Technology can take on management functions, such as sending workers automated 'nudges' or adjusting performance benchmarks based on a worker's real-time progress, while gamification renders work activities into competitive, game-like dynamics driven by performance metrics.

These apps and the data driving them will tell us a lot about how work is performed and buildings are being used, which will soon change how we think about the design, construction, finance and valuation of real estate assets. Understanding the drivers of occupier productivity will become essential for any real estate owner or operator.

Transport technology

As the time-distance-space relationship begins to change through the development of new transport and digital connectivity solutions (and as carbon management simultaneously forces the abandonment of vehicles using fossil fuels), physical location may become less important for many businesses and workers.

Historically, teams of colleagues had a need to locate in similar locations in order to function effectively as a working unit (the drivers being industrial agglomeration in the 19th and early 20th centuries; and knowledge agglomeration in the late 20th and early 21st centuries). However, with the ongoing development of the internet and cloud computing in the last 10 years, digital connectivity breakthroughs have facilitated more efficient remote working. This has placed less emphasis on the need to co-exist in one physical location as documents can be accessed from anywhere in near real time and video conferencing is now a standard feature of most organisations. With the rise of immersive AR and VR technologies, this trend is set to continue.

As we are able to reach destinations with less friction and in less time, the need to co-locate become less apparent. The invention of the elevator had a huge impact on office design and the shape of cities. How might emerging technologies such as drones, autonomous vehicles, hyperloops and commercial space flight affect where we chose to locate our offices and how we chose to design them in the future?

The COVID-19 Pandemic

The final major driving force in the office occupier market was not imagined at the outset of this report, but is likely to reduce the attractiveness of a centralised workplace

for a 9-5 workforce for some time to come. The global COVID-19 lockdown has resulted in the world's largest-ever working from home experiment, and has accelerated many of the trends which we will cover throughout this remainder of this report. At time of writing, it is too soon to say with any confidence whether employees will return to work as normal. However, there is much talk of the potential impact in the market, with some commentators predicting a decline in prime office occupation of up to 50% across the next 5 years as a result of the accelerated cultural acceptance of working from home, coupled with the developments in digital connectivity technologies such as VR. Could we be ringing in a new era, that of 'the virtual workplace'?

Re-framing the workplace

Krekel, Ward and De Neve (2019: 18) undertook a literature review to provide evidence for re-framing the workplace:

"Bloom et al. (2015) conducted an experiment on flexible work practices at a NASDAQ listed Chinese travel agency with more than 16,000 employees, in which call centre agents (who volunteered to participate in the experiment) were randomly assigned to either working from home (the treatment group) or working in the office (the business-as-usual control group) for a period of nine months. The authors found that, at the end of the experiment, call centre agents who were working from home experienced fewer negative and more positive emotions, less exhaustion, and reported a higher overall life satisfaction compared to call centre agents who were working in the office.

Importantly, working from home also led to a 13% increase in performance, of which 9% was due to working more minutes per shift (attributed to fewer breaks and sick days) and 4% due to taking more calls per minute (attributed to a quieter working environment); staff turnover halved. After the success of the experiment (the company estimated to save about USD 2,000 annually per call centre agent working from home), the scheme was rolled out for the entire workforce (including giving workers who participated in the experiment the opportunity to change their working location again). This change almost doubled performance gains, to 22%, stressing the importance of selection and learning of workers about their own working preferences and styles.

Two other studies on flexible work practices stand out. Moen et al. (2011) examined the causal effect of switching from standard to more flexible, results-oriented working time at Best Buy, a large US retailer. By exploiting the staggered implementation of the scheme in its corporate headquarters, the authors found that staff turnover amongst employees who were exposed to the scheme dropped by 45.5% eight months after implementation. More flexible work practices also moderated turnover effects of negative home-to-work spill overs (i.e. when responsibilities at home reduce the effort employees can devote to their jobs).

In a related study, however, Moen et al. (2016) showed that a similar organisational intervention – aimed at promoting greater employee control over working time at an IT company – reduced burnout, perceived stress, and psychological distress, while raising job satisfaction (with benefits larger for women) twelve months after the intervention. Taken together, both studies suggest that organisational interventions aimed at raising employee wellbeing, for example, through raising employees'

autonomy over their working time, bear positively upon performance outcomes at the aggregate firm level – a win-win situation for both employees and employers."

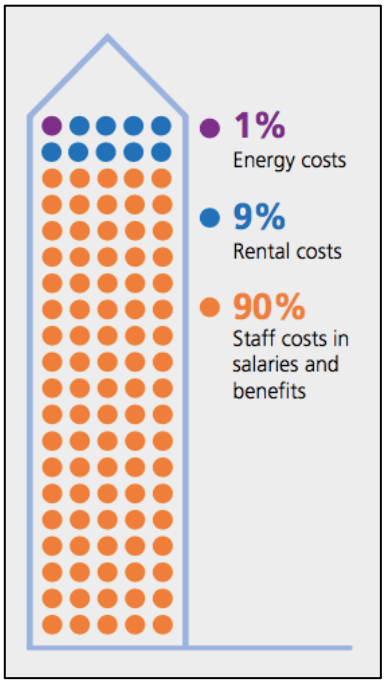
The successful business space owner or operator of the next 10-20 years will understand the impact of climate change and carbon management; the drivers of co-working, flexible working and working from home; the uses of digital data to measure or improve worker performance and develop smart buildings; the impact of transport technology; and the cultural impacts of a global health pandemic. This will be a very challenging period for office investors who rely on long leases and prime locations to manage their risk.

3. The user-centric revolution

In order to stay competitive in the evolving office market, it should go without saying that delivering occupant satisfaction and productivity will become increasingly important. (The fact that it may need saying illustrates the way in which landlords have been protected by long triple net leases, especially in the UK.) To retain existing customers and attract new occupiers will require provision of the best possible experience within any space. Identifying individual preferences within the building and curating a workplace which best suits differing needs will probably rely on the data obtained through smart building technologies. New job functions such as 'head of workplace' or 'community officer' are increasingly being designed to give accountability over these ever important experiential factors. However, this concept is nothing new. Wrennall (1999) called for the creation of a new "productivity scientist" role, whose purpose would be to look beyond cost reduction methods, and more towards how office environments can add value to organisations.

Companies do not want an office, they want a productive workforce. The World Green Building Council (2014), for example, states that for a typical business operating costs are 90% staff, 9% building rent and 1% energy bills. Even a small improvement in employee health, productivity or satisfaction is likely to represent a significant financial gain for employers, far above that of any savings on rent and certainly more important than energy costs. This is supported by the British Council for Offices (2017), who state that an effective strategy for delivering a productive workplace is likely to be the single most important contribution that property professionals can make to the success of their organisations, noting how a business could legitimately increase its property costs by 10% if this delivered a 1% improvement in employee productivity (BCO, 2017: 9).

Figure 3: typical business operating costs



Source: World Green Building Council, 2014

Despite this renewed awareness, Weatherhead (1997) argued that with staff costs in the region of 70-80 per cent and real estate costs approximately 20 per cent, then a relatively small increase in productivity is greatly more beneficial than a small reduction in real estate costs. So why, 23 years later, do we find ourselves repeating the same discussion on the importance of increasing occupant productivity?

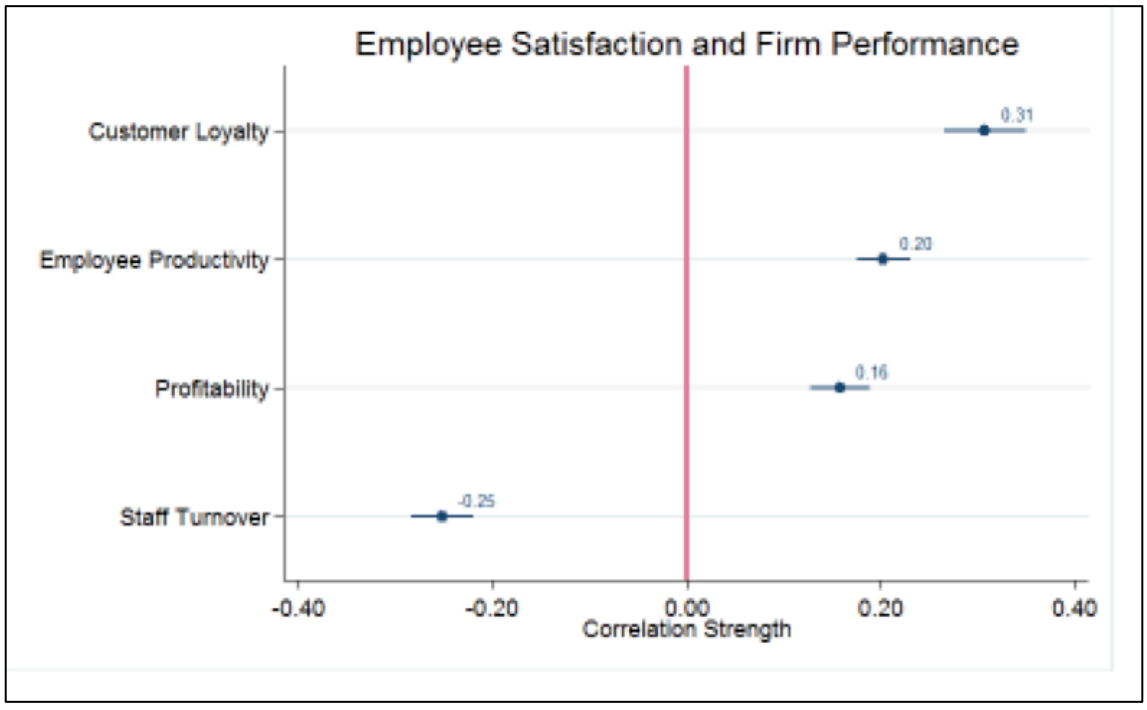
Measuring productivity

Any strategy for increasing occupant productivity naturally connects with employee satisfaction. Edmans (2011) studied the relationship between employee satisfaction and long-run stock returns using a value-weighted portfolio of the "100 Best Companies to Work for in America". He found that between 1984-2009 those companies listed in the top 100 delivered positive alpha and earned 2.1% higher stock returns than the industry average and had more positive earnings surprises and announcement returns.

It should therefore hold true that workplaces which are better able to demonstrate that they increase individual employee or organisational productivity, or satisfaction, should fetch a market premium. However, measuring and attributing the increase in productivity provided by each additional service or amenity within any given office space has proved difficult.

Currently, the wellbeing of an individual in a space is best measured through self-reporting. Traditionally, this has been through occupier surveys, such as the Leesman and Gallup occupier surveys, or the BUS Methodology from ARUP, which ask individual employees to rate the quality of their surroundings and amenities, and report on how productive they feel.

