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Nurick, Saul David

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IMPACT OF GREEN BUILDING FEATURES AND INITIATIVES ON INDIVIDUAL PRODUCTIVITY AND ORGANISATIONAL PERFORMANCE IN OFFICE BUILDINGS

BY

SAUL NURICK

2023

Supervisor: Professor Andrew Thatcher

Thesis submitted in fulfilment of the requirement for the Degree of Doctor of Philosophy.

Department of Psychology, School of Human and Community Development, University of the Witwatersrand

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SAUL NURICK

Abstract

The uptake of sustainability within the real estate sector has come to the fore in the last twenty years. More specifically this has involved the development and implementation of green certification tools within the commercial property market. There are various green building tools that are applied in the different developed markets to standardise building certification within each market. Some tools are adapted versions of another tool, for example Green Star (Australia) was used as the benchmark for the development Green Star South Africa.

One of the categories within every type of green building tool is indoor environmental quality (IEQ). Building occupants tend to be more aware of their indoor environment more than any other building component that may be classified as a green building feature and initiative (GBFI). Specific GBFIs impact the following IEQ factors: ventilation, natural vs artificial light, ambient temperature, humidity levels, noise levels, and office configuration.

Green building research has shown that operationally green buildings benefit both owners and tenants, which also has a positive impact on building values. Many green building advocates have stated that green buildings also result in improved individual productivity and organisational performance. There is, however, conjecture amongst academic researchers regarding the accuracy of measuring productivity of knowledge workers within an office environment. Common approaches for measuring productivity include creating a simulated office as an experimental environment and setting tasks for the participant to perform in different environmental conditions. Post occupancy evaluations (POE) and building user surveys are other instruments for gathering productivity data, however these are often in the form of self-assessment, which carries an element of bias.

The purpose of this research was to develop and test a theoretical framework that connected the implementation of GBFIs, specifically enhanced IEQ, to individual productivity and organisational performance. The theoretical loop is that enhanced IEQ may positively impact both individual productivity and organisational performance, which could justify the implementation of GBFIs within an office building in an on-going basis.

The research comprised four academic articles. The first article was a literature review looking at past research linking green buildings and productivity. This resulted in the proposal of the theoretical model. The second article was a scoping literature review that focused on the main methods that were applied in conducting research between green building and occupant productivity to provide support for the model. Papers three and four comprised empirical research that separately analysed individual productivity and organisational performance. The paper that qualitatively analysed individual productivity indicated that location and amenities, specifically those that focused on safety and reliable building services, positively contributed to individual productivity. The second empirical paper quantitively focused on organisational performance specifically focused on financial services companies (FSCs) and the average green return ratio (AGRRi) within the context green and non-green buildings and IEQ scores. Three funds (low, moderate and high risk) were analysed for each FSC to determine if there was a statistically significant relationship between annualised returns and IEQ, which was only apparent for the South African (SA) equity fund. It was

established when comparing the sample of FSCs based in green certified buildings versus conventional (non-green) in terms of group average returns, that the FSCs based in green buildings outperformed the FSCs based in conventional buildings. The differences in annualised returns have been forecasted (compounded monthly and annually), which provides an indication that on average, clients investing in FSCs occupying green buildings will yield great overall wealth over the long-term (thirty years) than clients investing in FSCs located in conventional buildings. It was further established that there was a sweet spot for IEQ scores, which relate to annualised returns for FSCs located in green certified buildings.

Based on the qualitative and quantitative findings there is potential for future research to expand the application of the theoretical model to other industries and real estate sectors. Furthermore, this research could be incorporated into environmental, social and governance (ESG) research studies, which could potentially provide justification at the executive level for further insight into unpacking the relationship between individual productivity and organisational performance arising from investing in the quality of the built infrastructure of the office.

Key words: green building features and initiatives (GBFIs), indoor environmental quality (IEQ), individual productivity, organisational performance, financial services companies (FSCs), average green return ratio incremental (AGRRi)

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In memory: RR (1922 – 2020), GG (1950 – 2021) y Pablo (1958 – 2022).

List of Abbreviations

ABW	–	Activity Based Working
AfRES	–	African Real Estate Society
AGRRi	–	Average Green Return Ratio Incremental
ANOVA	–	Analysis Of Variance
ARES	–	American Real Estate Society
BEST	–	Building Environmental Standards
BOMA	–	Building Owners and Managers Associations
BREEAM	–	Building Research Establishment's Environmental Assessment Method
BUS	–	Building User Survey
CASBEE	–	Comprehensive Assessment System for Built Environment Efficiency
CO_2	–	Carbon Dioxide
CRE	–	Corporate Real Estate
DCF	–	Discounted Cash Flow
ESG	–	Environmental Social Governance
FSCs	–	Financial Services Companies
FSPs	–	Financial Service Providers
FV	–	Future Value
GBCA	–	Green Building Council Australia
GBCSA	–	Green Building Council South Africa
GBFIs	–	Green Building Features and Initiatives
GBRTs	–	Green Building Rating Tools
GRRi	–	Green Return Ration Incremental
GSSA	–	Green Star South Africa

HR	–	Human Resources
HVAC	–	Heating Ventilation Air Conditioning
IAQ	–	Indoor Air Quality
IEQ	–	Indoor Environmental Quality
IRES	–	International Real Estate Society
IT	–	Information Technology
KPIs	–	Key Performance Indicators
LEED	–	Leadership in Energy and Environmental Design
MANCOVA	–	Multivariate Analysis of Variance with Covariates
MBI-GS	–	Maslach-Burnout Inventory-General Survey
NOI	–	Net Operating Income
OSI	–	Occupational Stress Indicator
PAQ	–	Perceived Air Quality
PEP	–	Psycho-Environmental Potential
POE	–	Post Occupancy Evaluation
PPM	–	Productivity Payback Model
PRISMA	–	Preferred Reporting for Systematic and Meta Analysis
REIT	–	Real Estate Investment Trust
ROI	–	Return On Investment
SBS	–	Sick Building Syndrome
UKGBC	–	United Kingdom Green Building Council
USGBC	–	United States Green Building Council
VOCs	–	Volatile Organic Compounds

WGBC	–	World Green Building Council
WHO	–	World Health Organisation

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1. Introduction

The relationship between green office buildings and occupant productivity levels is anecdotally stated to be strong, however this has not been satisfactorily proven by the academic community, as there are many variables that need to be considered when evaluating the relationship between the built environment and those individuals that occupy and work in buildings that have obtained green certification. This is the introductory chapter for a Doctor of Philosophy degree conducted including publication in the form of four academic articles, where three of the articles have been double blind peer reviewed and published, and the remaining article has been submitted to a journal for review. Two of the publications appear in international journals, while the other manuscript was published in a South African journal. The first two papers are theoretical in nature and comprise a broad literature review that examines past research and a scoping literature review that focuses on previously used methods. Papers three and four comprise empirical research that examines individual productivity and organisational performance, respectively, within the context of green buildings. Productivity was empirically researched by conducting in-depth semi-structured interviews of building occupants in green-certified buildings. Performance was assessed via a desktop analysis of annualised returns of three commonly offered investment funds across twenty financial services companies (FSCs), where ten FSCs were based across nineteen green certified building and ten FSCs were located in thirteen conventional (non-green) buildings. The first paper introduces an emergent research model, which is subsequently used as a theoretical framework for the scoping literature review, and furthermore tested at an individual and organisational level in the two empirical papers.

This chapter introduces green buildings, green building features and initiatives (GBFIs), the role of indoor environmental quality (IEQ) in green building rating tools, and workspace quality. There is also a brief narrative on previous research, which focuses on individual productivity and organisational performance in green buildings, organisational outcomes, and finally the relationship between GBFIs and productivity and performance. The chapter ends by stating the overarching research question and hypotheses that are addressed in the four academic articles that comprise the research.

1.1 Green Building

Global warming and climate change are issues that have attracted increased awareness from a variety of different stakeholders (Brundtland *et al.*, 1987; Parsa and Farchschi, 1996; National Geographic News, 2007). The built environment is a significant user of resources and contributor to global emissions both during construction, as approximately one third of carbon emissions are produced by the construction industry (Milne, 2012), and throughout the operational phase of buildings. Heat emissions generated by office buildings in order to provide adequate working conditions in terms of indoor air quality (IAQ) and indoor environmental quality (IEQ) requires heating, ventilation, and air-conditioning (HVAC) systems that both consume resources (water and electricity) and generate residual heat and water vapour, which contribute to global warming (Hedge *et al.*, 1996; Brown and Southworth, 2008). Typically resource consumption is directly linked to lighting, the running of office machinery (e.g., computers, printers etc) and the use of water for human consumption/use (drinking and sanitation) and general building maintenance (cleaning). The impact of buildings on the environment has resulted in increased awareness of alternative approaches to building in a more environmentally conscious manner. This led to the formal establishment of the green building movement as a structured way of addressing both the internal and external environmental impact of buildings.

Green building has gathered momentum over the last twenty years, especially since the establishment of the World Green Building Council (WGBC) in the late 1990s. Many developed countries such as the United States, the United Kingdom and Australia *inter alia* have their own green building councils. The different green building councils have developed a variety of green building rating tools, which consider specific climatic conditions, materials, and user demands. The prominent green building rating tools include LEED (North America), BREEAM (UK and Europe), DGNB (Germany and Europe), CASBEE (Japan), and Green Star (Australia and South Africa) (GBCA, 2015; UKGBC, 2015; USGBC, 2015; WGBC, 2015).

The Green Building Council of South Africa (GBCSA) was established in 2007, and in 2009 the first office building in South Africa was awarded green certification. The GBCSA developed Green Star SA (GSSA) Office as their rating tool, which is derived from Green Star Australia, as both countries share similar climatic conditions. GSSA Office comprises ten mandatory

categories, which are used to assess a building that is applying for green certification. One of these categories is IEQ, which specifically focuses on workspace quality (GBCSA, 2015b; GBCSA, 2017), i.e., the occupant's experience of their physical working environment.

The benefits of green building are most noticeable in terms of environmental and financial benefits. Environmental benefits relate to lower building emissions as a result of reduced electricity and water consumption. This also translates to a reduction in utility costs, which benefits both the owner and tenant. The owner benefits from cost savings through increased capital value and indirectly via lower vacancies in terms of tenant retention (Nurick *et al.*, 2015), which de-risks the building thus reducing discount and capitalisation rates, which ultimately yields a higher building value. Tenants benefit by incurring lower utility costs, while still occupying high premium office space. The quality of the workspace from an occupant perspective is underpinned by the IEQ, which can at least be partially linked to the green building features and initiatives (GBFIs), such as improved ventilation/air quality, lighting, temperature, and humidity levels.

1.2 Green Building Features and Initiatives (GBFIs)

Despite the rating tools, there are still many buildings that contain GBFIs but choose not to apply for green building certification as building owners feel that the actual certification process is not necessary from a cost, time, and branding perspective. GBFIs are broken into two separate categories. The first category is features, which are defined as building elements or systems that reduce resource consumption, for example motion sensing lighting. The second category is initiatives, which are defined as installations that locally increase resource consumption but reduce the total carbon footprint of building occupants, for example, installing showers in an office building in order to encourage occupants to walk, run, or cycle to work (Michell and Nurick, 2014).

1.3 The Role of Indoor Environmental Quality (IEQ) in Green Rating Tools

IEQ plays a significant role within the green building rating tools, including GSSA Office, with a weighting in the final score that is only behind energy in the office green building tool, as shown in Table 1.1, where is allocated 25% and IEQ 20% of the points for GSSA.