Figure 4: the organisational benefits of increasing employee satisfaction



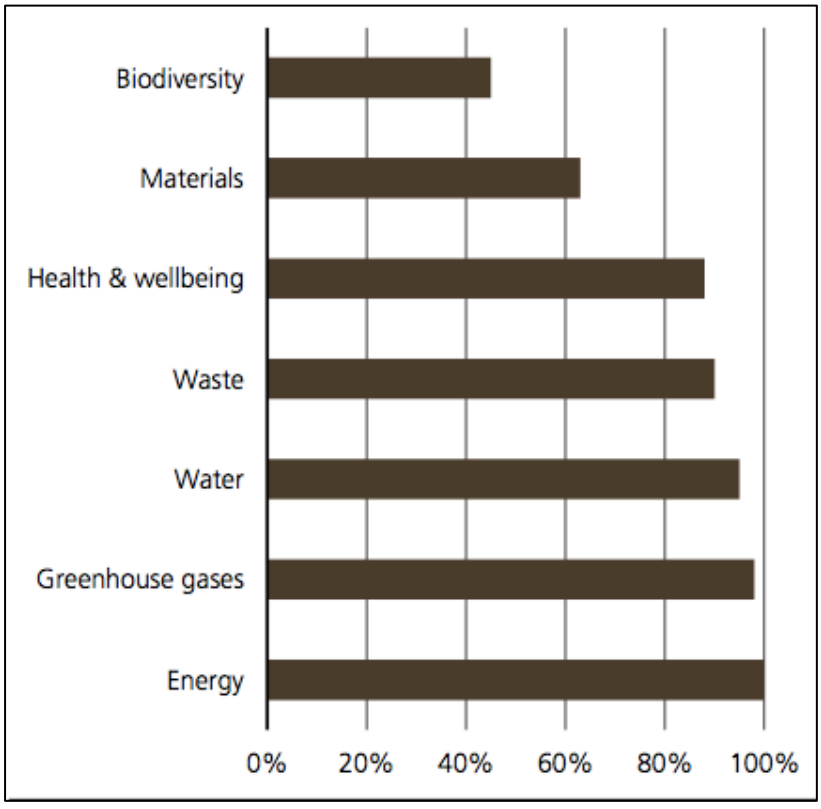
Source: Krekel, Ward and De Neve, 2019

Krekel, Ward and De Neve (2019: 13), used the data obtained from the Gallup occupier survey database to conduct a study on a sample of over 1.8m employees from over 82,000 individual firms. Figure 4 reveals their findings: that customer loyalty, employee productivity and firm profit were positively correlated with employee satisfaction, while staff turnover shows significant negative correlation. Ultimately, they show how higher wellbeing at work is positively correlated with more business-unit level profitability.

A follow up study attempted to produce more empirical evidence for employee satisfaction increasing individual productivity, through assessing the performance of call centre workers. This was made possible through their easily measurable individual work output and KPIs, specifically the amount of time spent on the phone and the number of calls and sales undertaken by each employee. Bellett, De Neve and Ward (2019) find that, on average, workers made around 13% more sales per week when they reported being happy compared to when they are unhappy (although the direction of causation could be disputed).

However, critically, both of these studies fail to measure the impact of the working environment on employee satisfaction. Given that there is a strong link between employee satisfaction and both individual and firm performance, there is a need to better understand how to produce spaces which can facilitate satisfaction. However, Hoffer (2020) found that at present, real estate asset managers are primarily concerned with the environmental sustainability of their assets, with “health and wellbeing” only registering 5th on the list of most asset managers’ ESG considerations.

Figure 5: asset managers’ ranking of ESG issues

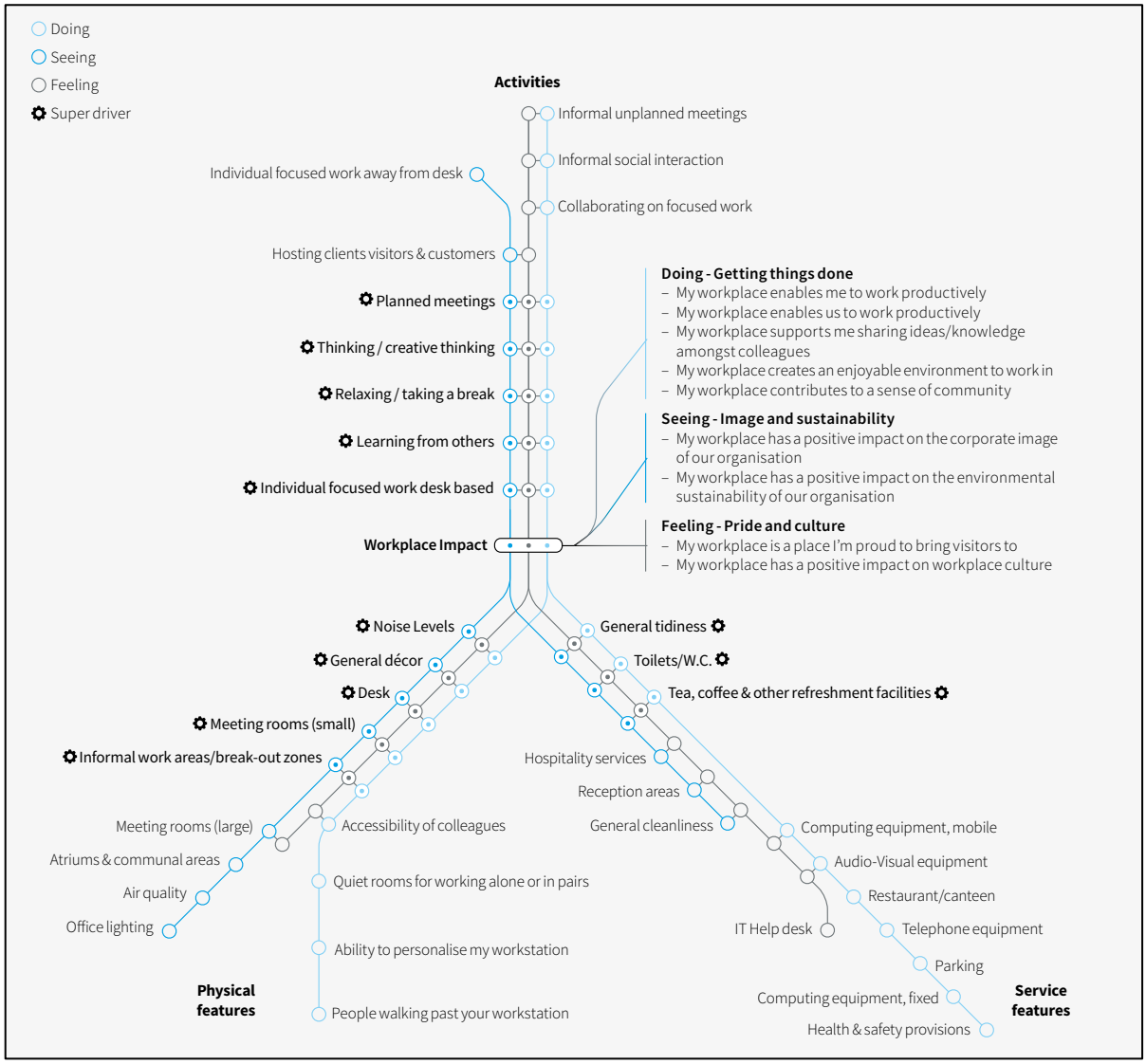


Source: Hoffer, 2020

However, perhaps this may be set to change: ULI (2019) found that 86% of real estate investors, developers, fund managers, consultants, valuers, and analysts surveyed expect their investment in wellbeing to increase in the next three years.

Leesman (2018). has begun to empirically unveil the drivers of workplace satisfaction. By correlating the quality of office services and amenities with self-reported satisfaction scores across 400,000 employees and 30,000 offices, Leesman has been able to identify 13 'super drivers' of employee satisfaction. These are: individual work, relaxing and taking a break, learning from others, thinking, planned meetings, noise levels, general décor, individual desk provision, small meeting rooms, informal work areas/break-out zones, general tidiness, tea/coffee and other refreshment facilities, and toilets. In offices where employees are highly satisfied with the quality of these 'super drivers', they tend to also rate their overall workplace satisfaction highly.

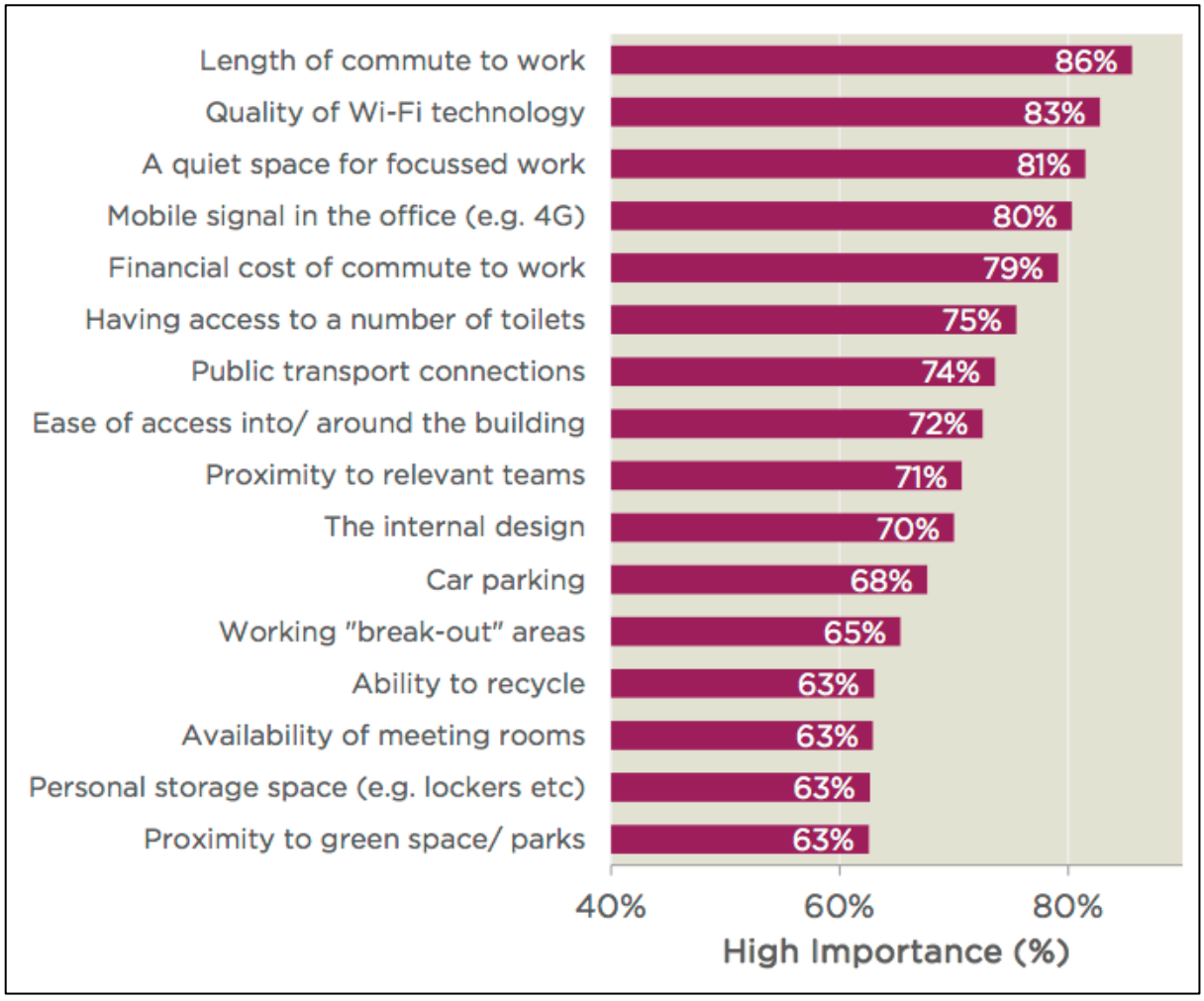
Figure 6: the Leesman drivers of workplace satisfaction



Source: Leesman, 2018

A similar attempt was made by Savills (2019), which surveyed 11,000 European office workers to determine what mattered most to them, revealing the importance of office location, an aspect overlooked by most occupier surveys. 86% of workers cited the length of commute as the most important factor for their ideal workplace. 61% of respondents would not add more than 15 minutes on to their commute each way for their ideal workplace, with 16% of these not willing to add on any time at all to their commute. Additionally, only 60% of workers with commutes under 15 minutes expect to move jobs within the next five years, against 78% of those who have commutes in excess of an hour.

Figure 7: the importance of workplace factors, Europe



Source: Savills, 2019

Sanderson and Edwards (2016) find that the aspects with most impact on occupiers' satisfaction are the office building itself, its location and amenities, and also communication with their property manager, a belief that their business needs are understood and the property manager's responsiveness to occupiers' requests. Occupiers' loyalty depends mainly upon feeling that their rent and service charges provide value for money, an amicable leasing process, the professionalism of their property manager and the Corporate Social Responsibility of the Landlord.

Critically, none of these occupier surveys take into account the variations which exist in workplace specification. For example, one would expect a newly refurbished office, fitted with premium amenities, to produce higher satisfaction scores. There is also a large element of overall employee satisfaction which exists within an individual's job satisfaction (Judge et al., 2001) and salary (Lazear, 2000) which is also unaccounted for. This is supported by Bellett, De Neve and Ward (2019), who find that strong enough extrinsic motivations may limit the scope of unhappiness on performance. Critically these organisation-specific variables are also by no means straightforward to define or measure.

Start-up The Centric Lab uses neuroscience studies to isolate the impact of the physical environment on an individual's satisfaction and productivity. Through identifying performance-inhibiting stress factors in any given location, they aim to propose a roadmap to increase building productivity through addressing each negative contributor in turn. No empirical results are as yet available.

Perhaps the most obvious way of empirically measuring the financial impact of high performing workplaces on a tenant's organisational performance is through HR, with employee absenteeism and retention data. Attema et al. (2018) highlight the financial benefits accrued by improving occupant wellbeing through the resultant reduction in employee absenteeism due to sickness and an increased employee retention rate, leading to fewer lost working hours spent re-training new staff. A hypothetical 820-employee company occupying a 150,000 square foot space can gain $3,395 per employee (or $18.56 per square foot) in annual profit. This is an NPV of $21,172 per employee, or $115 per square foot, over ten years, assuming a conservative $20 per square foot cost premium paid for a high performance building. However, these are largely measures of time saving, and not actual productivity or satisfaction.

John and Pury (2017) provide the most conclusive evidence for a link between the performance of the workplace and the financial value of the asset. Through correlating Gensler's Workplace Performance Index (a post-occupancy survey of Gensler's fit outs, incorporating measures of workplace focus, collaboration, learning, and culture) with online data provider CompStak's figures for effective rents across a sample of 1337 Manhattan office leases, they were able to show how those assets which scored highly on the Workplace Performance Index command an average effective rent premium of 28.73%. However, this study does not reveal the drivers of workplace design that correlate with productivity or satisfaction, and thus value. For that, one needs to look towards laboratory studies which aim to measure an employee's biological response to his or her physical environment.

Allen et al. (2016) found that, on average across 24 participants, cognitive scores were 61% higher in a 'green' building environment, with a low concentration of CO_2, than in a conventional building, where concentrations of CO_2 were more representative of the typical US city office. An HVAC control strategy which utilizes real time occupancy monitoring can reduce damaging CO_2 levels within an office, offering wellbeing and productivity benefits to individual employees.

A literature review of similar studies, unveiling the impact of high performance buildings on occupier productivity, was undertaken by The British Council for Offices

(2017: 10). While this study does not attempt to measure financial returns, it identifies the impact of individual environmental factors upon productivity (see Figure 8).

Revisiting the World Green Building Council 90:9:1 model of occupier cost, the average productivity gain of 2.7% obtained through improving workplace conditions represents the equivalent of an occupier saving twice their energy bill or reducing their rent by 25%. However, again, this study provides no data describing how much each of these retrofits will cost, so we cannot measure their financial effectiveness.

It is clear that while many studies exist which purport to identify increases in productivity caused by a number of comparative building factors, none are able to produce a clear financial metric upon which real estate investment decisions can be executed.

Figure 8: the impact of workplace factors on productivity

Factor	Number of studies reviewed	Average weighted impact on productivity (%)
Lighting	17	1.1
Noise	10	1.4
Temperature	16	1.2
Ventilation	16	1.4
Control	10	1.2
Furniture	8	2.1
Space	3	3.5

Source: BCO, 2017:10

It is safe to assume that for a closed and highly specific job such as that undertaken by call centre workers, those offices which maximise satisfaction will likely produce a more productive workforce. However, this type of repetitive and easy to measure work output is not as easy to quantify in the majority of job roles, making any claims about the workplace increasing employee productivity more difficult to support. How, for example, can we begin to imagine an indicator which can capture the productivity of chance 'water cooler conversations', and how do we begin to generalise the optimal office design with many different occupier types and varying job requirements, producing contrasting sets of spatial requirements, within any one floorplate? A study in Harvard Business Review found that one face-to-face conversation is more successful than 34 e-mails back and forth (Axworthy, 2020). We also state the caveat that closed, highly specific, repeatable job functions are those most likely to succumb to future automation, rendering the workplace environment largely inconsequential.

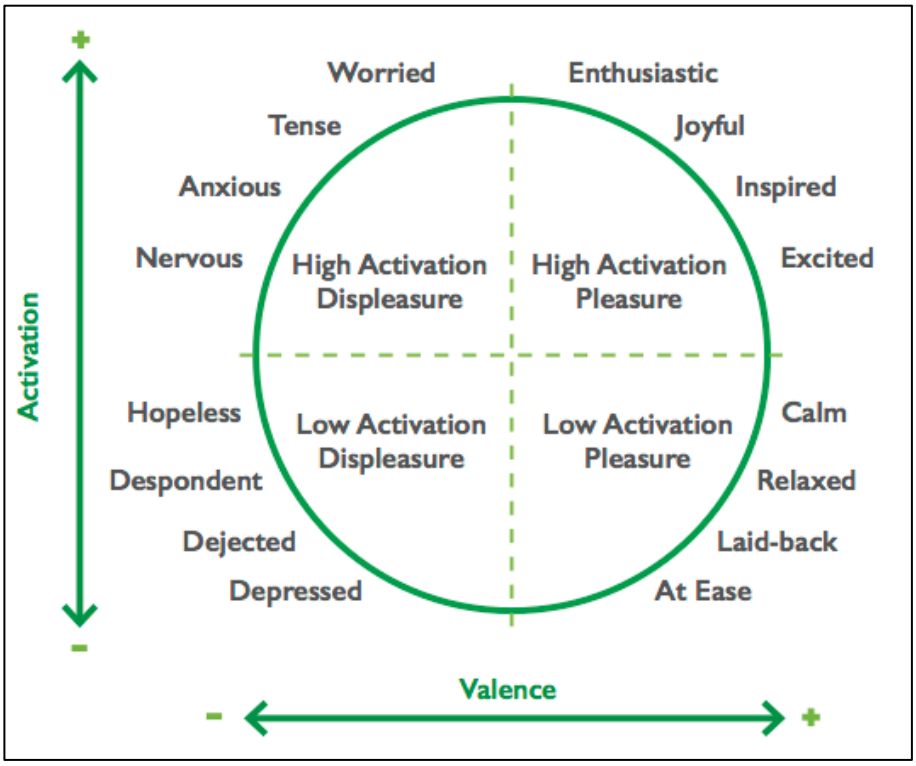
In addition, preferences vary across geographies, with 54% of Polish workers believing that hot desking has a positive impact on productivity, against only 12% in

the UK; indeed, 50% of British workers feel that hot desking has a negative impact on their productivity levels (Savills, 2019).

When attempting to measure such abstract and multi-dimensional concepts as employee productivity and occupier satisfaction, and to identify the effects which workplace design can exert upon them, we need to proceed with caution and avoid generalisation. We are reminded of a saying by Sir John Banham (date unknown): *"We are in danger of valuing most highly those things we can measure most accurately, which means that we are often precisely wrong rather than approximately right"*. For example, any measurement of satisfaction will be subjective, and flawed outputs will inevitably distort good investment decisions.

Figure 9 highlights just some of the intricacies of measuring 'satisfaction'. In this instance, measuring someone's levels of enthusiasm would create very different outcomes in terms of office design and policy than if we measured someone's increase in joy or their reduction in anxiety. It also provides an example of how self-reported satisfaction may be hugely subjective, as opposed more empirical measures such as biometric data and job productivity.