Table 1.1: GBRTs Points Weighting Comparison

CATEGORY	BREEAM	LEED	CASBEE	Green Star SA (GSSA)
Electricity/Energy	16%	32%	25%	25%
Water	7%	9%	30%	12%
Building Materials	15%	13%	10%	14%
TOTAL	**38%**	**54%**	**65%**	**51%**
Health and Wellbeing/IEQ	14%	14%	10%	20%

There are several green building rating tools that are implemented in various countries, for example, GSSA Office and LEED are both used in South Africa. Weightings for the different categories are not uniform; therefore, there is a variation in focus on the importance of IEQ and workspace quality between the different rating tools. GSSA has an explicit focus on IEQ, especially in their office rating tool (GBCSA, 2015b). According to Green Star Office v1, IEQ is given a weighting of 15%, which is second to Energy that has a weighting of 25% (GBCSA, 2015a), in compiling the total number of points awarded. IEQ addresses a number of building user related issues from external views to individual comfort control, noise levels, and exposure to hazardous materials (GBCSA, 2015a). Building occupants are more directly impacted by IEQ components than any other building component, as their comfort and wellbeing (physical and mental) can be linked to their working environment. Zitras *et al.* (2021) attempted to test a psycho-environmental potential (PEP) model to better understand the relationship between green buildings and various health, wellbeing, and productivity outcomes. It should be noted that the PEP model was only applied to LEED and BOMA-BEST certified green buildings (i.e., no Green Star certified buildings), which is a noteworthy limitation from the perspective of this study. It was established that GBFIs may simultaneously enhance and detract from the physical and psychological experience of the building occupant (Zitras *et al.*, 2021). For example, the complexities associated with amount of natural light may simultaneously lead to better lighting conditions for some and glare and increased thermal discomfort for others (Zitras *et al.*, 2021). Therefore, the association between the building's IEQ and its occupants should be viewed as an evolving long-term relationship, as opposed to an upfront static connection. This relationship is highly dependent on the individual building and the type of work being conducted by the building occupant, and to what degree this influences productivity levels (Zitras *et al.*, 2021).

The main IEQ components that appear in office buildings include:

1.3.1 Indoor Air Quality (IAQ)

The assessment of this component awards points for the appointment of an IAQ manager, the implementation of an IAQ system, and regular IAQ testing. The assessment of IAQ includes the monitoring of ventilation levels. The level of IAQ can impact productivity (Milton *et al.*, 2000; Fang *et al.*, 2004; Wyon, 2004) as this is linked to perceived air quality (PAQ) and sick building syndrome (SBS), which can be underpinned by aspects such as dust, perceived stuffiness, carbon dioxide levels, and volatile organic compounds (VOCs) used in the finished building materials (Park and Yoon, 2011). Poor IAQ can contribute to underlying respiratory health issues of the building occupants, in addition to eye irritation, which can also manifest as headaches. In extreme cases this can contribute to increased absenteeism or at the very least decreased productivity if the worker opts to remain in the office. In turn, this can affect mental wellbeing as consistently poor working conditions impact on affective properties of the workplace or productivity levels can potentially have an impact on long-term career progression. Historically, IAQ research has been done in relatively old conventional (non-green) buildings using relatively dated technology (Zagreus *et al.*, 2004). Furthermore, much of the IAQ research has occurred in experimental laboratory settings, which are not always an accurate reflection of a realistic office environment, due to an artificial setting as only one of the IAQ components can be manipulated at a time. Furthermore, tasks may not be a true reflection of the research participant's daily work (Veitch and Newsham, 1997; Wyon, 2004; MacNaughton *et al.*, 2015).

1.3.2 Lighting Comfort

This component comprises two attributes, lumens and lighting comfort. This essentially measures the quality of light and how this impacts the comfort of the building occupants. The quality of both artificial and natural light can create glare (Alker *et al.*, 2014), as this may cause visual irritation, which can hinder productivity levels, mood, comfort, and health (Veitch and Newsham, 1997). The artificial lighting is defined by the type of globe(s) installed in the building, for example, wattage and conventional versus energy saving can produce different

light quality. Most offices tend to opt for white lighting, while there are spaces in modern offices that make use of warm lighting, which can be less detrimental with regards to visual irritation (Thatcher and Milner, 2014a). Lighting quality can influence mental wellbeing after prolonged exposure to an uncomfortable level of light, whether it be too light or too dark, which can further impact productivity as strained eyes will hinder the efficiency of completing work related tasks. The light quality in older lower grade office buildings has tended to be poor, as this was not necessarily a priority when catering for lower and middle level workers who were generally located in open plan space. Furthermore, executive level workers were placed in single offices, which tended to be furnished with additional free standing and desk lighting, thus resulting in a higher quality of lighting, Moreover, executives tend to have direct access to natural light and possible view from their offices, which is addressed in section 1.3.5.

1.3.3 Thermal Comfort

This includes the assessment of both temperature and humidity levels and how they are managed and controlled by the building occupants, especially during different seasonal periods (Leaman and Bordass, 2007; Tanabe *et al.*, 2015). Thermal comfort can be linked to productivity, as this is usually underpinned by the physical comfort of the building occupants (Lan *et al.*, 2011; Alker *et al.*, 2014). Thermal comfort of occupants can be difficult to manage as different people (e.g., different genders) experience different temperatures as too cold or too hot. This can impact individual productivity, as a minority of workers will most likely have to accept the majority's defined comfortable temperature (provided that the temperature can be reliably modulated). Thermal comfort is also problematic to manage (Frontczak *et al.*, 2012) in large open plan offices as ventilation or lack thereof can affect building occupants depending on where they are located in the office, for example close to a window or close to a communal device that may generate residual heat or humidity or working next to ventilation outlets which may be far from the sensors which control the temperature. Another challenge is that in some buildings temperature and thermal comfort is automatically controlled, thus removing the option for building users to instantly make modifications without logging a call to the facilities management department. The impact of thermal comfort on mental wellbeing may only become apparent after a prolonged period of time, as users may experience differing levels of discomfort at different times of the year. Furthermore, the differing levels

of discomfort may be underpinned by the age and the quality of technology of the HVAC system.Poor quality thermal comfort and control can lead to health related problems, for example execessive dryness can potentially lead to increased chances in baterial infections, which can result in respiratory and dermatological problems. Moreover, high humidity levels can result in the build of bacterial and fungal spores in a poorly ventilated building, which can be transmitted to occupants.

1.3.4 Acoustic Quality

This component comprises the assessment of acoustic quality in terms of a high-level acoustic audit, acoustic operational guidelines, and quantitative acoustic testing. The way sound travels through a building can impact productivity levels as unhealthy noise levels, specifically speech and office noise can negatively affect mental capability (memory and arithmetic skills) (Banbury and Berry, 1998). Further research by Banbury and Berry (2005) found that in open plan offices ringing phones at vacant desks and background talking were two of the main acoustic distractions that impaired productivity. Conversely well designed office layouts can channel sound away from areas where occupants need to concentrate, but also allow for a level of ambient noise that feeds productivity (depending on the industry) (Kim and de Dear, 2012; Alker *et al.*, 2014). Furthermore, for certain industries where constant collaboration is required, office workers need to clearly hear their colleagues without the need to shout. Therefore, office design needs to cater for excessive noise while simultaneously allowing for close collaboration to occur without the overall acoustics creating distractions that hinder productivity. Building materials that support non-load bearing partitions should be adequately sound resistant to provide for workspaces that allow building occupants to effectively focus on their work. This will hinder the possibility of the impact on both physical (headaches) and mental (distractions) wellbeing, as the latter may only become obvious after a long period of time. One of the challenges of managing noise flow is the age of the building, ergo the internal design, which reduces the options of redesigning the internal space that can result in enhanced acoustic quality. Contemporary building design makes use of glazing both as a design feature and to allow for natural light (and possibly views), however this building material can inadvertently increase noise levels due to its large flat, hard nature, as noise can bounce off the internal glazing.

1.3.5 Daylight and Views

This component focuses on daylight access, glare control, views, and line of sight. Natural light and views can positively impact performance of building occupants (Edwards and Torcellini, 2002). Daylight can be linked to lighting comfort but direct sunlight and glare due to the orientation of the building, time of day/year can hinder productivity. This can be addressed by installing modern shading mechanisms, thus resulting in allowing building occupants to enjoy natural light and views, while maintining productivity efficiency, particularly cognitive ability (Jamrozik *et al.*, 2019). However according to Alker *et al.* (2014) views of nature can aid mental wellbeing in the workplace. One of the advantages for a building having a glazed finish as opposed to the conventional brick and mortar is that this allows for a high quantity of natural light (and potentially views of nature). A major disadvantage is linked to temperature control from direct sunlight as this can result in overheating the inside of the building (especially for those people working near the façade), which would result in increasing the HVAC usage, i.e., increasing electricity and water consumption. Another challenge is managing the optimum combination of artificial light in conjunction with natural light at different times of day during the four main seasons. If the internal light is too dark or bright then this could negatively impact both physical and mental comfort, which would in turn hinder productivity levels. The amount of natural light is determined by the orientation, age, and architecture of the building, i.e., the amount of glazing. The design of conventional buildings tended to be less focused on the natural light, as glazing increases the upfront building costs, which were historically viewed as negatively impacting return on investment (ROI), at least in the short-term. Additionally, the location of the building (density of the site and the greater urban setting) also contributes to the amount of natural light, as neighbouring buildings could block direct sunlight.

1.3.6 Look and Feel

The aesthetic space of an office environment plays a role in wellbeing. This includes the shapes, textures, colours, and spatial forms (e.g., ceiling heights) of the physical environment. Type of contours, such as smooth finishes tend to provide a sense of calmness, while sharper contours can give the illusion of a more tense environment (Wang *et al.*, 2020). The general

internal environment is often defined by the culture of an organisation, which is underpinned by the industry and dominant profile (age, gender, individual culture, qualification, religion) of the building occupants. While the look and feel may be considered to be a less obvious IEQ attribute, the overall working environment plays a role in mental and physical wellbeing, which inevitably impacts on productivity levels (Alker *et al.*, 2014). The correct look and feel of an office environment can meet the needs across generations of knowledge workers within the same organisation, specifically in spaces where collaboration occurs (Joy and Haynes, 2011). Further research by Haynes (2011) noted the corporate real estate (CRE) managers should note the needs and preferences of different generations within an office environment. Determining specific needs for each generation is challenging, however the look and feel of an office environment can be underpinned by different working styles, which can be supported by providing space for concentration, collaboration, and contemplation. Additionally, being aware of the psycho-social environment can alsoinfluence the physical layout of an office environment, specifically regarding ambient noise, ergonomic furniture design, and publicly supporting the health and wellbeing of building occupants (Haynes, 2011).

1.4 Workspace Layout

Workspace quality comprises the air quality, noise levels, light quality (natural and artificial), office layout, and general satisfaction of building occupants (Rashid *et al.*, 2012). All these attributes can have a direct and indirect impact on the psychological status of building occupants, which can potentially influence their productivity. Maintaining and enhancing knowledge worker productivity levels is a factor that is leading large corporate property owners and tenants to implement green building features and initiatives (GBFIs), with the possibility of gaining green building certification (Nurick and Cattell, 2013). There has been research (Kato *et al.*, 2009) that has attempted to link workspace quality with organisational outcomes such as absenteeism, employee turnover, productivity (Knight and Haslam, 2010), and presenteeism, which occurs when building occupiers are physically in the office (present), but their productivity levels are so low that they are in effect absent from work. The quality of the physical working environment can lead to increased cases of absenteeism or more subtly, presenteeism. Most research focusing on absenteeism and/or presenteeism tends to

focus on individual interactions with their work (i.e. their skills and motivational levels), collaborations with colleagues, psychological distress, and job satisfaction (Biron *et al.*, 2006).

The level of IEQ in terms of the types of GBFIs makes a direct contribution to workspace quality, which can potentially influence the level of individual work engagement and task efficiency (Alker *et al.*, 2014). Building occupiers may not be aware of the many GBFIs that contribute to IEQ (for example, carbon dioxide (CO_2) monitors that are embedded in an HVAC system), while there could be certain building elements that building occupants are aware of and link to their workspace quality, for example natural versus artificial light. Research for the WGBC identified that commercial building users have a relationship with the building, be it subtle or more overt (Alker *et al.*, 2014). The type of user/building relationship is a result of the workspace quality, or put in practical terms, the actual design of the building (Vischer, 2008; Alker *et al.*, 2014). The design of the building is linked to building components that directly link to IEQ. The components that are more noticeable by users are the build-up in the level of CO_2 (usually perceived as 'stuffiness'), the quality and the residual noise of the HVAC system, and the level of natural ventilation (Alker *et al.*, 2014).