Figure 9: the multi-affect indicator

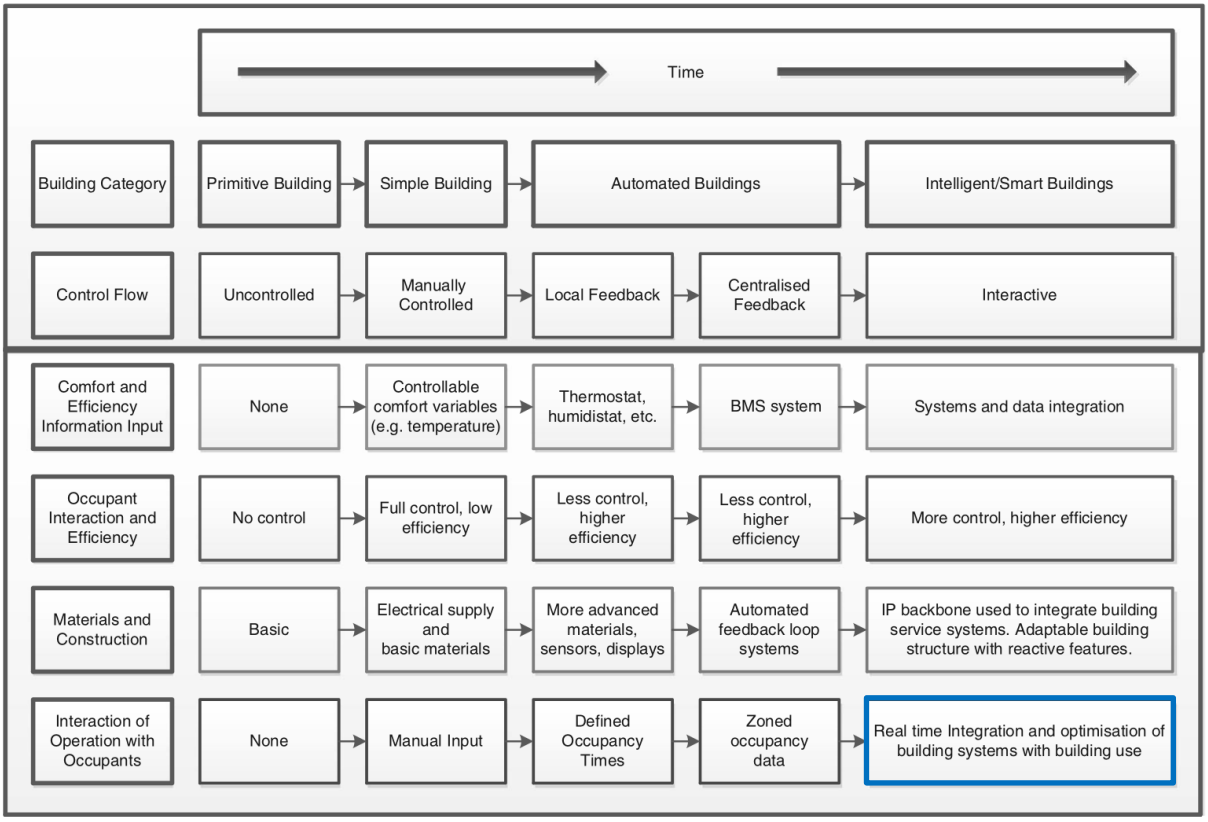


Source: Mitie, 2019: 8

4. The smart building concept

What exactly makes a building 'smart' has yet to be convincingly defined. Apparently, the term 'smart building' was first mentioned in an Iron Man comic in 1994 (Faraudo, 2019), suggesting the use of digital technologies used in synergy with building operating systems. A more academic conceptualisation is shown in the figure below, highlighting the integration of many different elements of building. In the context of this paper, we perceive the key element of a smart building as being the ability to utilise real time integration and optimisation of building systems in order to maximise occupier satisfaction and productivity.

Figure 10: the elements and functionality of a smart building



Source: Adapted from Buckman et al., 2014: 95

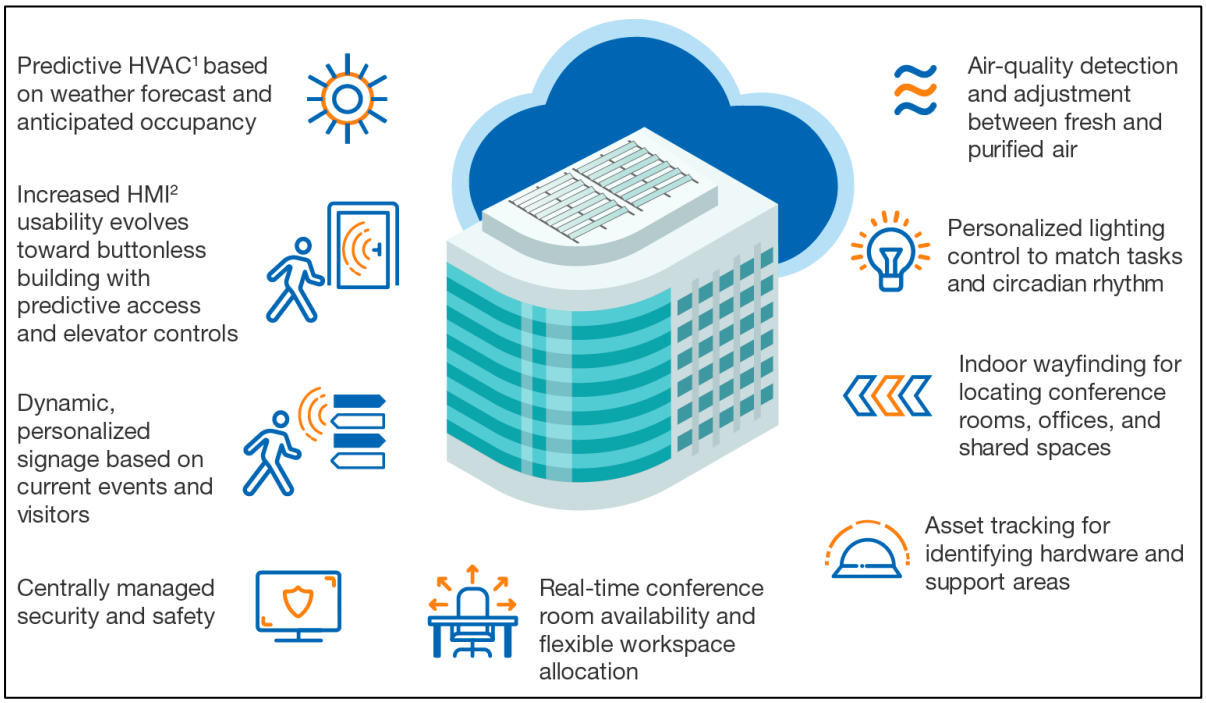
However, smart should also imply energy and carbon efficiency. Given that maximising occupant satisfaction and productivity through the built environment contains many separate elements, perhaps the best definition of a smart building comes from De Groote, Volt and Bean (2017: 8): "*A smart building (i) stabilises and drives a faster decarbonisation of the energy system through energy storage and demand-side flexibility; (ii) empowers its users and occupants with control over the energy flows; (and) (iii) recognises and reacts to users' and occupants' needs in terms of comfort, health, indoor air quality, safety as well as operational requirements."* Such a complex system requires the interoperability of many existing and emergent digital building systems to facilitate the measurement, analysis, adaptation and self-learning required to optimise results.

Traditional building management systems employ a three tier network, consisting of the sensor layer, the computation layer and the application layer (Kazmi et al. 2014). The sensor layer (inputs, more increasingly facilitated by the `Internet of Things' or IoT) consists of monitoring technology that collects data on the usage of the electrical devices and appliances within a building. The computation layer processes the data received from the sensor layer and generates information regarding energy wastage and control. Through a combination of algorithmic calculations and statistical analysis, the computation layer informs the application layer. The application layer (outputs) acts on the appropriate decision made by the computation layer.

Critically, a smart building management system (BMS) requires the ability to monitor occupants in real time through new technology incorporated in the sensor layer, while also being able to correlate all of this data and action it in real time through emerging AI powered computation and application layers. Such technologies are now beginning to hit the market, such as the EDGE Building in Amsterdam, which uses nearly 30,000 sensors to collect granular, area-by-area data on occupancy, temperature, humidity, light levels, and even coffee-machine and towel-dispenser use.

The current benefits provided by a smart BMS are detailed in Figure 11.

Figure 11: the user-centric capabilities of current smart buildings



Source: Fletcher, Santhanam and Varanasi, 2018

These benefits can be subdivided into three distinct categories, each relevant to the value of the asset and the productivity and satisfaction of those who occupy it. These are: environmental; economic; and social.

Environmentally, a smart BMS enables areas to be conditioned according to actual usage and not through fixed schedules or manual control. With HVAC (heating,

ventilation and air conditioning) and lighting accounting for 77% of a typical UK office's energy use (Pérez-Lombard, Ortiz & Pout, 2008), automating these systems based on occupancy profiles can save much of the energy wasted within a typical building, aiding the push towards net zero carbon emission targets and saving on energy costs.

One emerging technology which, when combined with the smart building framework, may help to internalise the costs of any wasted energy is that of blockchain-based utility tokens. For example, we can foresee a world in which smart building technology is able to attribute the energy used from an individual computer left running at night and automatically charge the culprit accordingly. Such a system would help to motivate effective action by individual employees, arguably the most effective net carbon strategy any single organisation can adopt.

Economically, the primary case for adopting smart building technology comes through the ability to measure spare office capacity and subsequently increase space utilisation. Termed 'space as a service', this phenomenon is based around two key principles: spare capacity and the cost of a transaction.

Spare capacity is an economic term which describes the potential for utilisation of an object, service or space that is not currently being used, or the unrealised potential of an unused resource through its inefficient allocation. The cost of a transaction determines how efficiently a resource can be allocated and re-allocated based on market demand and supply. These transaction costs can be divided into three separate categories (Dahlman, 1979):

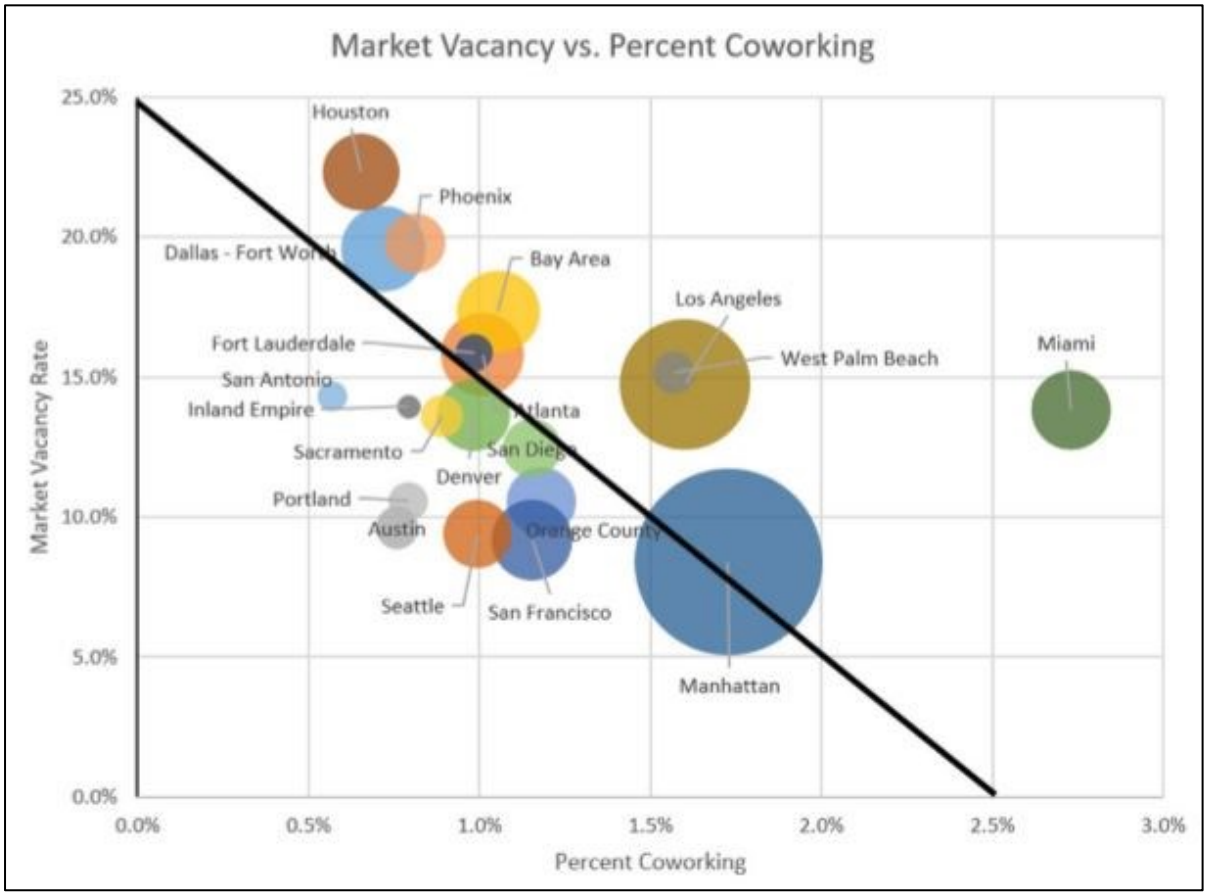
- Search and information costs: to determine that the required good is available on the market, and its lowest price, etc.
- Bargaining costs: required to come to an acceptable agreement with the other party to the transaction, drawing up an appropriate contract and so on.
- Policing and enforcement costs: to ensure that the other party sticks to the terms of the contract, and if necessary, the cost of taking appropriate action.

The rise of space-as-a-service has been enabled both through the emergence of smart building technologies, allowing for an accurate measurement of real estate spare capacity, and the development of financial technologies able to reduce the associated search, bargaining and enforcement costs of a transaction, facilitating a more efficient allocation of unused space. We have already detailed how In an average London office containing 500 workstations, occupancy monitoring enabling 100% desk utilization could save as much as £5M a year on rent alone (Stanton, 2019).

This concept has also been around a lot longer than most are aware. In 2002, Bootle and Kalyan estimated that £18 billion a year was being wasted through the inefficient use of space, presenting a great opportunity for real estate and facilities managers to contribute to organisational performance. The also estimated that £6.5 billion a year could be saved by adopting new working methods such as "hot-desking" (Bootle and Kalyan, 2002).

Figure 12 shows that in US cities with a higher percentage of space-as-a-service, there are indeed lower vacancy rates (Florilla, 2018).

Figure 12: US city vacancy rates vs co-working supply



Source: Fiorilla, 2018

A secondary economic case can be made through the ability to offer predictive maintenance. Start-ups like Demand Logic focus on the hardware of a building system, using AI powered insights to be able to study the operation of an individual unit, be it a lightbulb, a fan coil, or a PC, and to optimise energy performance while identifying any potential future faults for predictive maintenance.

Socially, we have already identified many of the benefits of increasing employee wellbeing, satisfaction and productivity brought about through the ability of a smart building system to detect and respond to unfavourable climatic conditions. The ability of an Artificially Intelligent BMS to learn from the data provided through a building's sensor layer to predict room usage and pro-actively condition the relevant areas accordingly has now evolved the concept of a 'smart building' beyond the automation of tasks to include a cognitive function, or learning. With any such a system it is important to collect digital data in order to train the AI systems tasked with operating a cognitive building. In doing so, we once again run into the problem of how to quantify emotive elements such as satisfaction and to attribute a financial return figure to the uplift in any individual's wellbeing.

As Fletcher, Santhanam and Varanasi (2018) write:

"*Traditionally, ROI has been the metric of record for determining whether a new feature is worth adding within the building infrastructure. This has worked fine when predicating use cases on energy savings. Motion sensors for lighting, for instance, are seeing significant uptake since the impact on energy savings can easily be translated into dollar terms. The same goes for smart thermostats, automatic window shades, and other conservation upgrades, which often pay for themselves within the first one to two years of use.*

With connectivity-enabled use cases, however, the value propositions are far more difficult to quantify. Take, for example, bio-adaptive lighting. Extensive research has been conducted on the health and performance benefits from adapting the lighting spectrum throughout the day to optimize the circadian rhythm. Yet the end result can vary widely according to the specific building, working environment, and occupant. Although the benefits are known, it is very challenging to directly attribute human productivity gains to this use case. A grey area such as this, where benefits are tangible but difficult to quantify and track, makes it hard for companies to justify the additional up-front cost. Other use cases, such as asset tracking, air-quality monitoring, and personal temperature controls, pose equally difficult ROI calculations".

This view is supported by the Urban Land Institute (2019), which finds that investors and developers have yet to see strong performance reasons to invest in wellbeing. While Haynes (2007:456) calls for "*a need for further research to demonstrate the linkage between the real estate and facilities management performance metrics with the organisational performance metrics*".

Despite these drawbacks, more than 80% of new construction incorporates at least one type of IoT or related smart building technology. The commercial smart building market is expected to grow nearly tenfold within the next five years to more than $51 billion globally by 2023, with North America projected to lead the IoT smart building movement with a 36% market share by 2023. Across all developed economies, roughly 90% of legacy commercial buildings will require substantial retrofitting to integrate smart technologies, contributing to rapid industry growth (Research and Markets, 2018).

5. The data-driven workplace

The emergence of the smart building and its associated technology will enable the collection of ever more granular occupant and space utilisation data, providing the missing link in the occupier market: understanding the users of the space. The successful development and deployment of smart buildings will require the merging of big data, machine learning, mobile applications and eventually human biological sensors with more traditional building hardware. Smart building development also requires the connecting of this infrastructure in a reliable, secure, and extensible manner. While questions of interoperability certainly exist, many PropTech start-ups are rallying to piece together this puzzle, proposing innovative ways of correlating the provision of physical components of a building with their associated uplift in human performance. Perhaps the easiest to fathom are those of Tenant Experience Apps.

In the world of smart phone technology and social media platforms, the rise of tenant experience apps offer a workplace experience much more familiar with that of the 'outside world'. Traditional facilities management (FM) uses a very manual format, with reception desks requiring visitor sign in and out, room bookings taking place via emailing an assistant who uses an Excel spreadsheet, with cleaning taking place on a scheduled hourly basis (even if a room has not been used). This is all highly inefficient and it is near-impossible to gain insights from the data format in which this information is exchanged. Bringing those FM functions onto a single platform used by all tenants in a building would enable these inefficient communication channels to be brought into a digital format, as is currently being pioneered by Tenant Experience (TeX) Apps such as HqO, District Technologies, Equiem and Locale.

These mobile platforms allows tenants to book and cancel their own meeting rooms, allow visitors to obtain a digital ID card for signing in and out, and permit cleaning to take place on an actual space usage basis. For the building owner, the data this produces can greatly aid in service provision and office design. Through understanding user preferences and offering a feedback mechanism, for example a system for app users to rate their experience with a given service or space, it enables the collection of real time, digital data which can be fed into AI systems to provide enhanced insight into the wellbeing and satisfaction of employees. This data can then be correlated with data regarding temperature, lighting, CO_2 levels etc. to inform building systems as to how better create a more pleasant experience within an individual room.

Such is the opportunity for these workplace apps that Sony recently released its own offering, Nimway, claiming that: "*Nimway is designed to address the common office problems employees face in a modern workspace: navigating (their way) to meetings, finding available rooms or desks and locating (their) colleagues. Sony takes care of the whole process including installation, adjustments, commissioning, monitoring and support, hence making the system maintenance free for the customer and maximizing the experience for the employees. Sony has developed one of the best sensor systems in the market for meeting rooms, delivering almost instant vacancy detection when the last person leaves a meeting"* (Nimway, 2019).

Another notable player in this market is the recent Unicorn (defined as a privately-held start-up company valued at over $1bn) Proxy. Their platform personalises users'

digital preferences based on the low frequency signals from their mobile phones, creating a seamless, tailored, digital experience as an employee moves around the building, from opening doors to logging into networks and ordering your coffee.

Combining this digital occupancy monitoring data with self-reported satisfaction and BMS data can offer a wealth of insights on which to build a user-centric approach to space provision. It is reported that in 2019, more than 50% of organisations were using some type of non-traditional employee tracking technique. This expects to rise to 80% in 2020 (Horton, 2020). However, some start-ups are already looking to go one step further, using biometric indicators to measure the benefits to the individual through the introduction of 'wearables' into the workplace. According to marketing group ABI Research, around 202 million wearable devices were given out by companies to their employees in 2016 alone (Bidwell, 2019).

One early adopter of workplace wearables was Hitachi, which developed a wearable ID badge to collect millions of hours of data on movement, work performance and happiness (Hitachi, 2015). Using an AI system to analyse this data revealed a link between specific physical movements, (self-reported) happiness and work productivity. Hitachi's research also uncovered unexpected ways to increase productivity at the team level. In one office, employees became happier and more relaxed when their boss left early, while in another office, scheduling meetings for mornings instead of evenings led to more content workers.

Another novel solution comes from US-based Humanyze, which has developed a smart badge that includes a microphone for real-time voice analysis, a device that tracks the wearer around the workplace, a Bluetooth sensor that can scan for proximity to others and an accelerometer to monitor physical activity. The behavioural data collected can be analysed alongside other business metrics via a dashboard, enabling companies to make adjustments to working conditions and to measure the effectiveness of their changes through A/B testing (which compares two variants to see which performs better).

In the UK, workflow analytics company Network Control Group has partnered with occupancy monitoring start-up Spaceti to provide a platform which can measure the digital output produced by any individual employee throughout the day. While this measure cannot capture verbal communications such as telephone calls, and remote work such as out of office meetings, Network Control Group claim to be able to show a direct correlation between indicators such as email response time or the quantity of documents produced and business unit level success.

5G, the newest form of mobile data connectivity, will enhance the capabilities of smart building technologies to measure the behaviour of the individual. The higher frequency of bandwidth required for 5G means that there is far less interference in its signal, creating pinpoint measurement of a device's location, increasing our ability to accurately position individual smart phone users within a building. However, as with all technology, obsolescence can deter investment; as an example, the University of Oulu in Finland has published a white paper for the rollout of 6G internet connectivity (Smart Cities World, 2019).

It is not within the scope of this paper to discuss the ethical issues concerned with the collection, processing and ownership of building occupants' personal data, but we are aware of the dangers of employers seeking to quantify soft skills such as sociability through tools like facial recognition and sentiment analysis. This will need addressing. We note the relevance of European GDPR regulation, and suggest that it is perfectly possible to anonymize occupant data at the individual sensor level prior to any disclosure or analysis. Proponents of blockchain technology also speak of its anonymity and ability to solve this personal data sharing issue. We believe a solution, or multiple solutions, will one day become apparent.

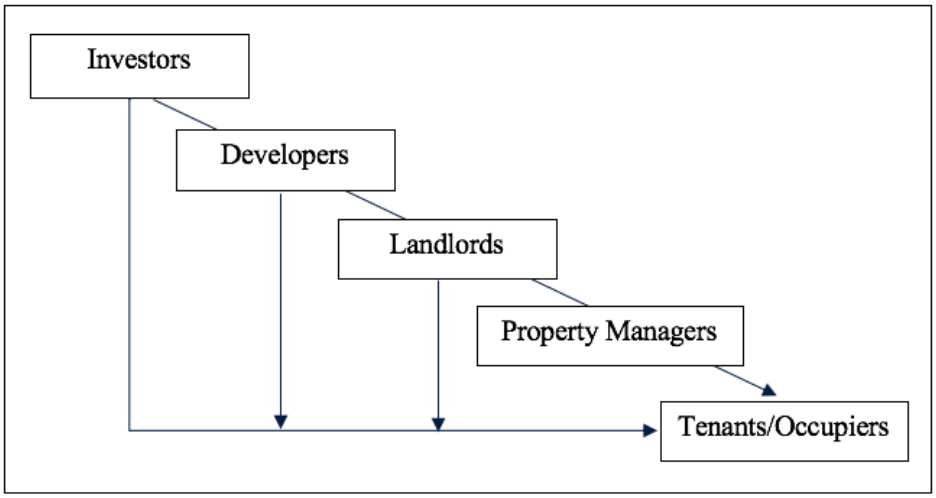
We should also point out the cyber security threats posed by the numerous network entry points offered through smart building connected devices. For a detailed overview of this issue, see Matescu and Nguyen (2019).