A building's internal (and to some extent external) design is a reflection of a specific industry and the company's culture (Earle, 2003). Research by Chadburn *et al.* (2017) indicates that knowledge workers across the industries of property, construction, accountancy, consulting, and marketing tend to be based in open-plan offices, however approximately a third (30%) are located in shared offices (2-3 people per office), semi-cellular space, or private offices. The internal design of offices for different types of industries is not only a reflection of the company culture but also the type of work that is being conducted and hence the type of organisational outcomes expected by the organisation. This is supported by the concept of Activity Based Working (ABW), which is defined by the creation of a variety of spaces depending on the task type being performed by the building occupant(s) (Candido *et al.*, 2016). ABW has found to provide superior occupant satisfaction with the IEQ, which is mainly due to the dynamic design of the workspace spatial configurations that invariably meets multiple needs of building occupants in different work settings as opposed to a single generic spatial configuration (e.g., cubicles) that only meets the needs of the majority of the building occupants (Candido *et al.*, 2016).

Workspace layout contributes to IEQ at its simplest level in that it provides occupants with a feeling of the comfort level of the office environment. Therefore, workspace layout can potentially contribute to a green building certification submission. Research conducted by Thatcher and Chunilal (2015) provided preliminary qualitative evidence that workspace layout in a green versus conventional (non-green) buildings was considered to be superior in the form of: general layout, wireless office resources, meeting rooms, access to quiet working spaces, and a layout that facilitates collaboration. Laughton and Thatcher (2018) had mixed findings with regards to workspace layout. For example, shared offices and agile spaces indicated relatively high psychological wellbeing, compared to reserved and open-plan spaces. Workspace layout can potentially contribute towards individual productivity (Alker *et al.*, 2014) and organisational performance. Informed workplace layout planning should be implemented to allow for different modes of work that range from distraction-free individual spaces to layouts that facilitate collaboration (Lee and Brand, 2005). It was found that relatively quiet workspaces (private workstations or offices) in an environment with good ventilation and control over temperature tend to result in higher productivity levels by office workers (Chadburn *et al.*, 2017).

1.4.1 Advantages of Workspace Layout for Green Buildings

Green building design often results in office layouts that compliment IEQ components. Many contemporary office layouts are usually open plan, with a few cellular offices for senior executives, however this is changing to fully open plan for all staff (Maher and von Hippel, 2005). These layouts can hinder some IEQ components, such as thermal and acoustic quality, as controlling temperatures and noise levels can be difficult in large open spaces as they cater to the majority of building occupants and are frequently automated. The ambient environment is also influenced by the availability and positioning of communal office resources (e.g., photocopiers and water coolers), collaboration spaces and quieter concentration pods, which can all impact individual productivity levels. Furthermore, the ambient environment is also influenced by the internal design, such as double volume ceilings or mezzanine floors, both of which require attention in terms of ventilation, thermal comfort, and noise control. Workspace layout in green buildings can also include a focus on physical

comfort in terms of ergonomically designed furniture, which in the long-term has an influence on mental wellbeing. Other features in green buildings that form the greater layout design of the building include green roofs and/or the placement of internal biophilic displays to provide a sense of calmness and simultaneously act as a pseudo partition in larger open plan offices.

1.5 Location and Amenities

Amenities can be located within a building or offered within the greater building location and urban precinct. Some contemporary buildings offer gyms and grocery stores for convenience for the building occupants. There are companies that focus on the location of their buildings in terms of access to arterial routes for private and public transport, ease of access to medical facilities, as well as other service facilities such as mobile phone shops or coffee shops (Ott and Hahn, 2018). From a macro real estate development perspective, the inception of mixed-use precincts can add value to individual buildings, as offices can be complimented by retail buildings that are in walking distance. This encourages building occupants to walk when accessing retail services, which positively impacts mental and physical wellbeing, , which in turn results in alleviating stress levels and other psycho-physical conditions and in turn might aid productivity levels (Alker *et al.*, 2014). The ease of cycling and walking to work provides a mutual benefit to both employer and employee, as this physical activity can reduce absenteeism through healthier workers, assuming the urban environment provides the necessary infrastructure, safety and the distance is not heavily time intensive. Access to open spaces, such as green roofs or nearby parks provides for breaks that alleviate mental fatigue, which has a long-term benefit on mental and physical wellbeing (Hendriksen, 2009; Gensler and Urban Land Institute (ULI), 2011). Providing amenities that make companies more attractive is an indirect approach to enhancing productivity as this can result in attracting higher quality talent. Thus, amenities (and location) can be used as a competitive advantage by commercial property tenants and owners (Brown *et al.*, 2010; Harris, 2018). The quality and location of simple building amenities is often overlooked. For example, the number and speed of elevators in an office building, the size and cleanliness of bathrooms, sufficient parking bays and cafeterias that offer a wide range of healthy food might all impact of occupant comfort and wellbeing (Vischer, 2008). These types of simple amenities can send a subtle message to the building occupants about the company's culture in terms of caring for

their employees and guests, which can potentially attract high calibre (more productive) staff (Harris, 2018). The Australian office market identified that green leases were linked to buildings with high quality amenities, that could potentially be linked to higher productivity levels (Rameezdeen *et al.*, 2019). Research conducted by Fuerst and van der Wetering (2015) on green versus conventional (non-green) buildings indicated that walkability (location) to certain amenities, such as retail centres and schools could possibly result in a rental premium for a green office building, which was somewhat confirmed by Ott and Hahn (2018), subject to specific market conditions, time frames and assumptions when conducting commercial real estate valuation.

1.6 Previous Research on Productivity and Performance in Green Buildings

Conventional buildings, depending on their quality can hinder individual productivity and potentially organisational performance. In worst cases, this can occur due to sick building syndrome (SBS), which can negatively affect the physical health of building occupants (Ghaffarianhoseini *et al.*, 2018). An overarching definition of SBS is a collection of non-specific symptoms that generally result in eye, nose, and throat irritation, headaches, and nausea, due to occupying certain workspaces (World Health Organisation (WHO), 1983; Shan *et al.*, 2016). Conventional buildings provide occupants with certain basic needs, such as shelter from the elements, a place to operate (intended to support their productivity), which gives the organisation a sense of coherence (intended to support the organisation's performance). However, conventional buildings can also contribute to building occupants' not reaching their optimum levels of productivity, which can result in hindering organisational performance.

The terms productivity and performance are often used interchangeably within academic and corporate literature. For the purposes of this research productivity and performance will relate to the individual and organisation, respectively. Feige *et al.* (2013) describe individual productivity to be how employees contribute towards organisational objectives. Feige *et al.* (2013) state that performance equates to the organisation's turnover divided by the number of employees. Haynes (2007b) and Feige *et al.* (2013) describe productivity and performance differently. Both authors incorporate the role of the individual. However, the manner in which the individual is measured and contributes to an organisation differs. This could partially be

due to the two terms (i.e., performance and productivity) being used interchangeably. Regardless of the subtle differences in terminology, both authors point to the importance of the relationship between the individual outcomes and the organisational outcomes. Thatcher and Milner (2012) conducted a longitudinal study of green and conventional buildings indicated that occupants that moved to a green building did not experience significantly enhanced physical and mental wellbeing, nor reported higher perceived productivity levels. This was further supported by Zitras *et al.* (2021), who acknowledged that there were mixed findings regarding the positive impact of green building on health, wellbeing, and productivity, which illustrates why research in this area is still ongoing.

Green building advocates claim that occupants of green buildings are more productive, which arguably has a direct impact on the financial performance of their organisation (Milne, 2012). This has yet to be fully supported as there are many critics of the legitimacy with regards to the measurement of productivity (Thatcher and Milner, 2014b; Byrd and Rasheed, 2016; Mulville *et al.*, 2016; Bortoluzzi *et al.*, 2018), especially within the service/knowledge based sector of the economy where the predominant form of measuring productivity is a combination of self and supervisor assessment, which can contain an element of subjectivity from both parties (Haynes, 2007a; 2007b; 2008a; 2008b). However, there are also many other different methods of productivity measurement. Other measures that have been used within this sector include post-service customer ratings, the ability to process new business, contracts closed, errors made, and employee turnover rate (Collier, 1995). However, self- and supervisor-assessments are still the most commonly applied measure. Organisational performance within a corporate context is normally measured against quantifiable elements. The most commonly used measure is the organisation's bottom line (i.e., profitability). Other measures include comparing an organisation to their competitors with regards to a number of criteria, such as: value for money (ROI), client service, and short/medium/long term performance within the context of a specific industry (e.g., financial services).

Productivity is considered more difficult to measure as there are different approaches which all have their respective strengths and weaknesses. The three main approaches that have been adopted by previous researchers are (1) laboratory-based studies, (2) office-based studies, and (3) laboratory-meets-the-office studies, which comprises the use of wearable

technology in order to measure the environment and movement of building occupants (Alker *et al.*, 2014). A common data collection approach is to ask questions and then have respondents use a variation of scales in order to choose the option that best reflects their perception of their productivity levels; which are underpinned by health-based (absenteeism, presenteeism) and perceptual (mood, fatigue, job satisfaction, and engagement) measures (Sullivan *et al.*, 2013). One of the problems with measuring perceptions of productivity is that it is not always an accurate measure of actual productivity in terms of key performance indicators (KPIs) (Bortoluzzi *et al.*, 2018). However, there is an argument by some researchers (Leaman and Bordass, 2000) that perceived productivity is at least, in some way, a reasonable indicator of actual productivity. According to Sullivan *et al.* (2013) the conversion of perception data to numerical outputs should be treated with a degree of caution as this type of data only provides a certain kind of conclusion without necessarily providing a comprehensive set of results that could potentially offer a richer set of results.

1.7 Organisational Outcomes

Ideally, employee and organisational outcomes should be aligned. However, this is not necessarily the case, as expectations from an organisational perspective do not always mirror reality from an employee's point of view. This can partially be a result of the physical working environment which has an impact on productivity levels (Knight and Haslam, 2010) and thus has a bearing on whether organisational outcomes are indeed achieved. The quality of the physical working environment can lead to increased cases of absenteeism or more subtly, presenteeism. Most research focusing on absenteeism and/or presenteeism tends to focus on individual interactions with their work (i.e. their skills and motivational levels), collaborations with colleagues, psychological distress, and job satisfaction (Biron *et al.*, 2006).

There is often a disconnect between individual productivity levels and organisational outcomes. Organisational outcomes, which underpin organisation performance (i.e., financial performance) can be defined by the corporate culture, management systems, operational systems, resources, products, and markets (Flamholtz, 2009). The level of success of organisational performance can be determined by the alignment of strategic development and organisational complexity. Corporate culture of some organisations will include policies

that speak about the environmental awareness, which may also include IEQ (Flamholtz, 2009). Hence, this can result in the implementation of environmental initiatives within the organisation, which in turn is linked to workspace quality and could potentially impact overall organisational outcomes. Harter *et al.* (2003) stated that worker productivity could be attributed to emotional states which could partially be a result of aspects of workspace quality. According to Viswesvaran and Ones (2000) productivity is defined as the manner in which employees engage in order to bring about organisational goals. The level of engagement should be measurable in terms of their actions and outcomes. Another definition is that productivity is considered a sub-set of organisational performance, i.e. performance occurs at the organisational level, while productivity is defined by the individual activities (Haynes, 2007b). It was found that workers that are in a positive mind-set (and in this study this might partly be due to the quality of the physical working environment) tend to impart increased care towards their work and colleagues, which results in greater individual productivity and therefore greater overall performance of the organisation. From a management perspective, this can result in a higher degree of attention to each individual employee (Harter *et al.*, 2003). Simply put, human capital and real estate are the two most expensive items for an organisation. Therefore the alignment of these two assets should lead to maximum "asset performance" (Haynes, 2008a).

There has been research that has attempted to find a relationship between the internal building environment and occupant comfort levels, in addition to individual productivity, and organisational performance (Akimoto *et al.*, 2010; Kossek *et al.*, 2012; Dimoff *et al.*, 2014; Tanabe *et al.*, 2015). However, due to the infancy of this area of research and the lack of sound empirical tests of the emergent models, more in depth research is required to examine existing theoretical models (Vischer, 2007; 2008) that look at environmental comfort and workspace quality, where the ideal scenario is occupant satisfaction and well-being.