6. The landlord-tenant dilemma

A wealth of research into the concept of a smart building exists, warranting the use of occupancy monitoring technologies, smart BMS and tenant experience apps, carrying environmental, economic and social benefits. However, it still stands that very few offices have actually adopted any single one of these technologies. We believe the answer lies in the traditional lease structures under which most offices are occupied, giving rise to the existence of a landlord-tenant split incentive problem.

Commercial real estate contains many differing management models, incorporating numerous stakeholders into the retrofit decision making process. The stakeholder accountable for the technological operation within each building is largely dependent upon specific lease terms, and often completely removed from the HR department of the occupier firm, responsible for employee welfare. The figure below presents the authors own simplified account of where each of the typical stakeholders are located within the lease-dependant decision making process, illustrating how under the simplest management scenario, investors will finance, develop, own, manage and occupy a commercial building. However, currently the most common management structure is found under this model's most complex scenario, where all of the stakeholder groups are represented by differing organisations, each containing their own unique internal decision structures.

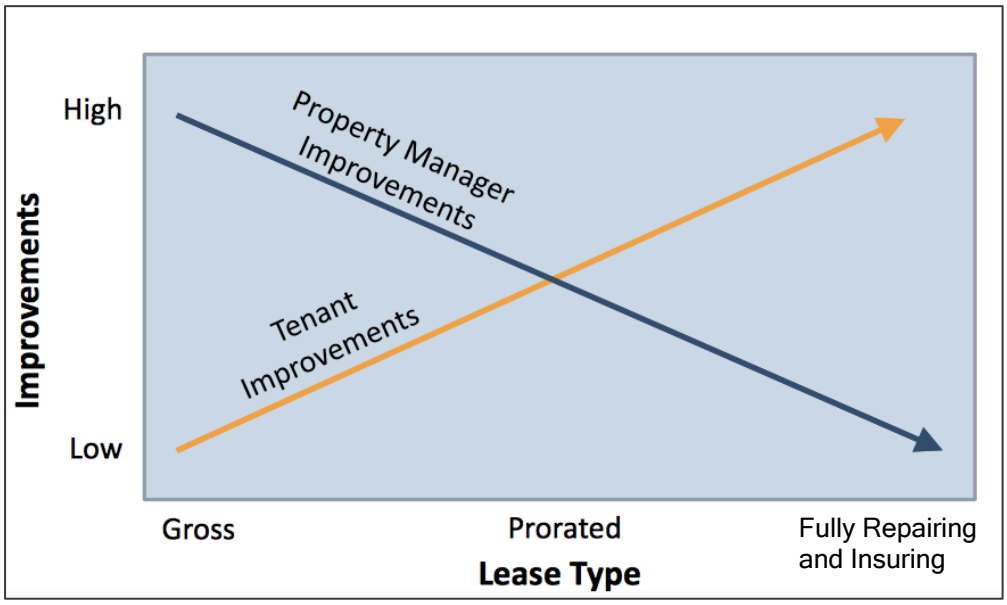
Figure 13: commercial real estate management models and stakeholders



Source: Authors

Fully Repairing and Insuring (FRI) leases represent the most common structure within UK commercial offices (MSCI, 2016). Under this agreement, operational costs are borne by the tenant, leaving the owner with little control or financial interest in the technological systems within the demise. Under such a lease, service charges make tenants responsible for the percentage of total operational costs proportional to the percentage of the building area which they occupy, so that they are billed through a regular recovery fee. In a gross lease, the owner is responsible for the cost of utilities and the tenant pays a flat fee covering these expenses. Under this last scenario, the owner has more control and financial interest in the building management systems of the leased area (US Department of Energy, 2016: 5).

Figure 14: the effect of lease structure on stakeholders' incentives to improve building systems



Source: adapted from Millette, 2014

A split-incentive problem exists under *"a circumstance in which the flow of investments and benefits are not properly rationed among the parties to a transaction, impairing investment decisions"* (California Sustainability Alliance, 2019). This concept represents a variation on the well-known economic theory of the principal-agent problem (Bird and Hernández, 2012). Accordingly, a 'split-incentive' problem, also referred to as 'the landlord-tenant dilemma' in real estate literature, can arise across multi-tenanted buildings. This is due to the financial disconnect between those responsible for the investment in any operational upgrades and those who benefit from them, worsened under more complex contractual arrangements. This often results in an underinvestment in necessary upgrades.

Directly referring to energy-efficient upgrades in multi-tenanted commercial office buildings, Castellazzi, Bertoldi, and Economidou (2017) cite four types of split-incentive. Efficiency-related split incentives occur when the tenant is responsible for bill payments, but not the upkeep of energy systems; usage-related split incentives occur when the tenant is not responsible for the bill payment; multi-tenant/multi-owner split incentives occur when decision structures act as a barrier to collective agreement on energy efficient systems; and temporal split incentives occur when the payback time of energy efficient upgrades falls outside the tenant's lease term.

In buildings financed, developed, owned, managed and occupied by the same organisation, this landlord-tenant incentive gap is reduced to zero, circumnavigating this problem of underinvestment in new technologies. Facebook and Google, which have developed, owned and managed their own headquarters operations, could be held up as trailblazers in office design. This is in part because of their status as technology providers, but also due to the fact that their office provision is perfectly integrated within a single company's decision structure. A similar, but lesser reduction in the incentive gap can be found in space-as-a-service operators, who are fully

responsible for the operational costs within the buildings they manage, motivating them to increase the efficiency of the systems in place.

Further anecdotal evidence comes from Eichholtz et al. (2016), who found that investors located closer to the buildings they owned achieved better rental cash flows than those located far away, with the main driver for better income being stronger occupancy rates than higher rents.

Regulation can also play a large role in overcoming any split incentives, by aligning landlord and tenant motivations. For example, regulations such as that imposed by the World Green Building Council's net carbon commitment has begun to create a shift in the market to reward a 'green premium' to those buildings which are able to meet carbon emission targets, helping meet the environmental benchmarks set. This should begin to prompt the financial motivation for the tide of green retrofitting which needs to occur in the decades to come.

A more novel approach to circumnavigate the landlord-tenant dilemma is currently being made in Seattle by energy provider Seattle City Light, and their 'energy efficiency as a service' offering. This program aims to deliver a solution through the introduction of a so-called 'energy tenant' into standard leases. The term refers not to the occupant leasing the property, but to the third-party provider that performs the energy upgrade. After implementing the improvements, the energy tenant can then sell the resulting surplus power back to the utility. Like an actual occupant, the energy tenant pays the owner for the privilege of marketing that electricity to the utility (Steele, 2020).

However, problems of inaccurate measurement and misplaced policy implementation threaten to cloud an already opaque market. To fulfil the intended outcome of any public regulation or private intervention targeting a narrowing of split incentives, careful consideration needs to be given to exactly what is being measured and how it is imposed.

For example, the majority of green building accreditations and regulations target the landlords of the space. The most widely known of these is a building's EPC rating, established in 2007. From April 2018, commercial landlords are unable to renew tenancy agreements or create new tenancies if the EPC rating of their building is E or lower. Such regulation has shifted the market, so that buildings labelled as 'more energy efficient' (those with an EPC rating of A or B, vs C or D) can now command higher rents, as shown in the right hand column of Figure 15.

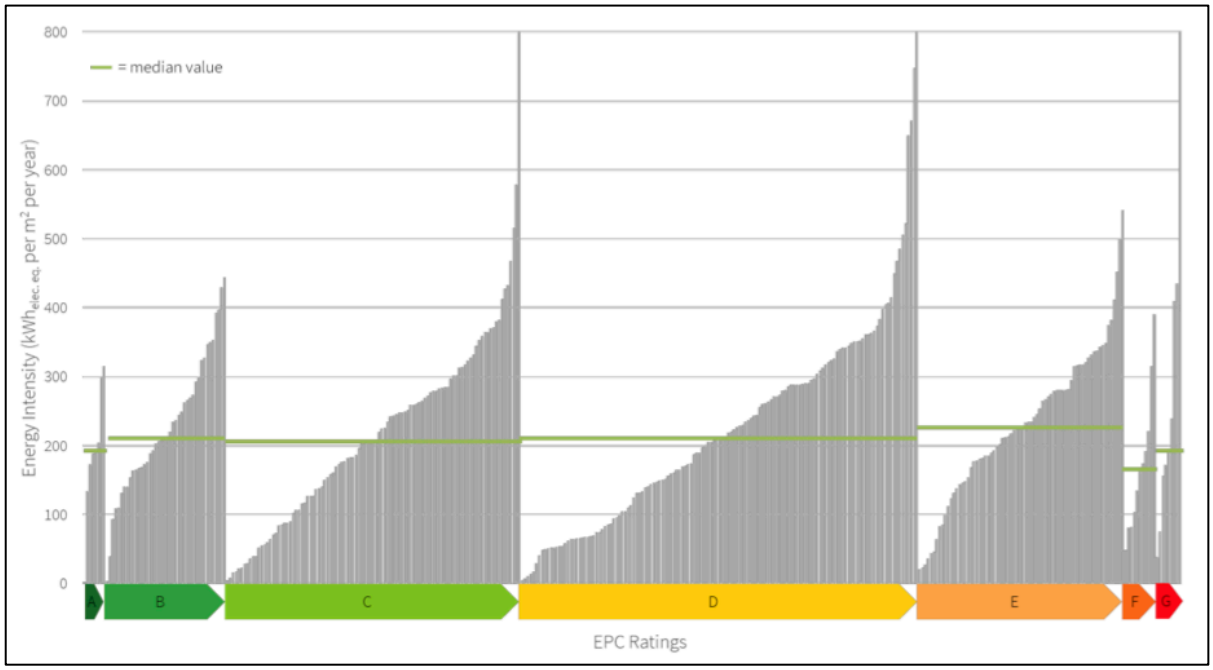
Figure 15: the effect of EPC rating on London office rents

Submarket	Sample size	No. of times AB rent was higher	No. of times CD rent was higher	Instances of rent being equal.	Average of AB rents	Average of CD rents	Difference between AB and CD rents
City Core	23	16	7		£58.10	£52.22	11.3%
City Fringe	18	8	10		£44.96	£45.54	-1.3%
Midtown	13	7	6		£56.81	£54.64	4.0%
Southern Fringe	6	4	2		£45.54	£45.13	0.9%
West End	32	19	12	1	£77.50	£69.22	12.0%
Grand Total	92	54	37	1	£61.27	£56.71	8.0%

Source: Shone, 2020

However, a study by the Better Buildings Partnership (2018) finds that assessing operational energy efficiency based on EPC ratings is highly inaccurate. The chart below reveals no correlation between energy efficiency and EPC rating across a large sample of offices, with both a similar median energy consumption of buildings with different EPC ratings and a similar range of energy usage across each EPC band.

Figure 16: EPC rating v. operational energy consumption of office buildings



Source: Better Buildings Partnership, 2018: 5

Accordingly, while 'green buildings' are fetching a premium in the market their actual carbon emissions show little reduction when compared to legacy office buildings, somewhat defeating the objective of using EPC ratings to deliver minimum energy

efficiency standards. This raises serious doubts over the suitability of EPC ratings as a focus for environmental policy within the commercial office sector as we strive to reduce energy demand by the 60% required in order to hit the 2050 net-zero deadline (Parsons, 2020).

With many market accreditations motivating the landlord to provide a high performing building (BREEAM, LEED, GRESB etc), thus making it attractive to potential tenants and commanding higher rents, the real issue is being ignored. Very little accreditation exists which promotes the tenant's responsibility for efficient operational energy usage within an asset. This has created a performance gap between the built capabilities of a building and its operational energy use. Buildings are on average 3.8x less efficient in operation than intended at design (Innovate UK, 2016). One building in this study which performed ten times worse in operation than intended had been awarded a BREEAM rating of 'Excellent'. This phenomenon could also be explained through the economic 'moral hazard' theory, a situation in which one party gets involved in a risky event knowing that it is protected against the risk and the other party will incur the cost. In this context, occupiers of a 'green building' may be more likely to practise inefficient behaviour based on the incorrect assumption that their more efficient building design mitigates their excess energy consumption.

Real estate needs to avoid misguided policy implementation when it comes to setting asset performance benchmarks, especially if these are going to be used to encourage asset retrofit investment decisions. As we suggested towards the end of Chapter 3, if smart building accreditations emerge which intend to include a measure of occupant satisfaction or productivity, they need to ensure they are capturing the correct indicators, so that only those buildings deserving of any social sustainability premium receive it.

It is likely that the split incentive problem will erode over time. At its most extreme, in the UK of the 1990s, leases of high quality offices in London were typically speculatively developed, without an end user in mind. They were leased on full repairing and insuring leases for 25 years with upward only rent reviews to market rents every five years. The tenant (often a single tenant) was responsible for dilapidations (restoring the building back to its original condition at the lease end). Incentives were split between the developer and investor, and between the investor/landlord and tenant. There was certainly no direct connection between the end user and the developer. Assuming that a tenant could be found, that tenant was on the hook for 25 years. Both the developer and the investor were insulated from the customer or end user.

The average lease length has now dropped significantly, multi-occupation is more common, and the 1990s model is clearly unacceptable to the majority of end users. The market is primed for significant change.

7. Building satisfaction

Currently the biggest motivation for a landlord to provide a satisfactory workplace is a reduced vacancy rate. However, in many cases this requires a bare minimum approach to amenity provision, as office space is a finite resource with little differentiation and a high inelasticity of supply. For tenants, their heads of real estate will likely not possess the correct information on which to identify the correct workplace to align with their corporate strategy, simply because very little information exists on what type of workplace their employees require. This could be about to change, most likely through the emergence of accurate, comparative measures of office building intelligence and occupier productivity/satisfaction.

At a base level, the categorisation of a smart building has begun, most prominently from start-up WiredScore, which currently offers an accreditation based on the digital connectivity and network capabilities of a building, while Reset claim to offer the world's first sensor-based performance related building standard. The 2020 development of the Intelligent Building Index, by (among others) Microsoft and EG could be a game changer. Green accredited buildings are beginning to fetch a premium for their environmental sustainability signalling effect, and we perceive a future in which highly accredited smart buildings will fetch a premium in a more sustainability-aware marketplace.

However, it is yet to be proven that smart (defined here as digitally connected) buildings increase occupant satisfaction or productivity, even if they command a premium in the market. Rather than assessing the digital connectivity of a building, should we not measure whether it satisfies the needs of its occupants? We should define a smart building as any building which fulfils its purpose of providing a satisfactory working environment, technologically capable or not, and it should be these buildings which fetch a market premium.

The WELL building standard is perhaps the most widely known building accreditation to include a measure of occupant wellbeing alongside some of the more common environmental sustainability criteria. In total it assesses seven 'pillars' which it uses to define the wellness of a building. These are: light, comfort, nutrition, fitness, water, air and mind. In their recent study they identified that 73% of early adopters of WELL-certified buildings saw faster lease-up rates and 62% saw increases in building values (Phillips, 2018), although we do not know how objective or defensible these findings are.

Given the importance of feedback platforms to the hospitality sector, and assuming the gradual erosion of the split-incentive problem as leases shorten, a 'satisfaction premium' is likely to arise through the emergence of an online platform for office space user experience ratings. The Airbnb of office space, for want of an easy comparison, may not be far away. Our rationale is as follows.

In 2019, approximately 13 percent of office space in the U.S. remained unused. With around 90 billion square feet of office space in the U.S., that accounts for almost 700 million square feet of unused space (Shenderovich, 2020). With the predicted continued growth of flexible working explained earlier, and with barriers to entry to the flexible office market low due to most co-working space involving small locations

(Fiorilla, 2018), a large number of landlords will turn towards occupancy monitoring technologies to capitalise on the opportunity to better employ this underutilised office space. It is highly likely that a landlord agnostic, desk brokerage platform will emerge, similar to current co-working agnostic brokerages such as LiquidSpace, PivotDesk and JLL-backed start-up Hubble.

Such a system would unveil online, publicly discoverable satisfaction ratings of individual offices, as happy customers reward good service with high reviews and are willing to pay more for the premium offerings. These ratings could then allow for AI-powered data analysis to understand exactly who the users of your space are and which amenities they most desire.

The most advanced attempt at revealing such insights will probably remain behind closed doors in WeWork's much-reduced research department. Fortunately, they have left some clues in academic publications by members of their research team. Bailey et al. (2018) discuss how WeWork's centralised data storage system allowed them to access everything from harvested BIM data in archived CAD models to information on sales, member churn, and the particular furniture in any space. This formed the foundation of a machine learning analysis which allowed them to predict those offices which were most difficult to rent, with a high level of accuracy. However, discussions with an individual close to this study revealed that, while the model was useful in highlighting those offices most likely to remain vacant, it could not identify why, making the required design changes difficult to specify.

Anderson et al. (2018) revealed how they used machine learning algorithms trained on WeWork's design data to inform optimal desk layouts, while Phelan, Davis and Anderson (2017) were able to accurately predict usage for 728 meeting rooms in the 56 WeWork locations used in their study. Figure 17 highlights the aims of additional, applicable, internal studies undertaken by WeWork. A more comprehensive list of WeWork's internal research aims can be viewed in Appendix A.

Figure 17: WeWork's internal research agenda, 2015-2019

2015	Meeting room success
2015	Room ratio
2015	Industry influence on meetings
2015	Member satisfaction survey
2015	Floor plan heatmaps
2015	Seasonal trends
2016	Community cohesion vs floor size
2016	Office churn
2016	Cost by space type
2017	Predicting desks without a test fit
2017	Human centred design
2017	Member productivity

2017	Autonomous layouts
2017	Human centred design
2017	Understanding regional design changes
2019	Meeting behaviour

Source: Anon

All of these studies were only possible due to the vertically integrated nature of WeWork's business model, allowing for access to a centralised data repository. However, such insights have long been available in hospitality, largely due to the vast amount of data produced through their room booking systems and online brokerage portals. The hospitality industry uses AI-powered revenue management solutions to "*leverage not only the repository of historic data that resides in a hotel's property management system, but also, in many cases, a vast array of market intelligence and other data, from competitor rates data to booking trends data. This makes it possible to more accurately forecast demand, and, as a result, increase hotel revenue and profitability in unprecedented ways*" (Starfleet Research, 2019).

The hospitality sector also demonstrates the potential of smart pricing. Office operators can use demand forecasts, competitor rates and price sensitivities, as well as demand drivers like seasonality, special event dates, and day-of-week differences, and personal data such as a guest's potential spend on recreational facilities, restaurants, spas, and various other ancillary revenue streams, to maximize room occupancy and total overall revenue. Additional business intelligence can also be derived from the AI-powered analysis of occupancy data, such as improving sales effectiveness, generating competitive intelligence, and providing insights into occupancy trends, guest demographics, market positioning, and channel profitability.

Such a development in data availability for the office market would be game-changing, with the following implications.

- Net promoter scores (customer satisfaction ratings) will be used to compare various commercial spaces and ultimately drive tenant demand. Building owners and occupiers will, like hospitality operators, begin to think about their business in terms of B2B, B2C and platform (Expedia etc) channels.

- The collection and analysis of space utilisation data will allow for the dynamic, smart pricing of spaces, increasing in price at peak times and decreasing in price when demand is low, thus enabling a fuller occupancy at all times and maximising the value of the asset.

- Building values will no longer be calculated universally based on the strength of the tenant's covenant and the terms of the lease, but increasingly on the basis of EBITDA or revenue per available desk.

The power of branding under such a scenario could lead to the emergence of 'anchor desks', given free of charge to individuals whose profiles are sufficient to demand an increased rent for all other desks in the immediate vicinity. The economies of scale

derived from a clustering of specific job functions could see the rise of specialised flexible working spaces, such as the recently launched ‘PropTech Place’ in New York or PropTech Central in London.

Another route to the emergence of aggregated occupier experience data may arise through the market capitalisation of a single Tenant Experience App, used across buildings and job functions. This comparative feedback would fill the current data void between landlords and tenants, helping to circumnavigate any split incentives imposed through traditional FRI lease structures with regards to office amenity provision and wellbeing investment, motivating and enabling landlords to provide more satisfactory, specialised spaces for those who occupy them.

8. A framework for future study: the price of productivity

We would like to develop a project or series of projects which explore the connection between the financial performance of commercial (office) space and the efficiency or productivity of the space. Financial performance may be a rent measure, a capital value measure or an EBITDA measure. Efficiency and productivity may be connected to customer satisfaction, and/or to energy efficiency and power use. The key issue is the measurability and objectivity of the efficiency variables.

There are several groups of variables which will affect efficiency. These are to do with personal circumstances, job satisfaction/rewards and building variables. We are interested in the latter. These real estate quality variables break down into location factors and building-specific factors. Again, in this we are interested in the latter, building quality. What makes a good/productive/efficient building? We will define building quality as a list of features, facilities, and accreditations.

Finally, we are interested in the relationship between building quality and the delivery model and management model. If these variables are measurable, we are interested in the way in which traditional ('indirect') models of office ownership and occupation compare with more direct models such as co-working.