According to Feige *et al.* (2013) argument about the difference between work engagement and productivity, this has resulted in the proposed model (see chapter 2, figure 2.1 – Emergent Research Model) that still requires further examination within the context of office buildings and the link of IEQ to individual productivity and organisational performance. Feige *et al.* (2013) attempted to link four components: (1) the building; (2) occupant comfort; (3)

occupant work engagement/productivity; and (4) financial gains to the company, i.e., return on investment (ROI). Their research could only establish that there was a relationship between occupant comfort and work engagement, but there was not sufficient empirical support to link comfort to productivity, which could potentially be used to improve the financial performance of the organisation.

There has been a variety of research attempting to link user comfort to productivity in the office environment. Some researchers have claimed that quantifiably measured proof (despite the inconsistencies in the range of measurement of productivity) does exist linking improved office productivity (and therefore an increase in business performance) to enhanced ventilation, a sub-category of IEQ (MacNaughton *et al.*, 2015). Other researchers (Byrd and Rasheed, 2016) have contested the methods with which productivity is measured and state that there is yet to be categorical proof within a commercial building space that links productivity to IEQ. Moreover, it was found that psychosocial factors (irregular sleep patterns, the status of personal and professional relationships, and management practices) may distort any reported correlation between productivity and IEQ (Byrd and Rasheed, 2016).

Other research has examined the work engagement and organisational performance link. Research by Mayo (2016), for example, found a positive connection between engagement and organisational performance, where organisations with highly engaged employees indicated lower staff turnover rates, higher customer loyalty, and higher productivity levels, all of which led to higher profitability. However, further research is needed to understand the full connections between these variables.

1.8 Formulating a Research Question and Hypotheses

There have been a number of studies that have directly analysed linear relationships between a number of individual IEQ variables (that have commonly included: lighting, ventilation, acoustics, general environment) and job satisfaction (Schwede *et al.*, 2008; Newsham *et al.*, 2009; De Been and Beijer, 2014; Tanabe *et al.*, 2015). There is a lack of robust modelling that creates a distinct link between ambient environmental office conditions and organisational effectiveness outcomes. The main purpose of this research will be to extend on the work of

Becker and Pearce (2003), Haynes (2007a), Newsham *et al.* (2009), Feige *et al.* (2013), Thatcher and Milner (2014b), Byrd and Rasheed (2016), and Zitras *et al.* (2021) by empirically assessing a more comprehensive emergent model (see Figure 2.1) of the relationships that link GBFIs to individual productivity and organisational performance.

Haynes (2007a) developed a theoretical framework that combined the physical and behavioural environments within an office that linked to occupant productivity. According to Haynes (2007a), the physical environment comprises office layout and physical perceptions of comfort, while the behavioural environment comprises the differing levels of interaction and distraction by office workers. This led to the findings that the physical environment (open plan vs. cellular offices) tended to contribute to certain types of behavioural environments that allow for both collaborative and individual working spaces, which had an impact on productivity (Haynes, 2007a). It was further established by Haynes (2008b) that the behavioural environment had the largest impact on productivity, both negative and positive, when compared to the physical components of the work environment.

Vischer (2007) defined environmental comfort as a combination of physical, psychological, and functional comfort(s). Further research by the same author revealed that environmental satisfaction and functional comfort resulted in better user experience in the workplace but were not necessarily linked to an increase in individual productivity (Vischer, 2008). In addition, it was stated by Vischer (2008) that individual productivity within the knowledge economy (e.g. financial services companies) requires efficiency and accuracy, due to the nature of the work, and that there is a possible link between sustainable building practices (i.e. GBFIs) and individual productivity. However, to facilitate the incorporation of GBFIs within this research context a more comprehensive understanding of individual comfort and its relation to organisational outcomes is required.

Feige *et al.* (2013) attempted to create a theoretical model linking building occupant comfort levels to work engagement and productivity. As already stated, while Feige *et al.* (2013) were successful in establishing a relationship between comfort levels and work engagement, they were unable to establish a significant relationship between comfort levels and productivity. However, the same authors did acknowledge that certain building features (e.g., lighting,

temperature, and manually operable windows) did effect comfort levels, which resulted in a limited impact on productivity. Feige *et al.* (2013) identified that further research into IEQ was required to determine the level of influence of IEQ on office workers' productivity. This research provides an opportunity to create new knowledge in this area by extending on the research of Feige *et al.* (2013).

Due to individual productivity and organisational performance continuing to remain a topical areas of research, Feige *et al.* (2013) research model, as mentioned above, looked to examine four components: (1) the building, which focused on IEQ, disruption frequency, office configuration, and environmental control; (2) comfort, which focused on physical, functional, and psychological comfort; (3) productivity and work engagement, which focused on the task and its related context; and (4) the company, which focused on the financial gains of the company (organisational performance) as a result of the implementation of GBFIs that have resulted in increased user comfort. The financial gains have yet to be categorically linked to comfort levels in terms of individual productivity and organisational performance. There are a number of ways to compare organisational performance within the context of financial gain. Not all methods allow for equal comparison, however the incorporation of a standardised method can create the link between organisational performance and financial gain. For example, the comparison of financial services companies that offer similar financial products creates an opportunity for an ideal comparison of organisational performance while simultaneously measuring financial gain.

An emerging research model (Figure 2.1) has been developed as part of this thesis (Nurick and Thatcher, 2021b) in order to visually identify where the gaps in the knowledge exist. The model identifies three different components of the built environment which emerged from the research of Alker *et al.* (2014): (1) the ambient physical conditions; (2) the design of the workspace; and (3) the associated aspects of the physical location. Comfort and satisfaction underpin all three of these components. Comfort refers to various forms of comfort throughout the day and the seasons throughout the year. Comfort can be categorised in a bottom-up framework (Vischer, 2007): (1) physical comfort, which links building users to their actual work environment; (2) functional comfort, which defines the ability of building occupants to operate efficiently within their work environment; and (3) psychological

comfort, which is a more abstract form of comfort that speaks to intangible relationships in the workplace (with colleagues/superiors and/or job stress). Psychological comfort is also linked to territory in the workplace (both individual and group), i.e. the amount and quality of space occupants are allocated in order to operate productively (Haynes, 2007a; Vischer, 2007). Satisfaction can be considered a continuation of psychological comfort as building occupants' satisfaction levels are often linked to the organisation. Dissatisfaction with an organisation can be linked to the physical aspects (office layout), work support aspects (e.g., managerial support), and the culture of an organisation. Simply put, satisfaction is an amalgam of the physical environment and psychological status of building occupants (De Been and Beijer, 2014). There have been cases where there is an indication of an inverse relationship between absenteeism and comfort and satisfaction, which indicate that as levels of comfort and satisfaction increase, employee absenteeism levels decrease (Smith and Pitt, 2011; Alker *et al.*, 2014). This links to a general improvement in well-being, which could potentially have an impact on occupant productivity and organisational performance.

The relationship between the ambient physical conditions and organisational outcomes has been examined extensively; e.g. Newsham *et al.* (2009) and Newsham *et al.* (2013). The connections between the design of the workspace and organisational outcomes (performance) have been less extensively studied; e.g. Carlopio (1996). The linkages between physical location and organisational outcomes (performance) have received the least amount of attention; e.g. Koslowsky (1997). The emergent model (Figure 2.1) by Nurick and Thatcher (2021b) indicates that some of these elements may have a direct impact on productivity; e.g. direct sunlight off a computer screen or inefficient workplace design could inhibit an employee to perform their work function at reasonable to optimum levels. Added to this, some workplace environments may negatively impact the physical health of building occupants, e.g., poor ventilation systems could contribute to an increase in respiratory problems, while some workplace designs could enhance the contribution to baseline physical fitness, e.g., by placing stairs in areas that have high occupant foot traffic. Finally, some internal and external building components could impact work satisfaction and psychological wellbeing, e.g., satisfaction with overall IEQ and the value-add of views. Research conducted by Davis *et al.* (2011) on workspace design, with specific focus on current and emerging issues, acknowledged that there is a gap for further research with regards to green building, as GBFIs

in conjunction with staff behaviour need to be examined in order to yield optimum workspace design for contemporary offices. The Nurick and Thatcher (2021b) emergent model (Figure 2.1) attempts to theoretically assess the impact of wellbeing and health on productivity and how this is moderated by work engagement (Schaufeli *et al.*, 2002), which is partially dependent on employees' perceptions of their work environment. The emergent model (Figure 2.1) attempts to draw distinctions between individual and organisational work outcomes (Parker *et al.*, 2001). It is also recognised that there are other variables that influence individual and organisational work outcomes, which can play a role in impacting individual productivity (Clements-Croome and Baizhan, 2000); e.g. supervisory style, level or structure of remuneration, individual skills and abilities, economic climate, leadership climate and job market (Newsham *et al.*, 2009). The emergent model does not intend to ignore these important variables, but rather to try and uncover the unique contribution of the environmental factors which are estimated to be 4% to 10% of the variance in productivity (Clements-Croome & Baizhan, 2000).

Within the context of green buildings this research aims to unpack the primary relationships to identify further drivers and barriers for the successful long-term strategy regarding the implementation of GBFIs within a workplace environment. Finally, the emergent research model (Figure 2.1) by Nurick and Thatcher (2021b) attempts to expand on the work of Feige *et al.* (2013) by showing that improved individual work engagement from better GBFIs can possibly lead to improved individual productivity, thus resulting in improved organisational performance, which in turn improves financial gain through increased return on investment (ROI). If this were to be the case, then an increased ROI would feedback to initial thinking regarding the location and amenities, spatial factors, and ambient conditions. This would, in turn, result in more incentives to the implementation of GBFIs in the initial building design/retrofitting. Becker and Pearce (2003: 229) posed the following question, which they were not fully able to answer: "…what percentage increase in productivity would be required to justify a particular capital expenditure?" Similar questions were raised by Miller *et al.* (2009) within the context of the Productivity Payback Model (PPM), which probed the issues of what level of increased employee productivity leading to improved organisational performance would offset workplace capital expenditure (ROI), and what is the probability that productivity will increase to acceptable levels, which could be converted to enhanced

organisational performance? The main reason why these questions remained largely unanswered is because most researchers were unsure how to measure productivity (Haynes, 2007a; 2007b; 2008b; 2008a; Byrd and Rasheed, 2016; Mulville *et al.*, 2016).

The above narrative resulted in the following research question and hypotheses:

1.9 Research Question and Hypotheses

Research Question

What theoretical and empirical pathways link GBFIs to individual productivity and organisational performance within an office building?

The overarching research question interrogates the theoretical notion that buildings containing GBFIs, more specifically enhanced IEQ result in superior individual productivity, which can be converted into enhanced organisational performance.

Hypothesis 1

Financial services companies (FSCs) located in green buildings in the long-term on average outperform competing companies located in non-green buildings.

Hypothesis 2

There is a relative improvement (i.e., ranking improves) of annualised returns for FSCs when compared to the number of IEQ points for a green building.

Hypothesis 3

Time in a green building (operationalised as years since occupation) has a positive impact on the relative improvement in annualised returns.

Hypotheses 1, 2 and 3 focus on organisational performance within the context of GBFIs in relation to IEQ points and attributes. This was done by analysing the annualised returns of twenty FSCs, ten based in nineteen green certified buildings, and ten located in thirteen conventional buildings. The annualised return data was analysed over three commonly

offered investments funds; income fund (low risk), balanced fund (moderate risk) and South African equity fund (high risk).

The four substantive chapters of this thesis (i.e., the journal papers) holistically answer the research question by formulating (Chapter 2), addressing (Chapter 3) and testing (Chapter's 4 and 5) the emergent research model (Figure 2.1). Chapter 2 comprises an overarching literature review, which assesses past research that focuses on the link between IEQ and productivity. Chapter 3 continues to interrogate the pathway links between GBFIs to individual productivity and organisational performance, by conducting a scoping literature review that specifically focuses on the research methods applied by previous researchers. Chapter 4 targets the research question by specifically focusing on the linkages between GBFIs and individual productivity. Chapter 5 addresses the three hypotheses by focusing on organisational performance within the context of IEQ and annualised return data of a sample of FSCs located in both green certified and conventional (non-green) buildings. The combined literature reviews and consolidated qualitative and quantitative results address the research question by focusing on different elements (theoretical, methodological, and empirical), which provides a robust investigation (i.e., answer to the research question) to the different pathways and elements contained in the research question and hypotheses. The results are discussed in the main concluding chapter (Chapter 6).