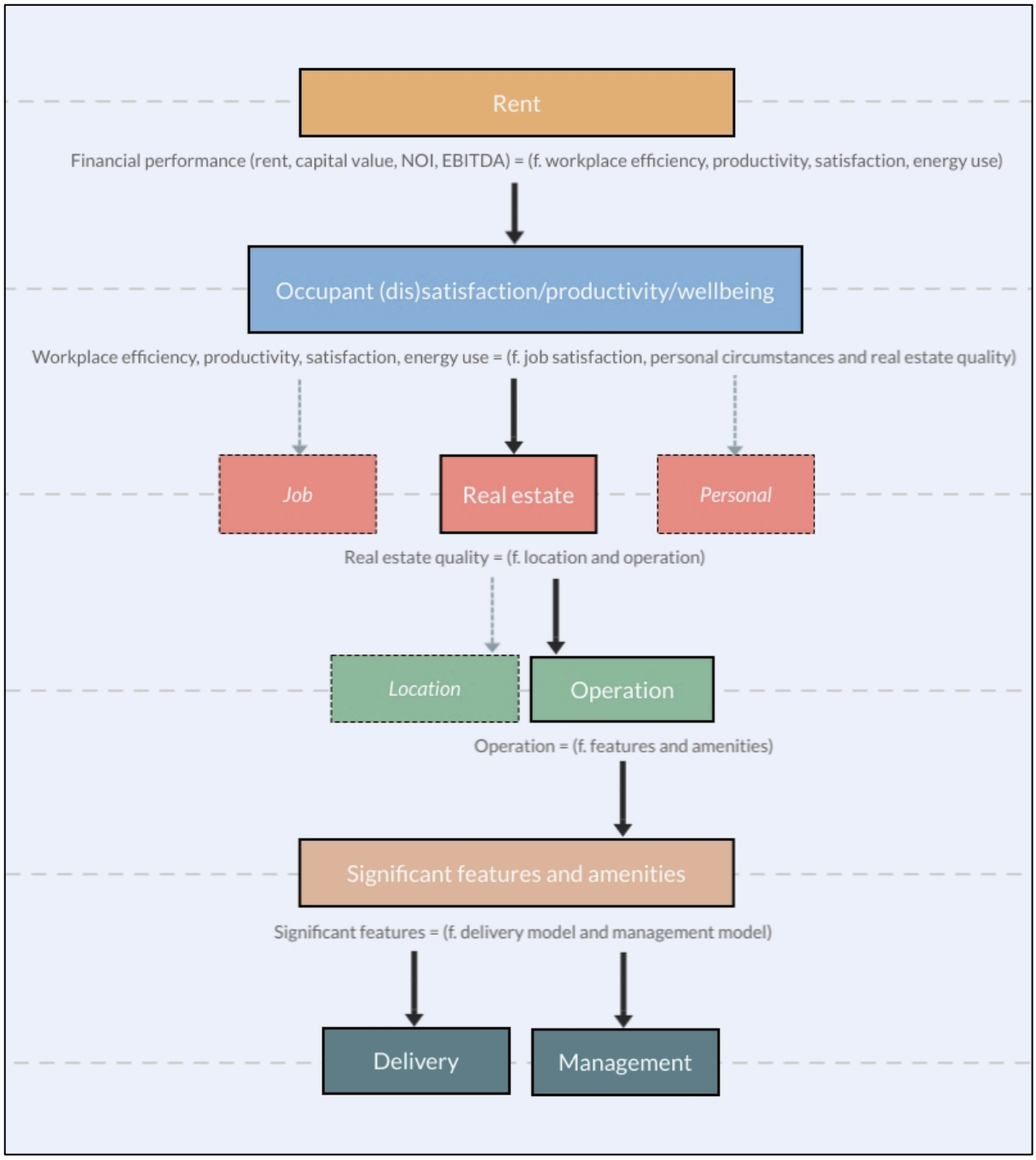
Business and especially marketing principles applied to this issue can be very insightful. Understanding the supplier-customer relationship and using data to inform that relationship is a basic resource for vendors of goods and services. There are possible analogies in hospitality, and in the private rented residential (PRS) sector. Hotel groups understand their B2B business relationships, their B2C relationships and the importance of sales platforms such as booking.com or Trip Advisor. PRS developers either act as or use operators to maintain communications with their occupiers. But in commercial real estate it is rare for the owner to have a vendor-customer relationship. Many do not know who their customers are, somewhat weakening the information collection process

At one extreme – the hotel – customers have a direct relationship with the operator (the hotel group). The hotel group may also be an owner. The same goes for PRS, student accommodation, retail and leisure. But in offices, WeWork and other co-working brands have shone a light on the lack of analogies in the traditional leasing market. As an operator, WeWork or Spaces has a B2B or B2C relationship with small business and self-employed customers. At the other end of the spectrum, however, might be a German pension fund or core fund owning a UK office; with a local asset manager (say, APAM); and a sub-contracting property manager (say, CBRE). It would be normal to lease the asset for 10 years to a FTSE 250 company represented by a corporate facilities manager on triple net terms. In such a case the connection between the customer/user and the vendor is extremely fragmented or non-existent. How can this produce an efficient use of space?

If the developer has produced the building though a speculative scheme, the connection between design and use is further compromised. We are also interested in the way in which the traditional lease terms might change to accommodate more efficient models of space use (by becoming shorter, or including power supply). We

are also interested in the ESG implications of the traditional lease and its contribution to efficiency, environmental effects and social value.

Figure 18: an occupant-centric model of building value



Source: Authors

With many studies reporting on the benefits of individual amenities and services, we aim to use the framework shown to provide a contextualised understanding of exactly which variables have the greatest increase on workplace satisfaction and productivity, aiming to identify if any one real estate management or provision model is best able to provide these. Under a best case scenario, we would like to be able to determine a return on investment figure capturing the increase in employee satisfaction and

productivity produced with each incremental amount spent during a workplace fit out, identifying which individual variables possess the greatest cost-benefit ratio. In doing so we hope to provide the tools necessary for landlords to execute investment decisions to improve the wellbeing of their tenants, and occupier firms to identify workplaces which contain the correct variables to empower their employee base.

Discussion

A predicted increase in remote working, normalised as a result of the COVID-19 pandemic and facilitated through Virtual Reality and other collaborative digital technologies, will accelerate many of the trends discussed in this report, most notably the need to offer more flexibility in the workplace and an environment which promotes productivity and satisfaction beyond that offered when working from home. This will likely be highly varied across differing job functions and occupying organisations.

As we sit at what may be the dawn of a new era, one of the virtual workplace, it raises many questions in need of a clear and urgent response.

How do current real estate laws apply to the ownership, tenancy and taxation of virtual meeting rooms and home offices? What would be the impact of more home working on the use of physical office space and the occupier market? What regulations need to be implemented to avoid a collapse in the office market at the mercy of the 5G, broadband and software providers best able to offer this 'digital real estate'?

Our lack of understanding about how the digital and physical realms co-exist and our inability to capture the uplift in online sales generated through a physical store presence has contributed to the demise of many, once-powerful, retail firms. Is this about to be repeated in the office market?

As many predict a seismic shift towards working from home, we must remember that 22% of US marriages originated in the workplace (Kearl, 2018). We have a need to not only consider the productivity, wellbeing and satisfaction of employees, but also longer term, emotive elements, such as loneliness and love, and what the true costs of removing regular physical interaction may be.

9. Conclusion: the future of real estate occupation

In this report, we have presented evidence to support our belief that measurably productive office buildings will begin to fetch a premium in the real estate market.

This shift has been driven by five major issues driving change in the way we will use business space. These are climate change and carbon management; co-working; digital data, worker performance and smart buildings; transport technology; and society's reaction to the global COVID-19 pandemic.

The ability of a building to adjust its operating systems according to personal preference and individual departmental needs, thus offering a bespoke occupier experience, is slowly becoming a reality through the use of emergent occupancy monitoring technologies, also able to drive operational energy efficiency and efficient usage of space. However, measuring any uplift in subjective indicators such as occupant happiness, health and productivity as a result of smart building system adaptation is not so straight forward. It is even harder to relate the root cause of any change in these human variables back to factors within the control of landlord or tenant so as to attribute any financial gains correctly.

This difficulty in measurement and attribution has resulted in an underinvestment in social capital within the workplace, empirically shown to improve the performance of occupier firms. This is also largely due to the financial disconnect between landlord and tenant imposed by legacy lease structures, leading to a split incentive problem regarding retrofit decisions. However, this underinvestment in workplace satisfaction due to poor measurement and misaligned incentives is likely to change through the emergence of technology-based feedback loops and the continued growth of the sharing economy and flexible leasing.

Occupier satisfaction or dissatisfaction will initially reveal itself through individual customer retention, as those more satisfactory and well-priced spaces will continue to maintain low vacancy rates despite the short term leases allowing for an increased freedom of workplace choice. As tenant experience technology matures, and market leading platforms emerge, so too will comparative satisfaction ratings. This crowdsourced granular data will allow for landlords to understand which facilities and offerings are being used and enjoyed by their tenants as they book, rate and report, all through one data-driven smart phone app.

Companies holding this aggregated data across buildings will be able to contrast and analyse multiple variables which impact occupier satisfaction and productivity, often unique to each location and job function, and to deliver insights to landlords on how best to optimise their buildings. It is worth once again mentioning that those who feel that WeWork is not a technology company should consider the mass of data they currently have describing these parameters across hundreds of global locations, and the enhanced market insights this provides.

As landlords begin to realise the opportunity cost of their underutilised space, a platform will emerge through which individuals who do not require security of tenure are able to book into their workplaces on a short term basis. The same principles which led to the rise of Airbnb to compete with major hotel operators through democratising

the market for overnight stays, will drive such a landlord-agnostic platform to compete with WeWork et al., democratising the market for short term desk rental.

The shifts in real estate markets that this development would facilitate would be game-changing, leading to the use of net promoter scores, the collection and analysis of space utilisation data and more correlation between building value and EBITDA or revenue per available desk.

The emergence of this data could offer new insights when correlated with information collected from technologies such as workplace wearables and Smart BMS, to truly understand the need of individual customer's and allow for landlords to position themselves as premium or budget offerings and to price their workplaces accordingly.

Subsequently, it is important that current landlords gain a head start and begin to collect data on their workplace and occupant satisfaction to unveil insights about the product they are offering. As urban mobility increases in the near future, and remote working becomes more appealing due to enhanced cloud services, the emergence of immersive, collaborative technologies such as augmented reality meeting rooms and increasing social acceptance resulting from the global COVID-19 lockdown, location may become less important. The value of an office building will continue to depend on its proximity to the CBD and the quality of local transport links, but more and more tied to the quality of its product offering. Occupant wellbeing will become a financial imperative.

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Appendix A: WeWork's internal research agenda, 2015-2019

2015	Indoor positioning
2015	Space analytics
2015	Temperature measurement
2015	Meeting room success
2015	Back of house
2015	Room ratio
2015	Industry influence on meetings
2015	Member satisfaction survey
2015	Company size vs. conference size
2015	Cultural context
2015	Floor plan heatmaps
2015	Seasonal trends
2016	Commons study
2016	Community cohesion vs floor size
2016	Occupancy sensors
2016	Large rooms
2016	Office churn
2016	Travel between locations
2016	Cost by space type
2016	Member Satisfaction survey
2016	Spaces: Develop methods for analytically determining programming
2016	Adaptive programming
2016	Designing for large members
2016	Data-driven programming - phone booths and nooks
2016	FF&F product study
2017	Furniture and storage
2017	Av & it research
2017	Mining building schema for design patterns
2017	Coworking classifier: ZIP code analysis & model
2017	Predicting desks without a test fit
2017	Human centred design
2017	Machine Learning in practice
2017	Member productivity
2017	POE in practise

2017	London coworking classifier
2017	Autonomous layouts
2017	Enterprise workplace assessment
2017	Human centred design
2017	Poes at Scale
2017	Mapping our community
2017	Understanding regional design changes
2018	Workplace mobility
2018	Hot desks
2018	Purposeful connections
2018	Socialization into the community
2018	The value of a network analysis
2019	Meeting behaviour

Source: Anon