1.10 Limitations

The main limitation of the study is that it only focused on occupants in office buildings, specifically knowledge workers employed by financial services companies (FSCs). The green certified office buildings that comprised this study were only rated according to the Green Star South Africa rating tool. All buildings that were included in the study, both green certified and conventional (non-green) were located in South Africa. The data comprising annualised returns was sourced from publicly available fact sheets produced by each of the FSCs. Therefore, the underlying quantitative data was not within the control of the researcher, however all the FSCs are licensed financial service providers (FSPs), and thus must adhere to financial reporting standards that underpin how investments are presented to the public to facilitate future investment decisions.

1.11 Chapter Summary

This chapter began by providing the reasons and structure of this document, in the form of a high-level breakdown of each of the four journal articles. The main research thrust was introduced, which elaborated on green buildings, GBFIs, the role and main components of IEQ in green building rating tools, and workspace quality. A narrative on previous research on productivity and performance within the context of green building was provided. Further, the discussion focused on organisational outcomes and the relationship between productivity and performance. The chapter ended by stating a main research question and specific hypotheses that will be addressed in at least one of the four research papers that comprise this study. Additionally, a narrative on the limitations of the main study was stated. The subsequent chapters will be the four academic papers, starting and ending with the theoretical and empirical articles, respectively. Following the four papers, a concluding chapter is provided, which discusses the key findings of the research that add to body of knowledge in this evolving field of research. The concluding chapter will culminate by re-visiting the research questions and hypotheses to provide an acceptance or rejection thereof.

2. The Link between Green Office Buildings to Productivity and Performance

2.1 Introduction

The first paper of this research study is a literature review that examined the impact of GBFIs (specifically IEQ) on individual productivity and organisational performance in terms of previous research. Three approaches were assessed: (1) Experimental laboratory studies, (2) Field studies, and (3) Linking GBFIs to organisational outcomes. This resulted in the development of an emerging theoretical model (mentioned in chapter 1 – Figure 2.1), which underpins the remaining three journal papers.

This paper addresses the following research question:
What theoretical and empirical pathways link GBFIs to individual productivity and organizational performance within an office building?

This paper serves as the introductory theoretical starting point by conducting a broad-based literature review on the fields of green office buildings, individual productivity, and organisational performance. Following the main literature review, a theoretical model is introduced, which is used to underpin the subsequent three papers that form part of the overall research project. The main framework for this literature review was to examine and critique the three main data gathering approaches that were applied by previous researchers. This resulted in the development of the emergent research model (Figure 2.1), which exhibited three new pathways: (1) Linking GBFIs to wellbeing, health and comfort, (2) Linking comfort, health and wellbeing to work engagement, and (3) Linking work engagement to productivity, performance and financial gain.

Contribution by the authors:
Nurick wrote the paper as first author, which included conception, structure and all the associated reading, and model development. Nurick also handled all the correspondence with the *Journal of Real Estate Literature* with regards to submission (including re-submission with a schedule of corrections).

Thatcher provided oversight and input at a theoretical level.

The *Journal of Real Estate Literature* was selected as an ideal venue as it is an international journal (Scopus rated), which forms part of the suite of journals published by the American Real Estate Society (ARES). The journals published by ARES are accessed by both real estate academics and practitioners that are based across multiple real estate markets. The ARES is one of the six regional groups that falls under the International Real Estate Society (IRES), who promote real estate education and research.

The Relationship of Green Office Buildings to Occupant Productivity and Organizational Performance: A Literature Review

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Abstract

The purpose of this paper is to identify and critically evaluate previous research that looks at the link between green office buildings and the productivity of commercial building occupants. The overarching approach was to highlight and critique the key findings from a variety of researchers that have attempted to find links specifically between indoor environmental quality (IEQ) and individual productivity. This was done in order to develop a theoretical model that links green building features and initiatives (GBFIs) in office buildings to individual productivity and organizational performance. The paper first provides a background of the emergence of green buildings, specifically with regards to utility costs, which led to changes in design and hence to the indoor environment. The core focus of the paper is to provide a literature review of the research that has attempted to link GBFIs to productivity. Various studies have focused on a single, or multiple, components of GBFIs within different settings, such as controlled laboratory settings, field studies, or longitudinal studies. Other studies have chosen to focus on occupant health, comfort, and organizational outcomes in relation to GBFIs. This paper attempts to consolidate this area of research by showing what has been done and what were their findings in order for a new theoretical model to emerge. The proposed model links GBFIs to increased individual productivity and organizational performance which results in increase building value, thus justifying the initial capital expenditure for the implementation of GBFIs.

Key words: green buildings, green building features and initiatives (GBFIs), wellbeing, productivity, performance

Introduction

Green buildings have become an increasingly topical area for researchers, as their prominence has increased rapidly in developed markets in the last two decades (Steinemann *et al.*, 2017). There are a number of green building rating tools (GBRTs) used around the world that predominantly focus on energy and water consumption. This is argued to be the case because these utilities can be directly linked to the financial performance of the building, which in turn provides an incentive to owners and tenants to monitor consumption, as net income impacts the value of office buildings. Therefore, arguably the main focus in order to attain green certification for office buildings is that of savings in utilities (e.g. electricity, water, and waste removal) and building materials as shown in Table 1. This growth in the green building movement (and the use of the associated GBRTs) has provided positive incentives for real estate to produce assets of higher quality while also reducing costs (such as utility costs) to building occupants. Most of the research on green buildings has focused on "hard" commercial issues, such as green building premiums in relation to payback periods regarding the installation of green building features and initiatives (GBFIs). Although a reduction in operating costs is beneficial to both commercial property owners and their tenants, the implementation of GBFIs that address indoor environmental quality (IEQ) have the potential to realize a comparatively greater financial impact on the organization because they have a direct impact on the employees through improved wellbeing and possibly also increased productivity. Therefore, this has shifted the motivation for incorporating GBFIs into office buildings. Clements-Croome (2005), citing numerous sources, stated that operating costs are only a fraction (1% to 5%) of the staff costs, and therefore a marginal increase (of between 3% to 10%) in productivity through a focus on IEQ should offset operating costs significantly, thus having a marked impact on payback periods. However, existing theory does not yet draw the theories from various disciplines together in a way that provides an integrated model to show how improved IEQ leads to improved organizational outcomes. Given the strong possible economic drivers for green building, there is a distinct need to review the literature in order to develop a speculative model that elaborates on these connections.

Different built environment stakeholders have seen the benefits of green buildings, resulting in an exponential growth in green buildings across the different real estate sectors. One of the selling points made by the World Green Building Council (WGBC) of building green offices is the assertion that enhanced IEQ results in improved organizational performance (Alker *et al.*, 2014). However, the focus on occupant wellbeing is not as heavily prioritized in the rating tools, probably because it is more difficult to monetize and therefore is a harder selling point to commercial property investors. Table 1 provides a summary of four prominent GBRTs (BREEAM, LEED, CASBEE, and Green Star South Africa (GSSA)), which indicates the heavy weighting attributed to water, electricity, and building materials. Over half the points for LEED (54%), CASBEE (65%), and Green Star South Africa (51%) are attributed to the three categories that influence initial building costs and operating costs. However, it should be noted that GSSA has attributed 20% of the points to IEQ, which indicates that the GBCSA acknowledges that office buildings primarily exist, in principle, to allow occupants to operate at optimum efficiency levels. In addition to the four mainstream GBRTs listed in Table 2.1, there is another tool that cannot be directly compared to these other GBRTs because it only looks at the indoor components; WELL intentionally focuses on a list of categories that underpin health and wellbeing including IEQ (e.g. air, thermal comfort, sound, and mind) amongst other factors such as nutrition, exercise, and community connections. While WELL is certified by the Green Business Certification body, it is not specifically a GBRT.

Table 2.1: GBRTs Points Weighting Comparison

CATEGORY	BREEAM	LEED	CASBEE	Green Star SA (GSSA)
Electricity/Energy	16%	32%	25%	25%
Water	7%	9%	30%	12%
Building Materials	15%	13%	10%	14%
TOTAL	**38%**	**54%**	**65%**	**51%**
Health and Wellbeing/IEQ	14%	14%	10%	20%

As shown in Table 2.1, occupant health and wellbeing/IEQ can be found in most GBRTs. This aspect focuses on the quality of the user experience within a building. IEQ is, in part,

underpinned by the overall design of the building, its implementation, and the management of sound quality, lighting, heating, ventilation, and air-conditioning. As already mentioned, the measurement of energy, water, and building material usage is relatively easy to measure (Rashid *et al.*, 2012) and has been well established with regards to long-term utility savings, however the impact on office building occupants is more difficult to measure because they are affected not only by the building, but also by other occupants in the building (e.g. managers or colleagues) as well as other interactions that they have outside of the building (at home, in the traffic, their general health, etc.). Currently the most common form of measuring health and wellbeing is by conducting post occupancy evaluations (POE) because these can be used as diagnostic tools for isolating building related problems (Prieser, 1995; Cooper, 2001; Tagliaro and Ciaramella, 2016).

The purpose of this research is to show the development of a new theoretical model that links GBFIs to occupant wellbeing, individual productivity, and organizational performance in an office building. This is done by synthesizing and then extending on existing theory in a transdisciplinary manner. As will be shown in later sections of this paper, the existing theory only provides limited insight into individual productivity (sometimes also referred to as work performance) in relation to one of the physical office environment features, the comfort levels these evoke, and the work engagement that results. The implementation of GBFIs can potentially influence individual productivity within an office building, which may impact organizational performance (i.e. the tenant's profitability). This is underpinned by the notion that gains from improvements in organizational performance outweigh the savings from utility costs due to the implementation of GBFIs (Loftness *et al.*, 2002). If individual building occupants are satisfied with their environment, then the organization would be less likely to vacate the premises. A decrease in building vacancies would increase the building's net operating income (NOI), and de-risk the building from the owner's perspective, thus resulting in a reduction in capitalization and discount rates. This would culminate in a greater value for the building, as commercial buildings are valued based on the NOI and a residual value which requires the application of a capitalization rate, and also a discount rate, depending on the valuation method. No researchers have attempted to test a theoretical model that encapsulates both individual productivity and organizational performance in a feedback loop

that justifies the implementation of GBFIs, where a by-product is enhanced office building value.

Therefore, there is firstly a need for a consolidated review of the literature that addresses and identifies the main gaps in the existing body of knowledge that links IEQ to individual productivity levels. There have been different approaches and preliminary models to determining to what degree a link exists and also conjecture amongst researchers regarding the manner in which productivity is measured. Secondly, this will be followed by the development of a new theoretical model that will aid in graphically depicting the current linkages in the literature and also how these linkages flow into how individual productivity and organizational performance are potentially impacted by different components of IEQ. A product of this paper is the formulation of this new theoretical model, which is underpinned by the following research question: *What proportion of impact do GBFIs have on individual productivity and organizational performance within an office building?*

Previous work (existing models)

The impact of the environment on wellbeing and work efficiency has been researched for many years prior to the emergence of the green building movement (e.g. (Wohlwill, 1966; Fanger, 1970)). In one example, Campion and Berger (1990) defined four job design approaches – motivational, mechanistic, biological, and perceptual/motor – that could lead to effective organizational outcomes. The relevant design approach to consider for this paper is the biological approach which was derived from ergonomics. Simply put, this approach seeks to understand interventions that minimize the physical strain on an employee by reducing strength and endurance requirements, while simultaneously reducing environmental conditions that could hinder work efficiency. The argument is that this should reduce employee discomfort, fatigue, and illness. However, because most office workers are now mostly working in knowledge-based jobs, the focus on physical attributes of physical strain and exposure to harsh environmental conditions such as sunlight exposure, extreme cold or heat, or windy conditions are less of a concern since in a physical office the built environment moderates many of these harsh environmental effects. More recently, work

design models have also included aspects such as ergonomics (i.e. the physical layout, the environmental conditions, and work-equipment design) which have an impact on wellbeing and productivity outcomes (Humphrey *et al.*, 2007). Knight and Haslam (2010), for example, have found that workspace quality and a greater quality physical working environment impact on mental performance and thus individual productivity in a knowledge-work environment.

A variety of literature was reviewed that covered GBFIs, workspace quality, individual productivity, and organizational performance in green buildings, with a specific focus on organizational outcomes, and the integration of GBFIs and productivity in office buildings. This required a great deal of cross-disciplinary reviewing of literature involving the fields of organizational psychology, the sustainable built environment, indoor air quality, occupational health, and ergonomics (amongst other disciplines) thus requiring an understanding of various non-uniform terminology and different research methods. This past research generally fits one of the following three types: (1) experimental laboratory type studies, where there is an attempt to link one or more IEQ features to productivity or performance; (2) field studies that try to link one or more IEQ features to health and/or productivity and/or performance; and (3) exploratory studies that try to find relationships between IEQ features and organizational outcomes. Tables 2.1, 2.2, and 2.3 summarize each of the aforementioned types. Following on from a review of the findings of these types of studies we give a number of observations and critiques, which are also summarized in these tables, that refer to the challenges associated with how multiple building and non-building related variables impact on individual productivity and organizational performance.

Experimental Laboratory Studies

Table 2.2 focuses on experimental laboratory studies that have explored the possible organizational performance benefits. This research focused on a variety of IEQ factors, such as light quality (Veitch and Newsham, 1997), indoor air quality (Wyon, 2004; Park and Yoon, 2011), temperature (Zhang *et al.*, 2010; Park and Yoon, 2011; Tanabe *et al.*, 2015), and ventilation rates (MacNaughton *et al.*, 2015) – all in relation to some measure of performance. Our general critique was that these types of cross-sectional studies limit what

we can say about the long-term effects of environmental conditions and that longitudinal studies may be a better approach to determine whether there are any lasting effects that have an impact on organizational performance.

Table 2.2: Summary Examples of Previous Work – Experimental Laboratory Studies

Author(s)	Outcome	Critique
Veitch and Newsham (1997)	Tested if changes in light quality and energy efficiency affected task performance, mood, health satisfaction, and comfort. Inconclusive results regarding light quality and task performance.	All these studies were cross-sectional in nature. A longitudinal study design in an actual work context may be a better approach. Longitudinal designs would help determine whether any benefits are temporary or long-lasting (i.e. if performance benefits are only short-term this would only have a minimal effect on organizational performance). Laboratory conditions are often difficult to replicate in real world contexts, especially organizational contexts, where there are both financial and social incentives to perform.
Wyon (2004) Park and Yoon (2011)	The impact of indoor air quality (IAQ) on behaviour and productivity. The research involved removing indoor air pollutants and increasing the supply of clean air. Poor IAQ can reduce performance of office workers.	
Zhang *et al.* (2010)	Simulated a range of winter and summer conditions (18^0C to 30^0C) in an office environment. The participants were given three different tests to assess their productivity. Results indicated that changes in temperature did not significantly impact the performance of the subjects.	
Park and Yoon (2011)	Experiments on ventilation rates and work performance in experimental offices over an eight hour period. Results indicated that increased ventilation rates led to a perception of improved air quality, resulting in a marginal, non-significant, increase in work performance. Temperature changes did not significantly impact performance. The researchers acknowledged that variations in improved work performance were dependent on the type of tasks that were used in the laboratory setting.	

MacNaughton *et al.* (2015)	Increased ventilation rates resulted in a marginal non-significant increase in performance, where similar controlled experiments were conducted that involved cognitive functioning scores with exposure to carbon dioxide, adequate ventilation, and volatile organic compounds (VOCs).	
Tanabe *et al.* (2015)	Laboratory experiments in a climate chamber that included five different scenarios that involved changes in temperature, omission of certain clothing, and inclusion/exclusion of certain portable cooling devices (e.g. fans). Weak correlation between temperature and individual performance.	

Although many of the studies listed in Table 2.2 focus on different IEQ factors there seems to be a common trend relating to poor to moderate results linking IEQ to performance. In studies involving light quality (Veitch and Newsham, 1997), the results were inconclusive. Wyon (2004) and Park and Yoon (2011) concluded that poor indoor air quality can reduce performance of office workers, while Zhang *et al.* (2010) found that changes in temperature did not significantly impact the performance of the research participants. Park and Yoon's (2011) research on ventilation rates found that increased venitlation led to the perception of improved air quality. This resulted in a marginal but non-significant increase in work performance. MacNaughton *et al.* (2015) had similar findings to that of Park and Yoon (2011). Tanabe *et al.* (2015) conducted scenario testing and found a weak correlation between temperature and individual performance. The aforementioned studies, although based only on IEQ attributes, are often loosely used by green building councils (including the World Green Building Council) to justify that green buildings result in improved individual productivity and organizational performance (Milne, 2012; Green Building Council Australia (GBCA), 2015; Green Building Council of South Africa (GBCSA), 2015b; United Kingdom Green Building Council (UKGBC), 2015; United States Green Building Council (USGBC), 2015; World Green Building Council (WGBC), 2015). However, this view is sometimes contested (discussed in more detail in Section 3).

Field Studies Linking GBFIs to Health and/or Performance

A summary of examples of field study-based research is given in Table 2.3. This research has focused on a variety of factors, which have included indoor air quality (Wyon, 2004), comfort (Roulet *et al.*, 2006), temperature (Akimoto *et al.*, 2010), improved indoor environmental quality (IEQ)/physical quality of work environment (Biron *et al.*, 2006; Fisk *et al.*, 2011; Tanabe *et al.*, 2015), ventilation, and temperature (Chadburn *et al.*, 2017). Most of these studies have attempted to find a link between one of the aforementioned factors and individual productivity or organizational behaviour. The research cited in this section highlights examples of field studies within the context of IEQ and health/performance. It is not intended to be comprehensive analysis of research in this area. The overarching critique is that field studies tend to find stronger relationships between IEQ factors and productivity and performance, however the results are often more varied than laboratory studies. Some researchers found strong correlations between building factors and perceived comfort, while other researchers struggled to establish significant relationships between IEQ and productivity, as the results were often found to be inconsistent, possibly due to the influence of non-physical factors (e.g. the psychosocial or behavioural environment).

Table 2.3: Summary Examples of Previous Work – Field Studies

Author(s)	Outcome	Critique
Wyon (2004)	Conducted two, eight-week field studies in call centres in Northern Europe. Decrease in performance due to poor IAQ was actually larger in a field study when compared to the laboratory/simulated environment. Poor indoor air quality resulted in a decrease in performance.	Generally, field studies tend to find stronger relationships between IEQ factors and productivity, however the results tend to be more varied than laboratory studies, i.e. there appears to be an element of inconsistency amongst the results, depending on the focus of the research study, which is stipulated in the Outcome column.
Biron *et al.* (2006)	Physical quality of work environment can lead to absenteeism/presenteeism, which impacts organizational performance.	

Roulet *et al.* (2006)	Studies in 64 office buildings in Europe indicated that there was a strong correlation between perceived comfort and buildings not containing sick building syndrome symptoms.	
Akimoto *et al.* (2010)	Examined the link between thermal comfort and productivity. The research looked at controlled changes in temperature in an office building and how this contributed to symptoms of fatigue and productivity. Results indicated that although there were observed increases in discomfort (i.e. symptoms of fatigue) the changes in temperature have a marginal impact on productivity.	
Fisk *et al.* (2011)	The research focused on the benefits and costs of improved IEQ in U.S. offices. The study looked at increasing ventilation rates and reducing environmental factors that contribute to dampness and mould. Although it was estimated that these types of environmental interventions reduced SBS and absenteeism, thus improving productivity, the authors were unable to accurately quantify the benefits of improved IEQ on productivity.	
Tanabe *et al.* (2015)	Evidence linking IEQ and productivity is inconsistent.	
Chadburn *et al.* (2017)	Offices with good ventilation and temperature control resulted in higher productivity levels. This formed part of a trial study in an office in London, where analyses of the findings indicated that personal productivity was dependent on both the physical and behavioural environments.	

There are obvious limitations with field work studies, as illustrated in Table 2.3. Issues such as motivation, work supervision, the office layout, interaction with work colleagues, different time pressures, and the appropriateness of the work tasks may be some of the factors which differ between laboratory-type studies and field studies. Generally, Wyon (2004) found that the decrease in performance due to poor IAQ was larger in a field study when compared to the laboratory/simulated environment. There have been a wide range of findings linking IEQ and the internal/external building design to health, wellbeing, and individual productivity (Heerwagen and Zagreus, 2005; Roulet *et al.*, 2006; Akimoto *et al.*, 2010; Fisk *et al.*, 2011; Alker *et al.*, 2014; Dimoff *et al.*, 2014; MacNaughton *et al.*, 2015; Chadburn *et al.*, 2017; Laughton and Thatcher, 2018). Roulet *et al.* (2006) found that there were strong correlations between IAQ, thermal, acoustic, and lighting comfort. It was also found that there was a correlation between perceived comfort and those buildings that did not exhibit sick building syndrome (SBS) (Roulet *et al.*, 2006). Research conducted by Akimoto *et al.* (2010) examined the link between thermal comfort and productivity. Their results indicated that although there were observed increases in discomfort (i.e. symptoms of fatigue) the change in productivity was marginal. The benefits and costs of improved IEQ were investigated by Fisk *et al.* (2011). Their study focused on increasing ventilation rates and reducing environmental factors that contribute to dampness and mould. Fisk *et al.* (2011) were unable to accurately and independently quantify the benefits of improved IEQ on productivity. Chadburn *et al.* (2017) found that quiet workspaces with good ventilation and temperature control tended to result in higher productivity levels within an office environment. The results indicated that personal productivity was dependent on both the physical and behavioural environments.

While most of the studies have tended to focus on IEQ, there are a smaller number of studies that have looked at other aspects of the built environment. For example, a study of an office environment prior to moving into a green certified building by Laughton and Thatcher (2018) established that different types of workspaces contributed to different types of physical stress in an office environment. It was found that discomfort attributed to the neck, shoulders, upper and lower back was high, regardless of the office layout. The types of organizational outcomes are frequently defined by the office layout which is often determined by the nature of the business. For example, open-plan layouts are found in a marketing firm while cellular

offices are typically found in a legal practice. In addition, the quality of the physical working environment can have an impact on productivity, which can potentially lead to absenteeism or more subtly, presenteeism (Biron *et al.*, 2006), and thus impact on organizational performance (Knight and Haslam, 2010). Despite the apparent consistencies described in this section, Tanabe *et al.* (2015) noted that the evidence for a link between IEQ and employee productivity was frequently inconsistent. In general, while field studies do find significant relationships between workplace factors and individual and organizational outcomes, these results tend to be more varied than in a laboratory environment.

Studies Linking GBFIs to Organizational Outcomes

Table 2.4 provides a breakdown of research that has attempted to find a link between GBFIs and organizational outcomes. There were a variety of findings that analysed corporate culture (Flamholtz, 2009), workplace quality (Harter *et al.*, 2003), office design (Kampschroer *et al.*, 2007), different types of comfort (Vischer, 2008), perception of the work environment (Vischer, 2008), and ultimately an attempt linking comfort to work engagement and subsequently a connection to financial gain (Feige *et al.*, 2013). The general comment is that non-environmental factors can also influence individual productivity. Only a partial link has been established between comfort and work engagement and no link was found between work engagement and financial gain. These findings might suggest that there are possible mediating variables in these relationships.

Table 2.4: Summary Examples of Previous Work – Linking GBFIs to Organizational Outcomes

Author(s)	Outcome	Critique
Harter *et al.* (2003)	Workspace quality can enhance engagement that contributes to productivity, which contributes to organizational outcomes.	Psychological well-being contributes to productivity. However this is very difficult to gauge at an individual level within an office environment.

Kampschroer *et al.* (2007)	A balanced scorecard strategy matrix was applied in order to test the links between goals, desired behaviours, workplace strategy, and outcome measures. Attempts to create a link between physical space, behavioural change, and organizational outcomes. A linear approach was applied where data were collected three years before and two years after a business moved from a modular office design to a more open plan office design containing an organic layout. Results indicated an increase in behavioural interaction and organizational performance.	It is acknowledged that non-environmental factors also contribute to organizational performance.
Vischer (2008)	Developed a workplace comfort model comprising physical comfort, functional comfort, and psychological comfort. The different types of comfort were underpinned by workspace quality attributes such as noise, lighting, air quality, thermal comfort, furniture layout, and ergonomics. These environmental factors influenced the following behavioural factors: employee satisfaction, employees' perceptions of the work environment with regards to territory, ownership and belonging, and individual productivity. The comfort model's IEQ factors influenced employee satisfaction and individual productivity.	One weakness of Vischer's (2008) model is that it does not consider non-IEQ factors that influence also IEQ, e.g. personal problems, financial troubles, physical and mental health issues unrelated to the building.
Flamholtz (2009)	Organizational outcomes are underpinned by corporate culture, management systems, operational systems, resources, products, and changing markets. Different corporate cultures have either policies or subtle prompts that mention environmental awareness, which may include IEQ. The implementation of IEQ features	IEQ is not a prominent factor within corporate policies, as it is easier to link management systems and other traditional business measures to organizational performance than features of the physical working environment.

	within an office could improve workspace quality and could potentially impact organizational outcomes.	
Feige *et al.* (2013)	A model was tested that attempted to establish a linear relationship between the building features, comfort, work engagement, and financial gain to the company (i.e. tenant). There was a relationship between building features and comfort. They only managed to partially confirm that there was a relationship between comfort and work engagement. No link was found between engagement and financial gain (outcomes).	More research is required to support the assertion of multiple green building councils that improved IEQ results in increased individual productivity and organizational performance.
MacNaughton *et al.* (2016)	Focused on IEQ in terms of environmental and functional comfort. Office workers were transferred from a conventional building to a green certified building with significantly lower CO_2 levels. Building occupants reported improved IEQ and therefore reduced physical symptoms. It was established that both the physical elements and the psychological perceptions played a role in influencing stated comfort levels.	Perceptions regarding tangible comfort influence psychological comfort, which is difficult to gauge.

One of the conclusions that can be drawn from Table 2.4 is that every organization is different and hence there is a variation in the desired outcomes. These are underpinned by corporate culture, management systems, operational systems, resources, products, and changing markets (Flamholtz, 2009). Corporate culture of some organizations will have either policies or subtle prompts that mention environmental awareness, which may include IEQ (Flamholtz, 2009). Therefore, the implementation of IEQ features within an office could improve

workspace quality and could potentially impact organizational outcomes. Workspace quality can contribute to worker productivity which contributes to organizational outcomes (Harter *et al.*, 2003). Kampschroer *et al.* (2007) tested the links between goals, desired behaviours, workplace strategy, and outcome measures. The same researchers also focused on organizational performance and thus there was an attempt to create a link between physical space, behavioural change, and organizational outcomes. Their results indicated an increase in behavioural interaction and organizational performance.

It was noted that there was still some uncertainty in this area of research with regards to acknowledging how the environment specifically impacts individual productivity; in other words an improvement in the physical environment could contribute to a change in behaviour, however there would always be other non-environmental factors that influence productivity levels (Kampschroer *et al.*, 2007). The defining feature of this set of studies is the presence of intervening variables that link IEQ to organizational outcomes. Vischer (2008) developed a model that arranged workplace comfort into a hierarchical framework, which comprised three comfort categories. The different types of comfort were underpinned by workspace quality attributes. In Vischer's (2008) model, comfort was the link between satisfaction (i.e. with the built environment) and productivity (i.e. workplace behaviour). It was acknowledged that occupant environmental preferences did not relate to productivity levels. One of the shortcomings of the theoretical model of Vischer (2008) was that it only considered factors within the building that influenced individual productivity, which was not entirely realistic as building occupants may experience external work related stressors that can equally impact productivity (e.g. family troubles, financial difficulties, and physical and mental health issues unrelated to the building).

In the last decade there have been numerous researchers that have attempted to find a link between the internal built environment and building occupant comfort levels in conjunction with individual productivity and organizational performance (Akimoto *et al.*, 2010; Kossek *et al.*, 2012; Dimoff *et al.*, 2014; Tanabe *et al.*, 2015). However, there is still a lack of widely accepted empirical tests or existing theoretical models. Further research is required to test current theoretical models by modifying and refining specific factors. Within the context of

general comfort, IEQ plays a central role as there is a clear relationship between the user/occupant and their work environment (i.e. the built environment) as the building design has a direct influence on IEQ (Vischer, 2008; Alker *et al.*, 2014). Feige *et al.* (2013) tested a model that attempted to create a linear relationship between the building features, comfort, work engagement, and financial gain to the company. Their research confirmed that there was a relationship between the building features and comfort, however they only managed to partially confirm that there was a connection between comfort and work engagement. No connection was found between work engagement and financial gain. This suggests that further research is needed in order to investigate what intervening variables are present to support the assertion of multiple green building councils that improved IEQ results in increased individual productivity and organizational performance (Milne, 2012; GBCA, 2015; GBCSA, 2015b; UKGBC, 2015; USGBC, 2015; WGBC, 2015).

The Emergent Model

This section comprises four sub-sections that: (1) examines the limits of existing models; (2) explores the creation of new pathways and the understanding/application of a new model; (3) represents how the new model addresses new pathways; and (4) portrays the manner in which the new model delivers new analysis.

Limits of existing models

The existing research models have managed to address certain elements that only partially establish a relationship between IEQ variables and individual productivity and organizational performance. There remains conjecture regarding the manner in which productivity is measured within a knowledge-based environment and how/if this can be attributed to IEQ. Measuring individual productivity within an office environment can at times be difficult, as noted by Viswesvaran and Ones (2000), as productivity is an abstract construct, where one cannot always point to a physical deliverable that accurately resembles productivity and competence. It is even more difficult to do this in a way that is standardized across all employees, even in a single organization. This has resulted in individual productivity being measured by theoretical “widgets” produced or self- and supervisor-assessments; the latter occur more often in an office environment which can contain an element of bias from both

parties (Haynes, 2008a; 2008b). Sullivan *et al.* (2013) and de Dear *et al.* (2013) have both acknowledged that measuring productivity is difficult and that there have been many different approaches to measuring productivity that makes comparisons between studies problematic. One approach is to ask respondents to self-rate their productivity, however often the questions in these types of surveys are based on perceptions and self-assessment which can often be inflated due to self-reported biases. As a result, the notion of improved IEQ leading to an improvement in individual productivity is not always supported within the context of a knowledge-based environment because of the manner in which productivity is measured (Thatcher and Milner, 2014b; Byrd and Rasheed, 2016; Mulville *et al.*, 2016).

Another challenge is linking GBFIs to individual productivity, as there are also numerous non-building variables that can impact on productivity (e.g. employee competency and ability, status of personal/professional relationships, the competencies of supervision and management, the support of colleagues, job satisfaction, motivation, etc.). Added to this are non-employee factors that can impact organizational performance, such as the status of the economy, the quality of the product or service, the quality of the marketing, the demand for the product or service, and mental and physical health factors not obviously related to the building (e.g. cardio-vascular disease, cancer, depression, etc.). As a result, it is likely that the influence of GBFIs on productivity (and therefore organizational performance) would only be a relatively small proportion of the overall organizational performance. However, there have been some encouraging signs of established links. For example, Mayo (2016) established a connection between work engagement and organizational performance, where organizations with highly engaged employees yielded lower staff turnover rates, higher customer loyalty, and higher levels of individual productivity, all of which led to higher profitability for the company. However, it should be noted that while Mayo (2016) established a link between work engagement and organizational performance, no link was found between work engagement and the building features/qualities, as the role of the building was not incorporated into the research. Finding consistency within previous research is therefore extremely difficult. In this paper we present a model that attempts to integrate this disparate literature.

A theoretical framework developed by Haynes (2007a) assessed the physical and behavioural environments in an office that were linked to occupant productivity. The physical environment was defined as the office layout and perceptions of physical comfort. Behavioural comfort was viewed as differing levels of interaction and distraction by office workers. According to Haynes' (2007) model, this results in the physical environment determining certain types of behavioural environments that allow for either collaborative or individual engagements. This impacts on productivity in different ways, as the behavioural environment, Haynes (2007) argued, is a larger contributor to productivity than the physical environment. Haynes (2007a) concluded that there were different physical components that were compared against different ways of working, such as individual processes, group processes, concentrated study, and transactional knowledge. Haynes' (2007) research model was empirically tested and it was concluded that the behavioural environment had the largest impact on office productivity. This is underpinned by interactions and distractions, which have both positive and negative impacts respectively on productivity (Haynes, 2007). The emergent research model (Figure 2.1) differs from Haynes's (2007) position, while acknowledging wellbeing (i.e. the behavioural environment), by having a more overt focus on the physical environment and its link to productivity by emphasizing the different pathways through which the physical environment has an impact on performance and productivity. These include direct pathways (i.e. physical impediments to work) and indirect pathways (i.e. distractions from work).

The research conducted by Vischer (2007) adds to the work of Haynes (2007a). Vischer (2007) suggested that environmental comfort comprises physical comfort (which links the building user to the actual work environment), functional comfort (which defines the ability of the building occupants to operate efficiently within their work environment), and psychological comfort (which is an abstract construct that is underpinned by human relationships, with colleagues or superiors), in addition to the influence of both personal and professional stress factors. Other contributing factors to psychological comfort were the quantity and quality of personal space that each building occupant is allocated to perform their work. This links back to functional comfort where the top three functional comfort dimensions are workstation comfort, thermal comfort, and air quality comfort according to Vischer (2007). As stated

earlier, Vischer (2007) also assessed some organizational outcomes (i.e. individual productivity), but failed to find a significant relationship between comfort and these organizational outcomes. It was also suggested that environmental satisfaction and functional comfort resulted in an enhanced user experience (Vischer, 2008) but this did not manifest in measurable organizational outcomes. This model implies that while there may be a relationship between sustainable building practices (GBFIs) and individual productivity, in order to incorporate GBFIs into this area of research, a more comprehensive understanding of individual comfort and the possible intervening variables (i.e. mediators) that connect comfort with organizational outcomes is required (Vischer, 2008). The emergent model (Figure 1) aims to integrate comfort, which is underpinned by wellbeing and health, in order to find a connection to work engagement (i.e. as the primary mediating variable) which impacts productivity levels. The new model will hopefully aid in establishing a link from individual productivity to organizational performance in order to address the concerns of Vischer (2008) regarding the link between comfort and organizational outcomes (performance). While the link between work engagement and productivity is well-established in the organizational psychology literature, research conducted by Feige *et al.* (2013) failed to establish a relationship between work engagement and financial gain, even though comfort predicted work engagement.

Creating new pathways for understanding and using a new model

The new model (Figure 2.1) represents a consolidated group of pathways that attempts to show the paths between the implementation of GBFIs through comfort and work engagement, to individual productivity and ultimately organizational performance that results in increased building value. This culminates in a feedback loop, justifying the initial implementation of GBFIs. The model defines a distinction between the individual and the organization by defining productivity as outputs at the individual level, while performance is defined as outputs at the organizational level. The proposed model creates a new paradigm by consolidating different areas of research into a holistic framework, providing a theoretical model to guide empirical research, which uses new (and existing) pathways.

There have been various studies that have attempted to analyse linear relationships between several IEQ variables (lighting, ventilation, acoustics, general environment) and job satisfaction (Vischer, 2007; Schwede *et al.*, 2008; Newsham *et al.*, 2009; De Been and Beijer, 2014; Tanabe *et al.*, 2015). However, there is a lack of robust modelling that demonstrates the link between ambient environmental office conditions and organizational effectiveness outcomes. This research aims to expand on the work of Becker and Pearce (2003), Haynes (2007a), Vischer (2007), Newsham *et al.* (2009), Feige *et al.* (2013), Thatcher and Milner (2014b), and Byrd and Rasheed (2016) by developing a more comprehensive model that proposes the relationships between GBFIs and their influence on individual productivity and organizational performance. There has also been previous research linking GBFIs to increased building value (Nurick *et al.*, 2015), but this has focused on operating cost savings; i.e. the link to occupants (both people and organization) was not considered. Previous theoretical frameworks that include green building literature and work analysis models with a specific focus on the built environment were therefore considered first.

How the new model addresses new pathways

This sub-section comprises three components that delve into how the new model addresses new pathways. The first component provides a narrative on linking GBFIs to wellbeing, health, and comfort. Graphically, this is represented in the top third of the new model. The second component speaks to the links between comfort and work engagement, which is shown in the next phase of the new model. The last component discusses linking work engagement to productivity, performance, and financial gain. This is illustrated in the bottom third of the new model.

Linking GBFIs to wellbeing, health, and comfort

Figure 2.1 shows the model that we propose emerges from the literature and that would need to be empirically tested. Following Alker *et al.* (2014), Figure 2.1 shows that the GBFIs implemented would consist of ambient conditions, spatial factors, and location, and amenities. Ambient conditions are underpinned by IAQ, ventilation, thermal comfort, lighting (natural and artificial), and noise/acoustics and these factors have been the most vigorously researched. These contributing factors often include some of the following items: volatile

organic compounds, particulates, aroma, fresh air ventilation, moisture levels, indoor air temperature, humidity levels, light quality, glare, and background noise and auditory distractions (such as loud noises or people talking). The underlying contributing factors can affect individual productivity in a number of ways; as poor ambient conditions that either physically disrupt the work directly (i.e. a direct path to productivity) or that force office workers to "escape" the environment through distractions (i.e. an indirect path through intermediary responses such as health, wellbeing, and/or comfort). For example, the quality of lighting and glare off computer screens also reduces the ability to work efficiently. This essentially hinders concentration levels, which has a direct impact on organizational performance or an indirect impact through impacting on health, wellbeing, and/or comfort.

Spatial factors are underpinned by interior layout/design, biophilia, external views, location, and access to office amenities. These contributing factors include some of the following items: the incorporation of ergonomic design layouts, break-away and social interaction spaces, connection to nature via internal vegetation and views, and appropriate design in terms of corporate culture. These contributing factors can impact individual productivity indirectly as they influence comfort levels of office workers, which may have an effect on concentration, thus impacting organizational performance. The physical layout of the office can also impact productivity directly. For example, being located close to "noisy zones" such as the coffee machine or a busy thoroughfare, can impair concentration and impact productivity directly through the inability to perform (e.g. adequately listen to a telephone call). Additionally, being located far from office resources such as printers or being far away from other close work colleagues, can reduce work efficiency.

Location and amenities include ease of access to retail centres, medical facilities, schools, gyms, parking, and public transport nodes. Direct effects might mean that office workers may spend less time at their work stations in order to make allowances to access these amenities. Conversely some buildings and commercial precincts provide amenities, which results in a less absent work force, thus having a positive impact on organizational performance. Indirect effects might mean that access to these amenities means that office workers spend less time feeling stressed about how they will access these services.

A theoretical model developed by Seppänen and Fisk (2006) highlighted a link between environmental controls (IEQ) with regards to operational and maintenance costs/benefits, which included a decrease in health costs, increase in number of working days, increase in output quality (individual productivity), increase in staff retention and a decrease in maintenance costs (organizational performance). In theory their conclusion was that the implementation of GBFIs that enhance IEQ had a direct positive financial impact on the organization, without the need for any intermediary variables (although both health and productivity are arguably intermediary variables). This was supported by Doggart (2006) who found that a well-designed commercial building, from a user comfort perspective can result in aiding an organization's financial performance. Doggart (2006) found that overhead costs per person could be reduced from 3% to 15% in a relatively short period of time, thus confirming that good building design is good for business.

As already noted, while it is possible that there are direct effects of these factors on individual productivity, previous models also suggest that many of the effects on individual work productivity are likely to be indirect and mediated or moderated by other individual and organizational factors. First, we argue that these three factors directly determine the levels of comfort, wellbeing, and health of employees experiencing these conditions. This starts with comfort, which is defined using Vischer's (2007) three pillars of environmental, psychological, and functional comfort. For example, environmental comfort was assessed by Gou, Lau and Chen (2012) through the implementation of a POE in a three-star green-certified office building in China. Their research found that although the vast majority of respondents were satisfied with the thermal environment there was still some discomfort experienced by office workers that were exposed to uncomfortably cold air in both summer and winter. An example such as this shows that a badly designed office environment can be uncomfortable whereas a carefully designed office environment can support employee comfort.

Inappropriately designed LEED IEQ attributes such as IAQ, temperature, humidity, ventilation, lighting, acoustics, and ergonomic design, all contribute to physical health and psychological wellbeing, be it clinical symptoms (asthma and respiratory allergies) and/or psychological symptoms (depression and stress), which impact productivity (Singh *et al.*, 2010). Empirical

findings from longitudinal research conducted in the United States by Singh *et al.* (2010) involving two separate case studies where occupants moved from two conventional buildings into two different grades of green-certified buildings found that on average there was a reduction in both clinical and psychological symptoms, which resulted in a decrease in absenteeism. Furthermore, the perceived improvement in health and wellbeing contributed to a perceived positive impact on productivity by the office workers. Furthermore, there is a significant body of literature supported by empirical evidence (Hedge, 2000; Seppänen *et al.*, 2006; Rashid and Zimring, 2008; Newsham *et al.*, 2009; Fisk *et al.*, 2011; Kim and de Dear, 2012; Wyon and Wargocki, 2013) that indicates that improved IEQ can contribute to both improved physical and mental wellbeing (see Thatcher and Milner (2016) for a review of this literature). However, this relationship is not always consistent. Research by Gou *et al.* (2013) involved a selection of conventional (non-green) and green certified buildings in order to determine the perceived levels of satisfaction and comfort by means of a building user survey (BUS). The findings indicated that workers located in a green building were not always more comfortable than those workers located in a conventional building. This shows that although green buildings may be more resource efficient, not all green buildings provide superior comfort levels for office workers when compared to conventional buildings.

Linking comfort, health and wellbeing to work engagement

Comfort, health, and wellbeing levels have, to a greater or lesser extent, impacted on work engagement, which can be defined as a persistent and purposeful cognitive state where dedication is applied in order to achieve certain objectives (Schaufeli *et al.*, 2006). This is vital within an office environment as it underpins the levels of individual productivity and therefore has an impact on organizational performance. Theoretically, it makes sense that an employee who is more comfortable, healthy, and psychologically well would be more engaged in their work and more likely to spend time in their workplace working productively. According to a literature review conducted by Kossek *et al.* (2012), surveys conducted in the United States revealed that employers that take an interest in employee's personal lives and provide support where necessary, result in higher levels of engagement in the workplace. Conversely, lower levels of engagement are ultimately reflected as an expense to an organization, where it is estimated that low engagement results in annual costs of

approximately $350 billion at the time (Kossek *et al.*, 2012). The underlying components of comfort impacting on work engagement was established by Gou, Lau and Shen (2012) when analyzing LEED certified buildings. As an example, natural light can sometimes hinder environmental and functional comfort as direct sunlight increases internal temperatures and results in glare from computer screens. This impacts on comfort levels which interferes with the employee's ability to engage with their work.

Similarly, to what we have described for the relationship between GBFIs and productivity, there may also be direct pathways between comfort and productivity. Research by MacNaughton *et al.* (2015) looked at the interconnections between comfort and productivity. Their previous research specifically involved increasing ventilation rates (i.e. environmental comfort) to test for an increase in employee productivity. Their research found that there was an increase in productivity with increased levels of environmental comfort, which they expressed as a monetary value in terms of costs per occupant. MacNaughton *et al.* (2015) did not look at work engagement as a possible mediator so it is not possible to say whether the relationship with productivity was direct or mediated. Theoretically though, feeling uncomfortable can directly influence a person's productivity through being a distraction, regardless of how engaged they might feel with their work.

Linking work engagement to productivity, performance and financial gain

Research conducted by Feige *et al.* (2013) could only establish that there was a link between comfort levels and work engagement, but could not find a link between productivity and work engagement. Feige *et al.* (2013) did propose that due to the link between comfort levels and work engagement that a comfortable working environment could positively influence staff retention and the attraction of high calibre staff. The link between work engagement and productivity is a key component of the new research model, as work engagement is the proposed intermediary between comfort and productivity despite Feige *et al.* (2013) not finding a significant relationship. In contrast, in other research Mayo (2016) found that there was a significant relationship between work engagement and organizational performance, but not between IEQ features and work engagement. It should be noted that Mayo's (2016)

study attempted to link work engagement to the work environment (organizational culture) not IEQ, i.e. relationships with co-workers and access to resources in order to efficiently work (engage). Therefore, in Mayo's (2016) study, buildings were not considered to be a contributing factor that influenced work engagement.

Theoretically, a literature review conducted by Bakker and Albrecht (2018) stated that high work engagement resulted in dedication and a strong work ethic, which has a positive impact on individual productivity and potentially also on the organization's financial results (i.e. organizational performance). Earlier research by Bakker and Bal (2010) using teachers as research participants found that there was a positive relationship between work engagement and job performance (individual productivity). Furthermore, it is suggested by Bakker (2011) that there are four reasons that support the superior performance of engaged workers compared to non-engaged workers: (1) engaged workers tend to experience positive emotions in the workplace, such as gratitude, joy and enthusiasm; (2) engaged workers seem to experience better health; (3) engaged workers tend to exhibit signs of pro-activity in the workplace (i.e. positive work behaviour); and (4) work engagement is contagious, thus setting a subtle workplace culture where engagement is considered the norm resulting in a positive reinforcing impact on organizational performance.

However, productivity, like work engagement, is influenced by many other factors such as equitable pay, motivation, supervision, and individual capability. The emergent model indicates that individual productivity levels contribute to organizational performance, although organizational performance is also influenced by senior leadership and the overall economy. Organizational performance might also partially be measured by using absenteeism and employee turnover as "proxy" measures. Ultimately, organizational performance is measured by financial gain in terms of return on investment. Satisfactory organizational performance can, as previously mentioned, be partially linked to occupant comfort (IEQ). From a commercial property valuation perspective this can impact vacancy assumptions, thus de-risking a commercial property resulting in lowering the capitalization rate and yielding a greater nominal value (Nurick *et al.*, 2015). This results in a positive feedback loop, if organizational performance increases, that justifies the initial implementation of GBFIs as a

result of an increase in individual productivity and organizational performance. In other words, the capital expenditure of implementing GBFIs is offset by an increase in organizational performance, which is underpinned by individual productivity. Another justification for the implementation of GBFIs is that the reduction in operating costs that are attributed to water, electricity, and waste removal will also positively impact the building's value, as this will increase the net operating income (NOI). This is a benefit to not only commercial tenants leasing space as they would incur lower utility costs, but also organizations that are owner-occupiers that would accrue the added benefit of enhanced building value. This would therefore further strengthen the feedback loop from financial gain to the implementation of GBFIs, as shown in Figure 1. Thus, the emergent research model provides a consolidated framework for the different relationships derived from the literature. Furthermore, Figure 2.1 also shows where new relationships need to be empirically tested in order to provide further clarity where other researchers have struggled to establish definitive conclusions.

Once the new model is empirically tested, the emergence of new pathways/relationships may also become apparent. Specifically, the differentiation between individual productivity, organizational performance (financial gain), and increased building value. There has been previous research linking GBFIs to increased building value by focusing directly on building related income and costs, which influence risk, and ultimately value, by means of the discounted cash flow (DCF) method (Fuerst and van der Wetering, 2015). This model intends to test if GBFIs can influence work engagement to a point where individual productivity and organizational performance can be directly included in valuation (DCF) variables, thus having a positive impact on value. Since the main focal points are people (productivity), the organization (performance), and the property owner (building value), the preceding contributing factors need to be well defined and based on previous research.

How the new model delivers new analysis

The new research model will allow for the researchers to isolate and analyse relationships between the indoor environment (GBFIs), building occupants, the organization, and building

value. As a result, the model delivers a holistic representation of how the implementation of GBFIs within an office building can potentially result in positive externalities where the individuals, the organization, and the property owner simultaneously benefit. This is done by highlighting the linear relationships between each of the main components (as discussed previously), where each relationship has a positive knock-on effect on the next component, as illustrated in the model. Ultimately the new model, once empirically tested, can be used as a theoretical framework to establish to what level the implementation of GBFIs in an office building results in enhanced individual productivity and organizational performance.

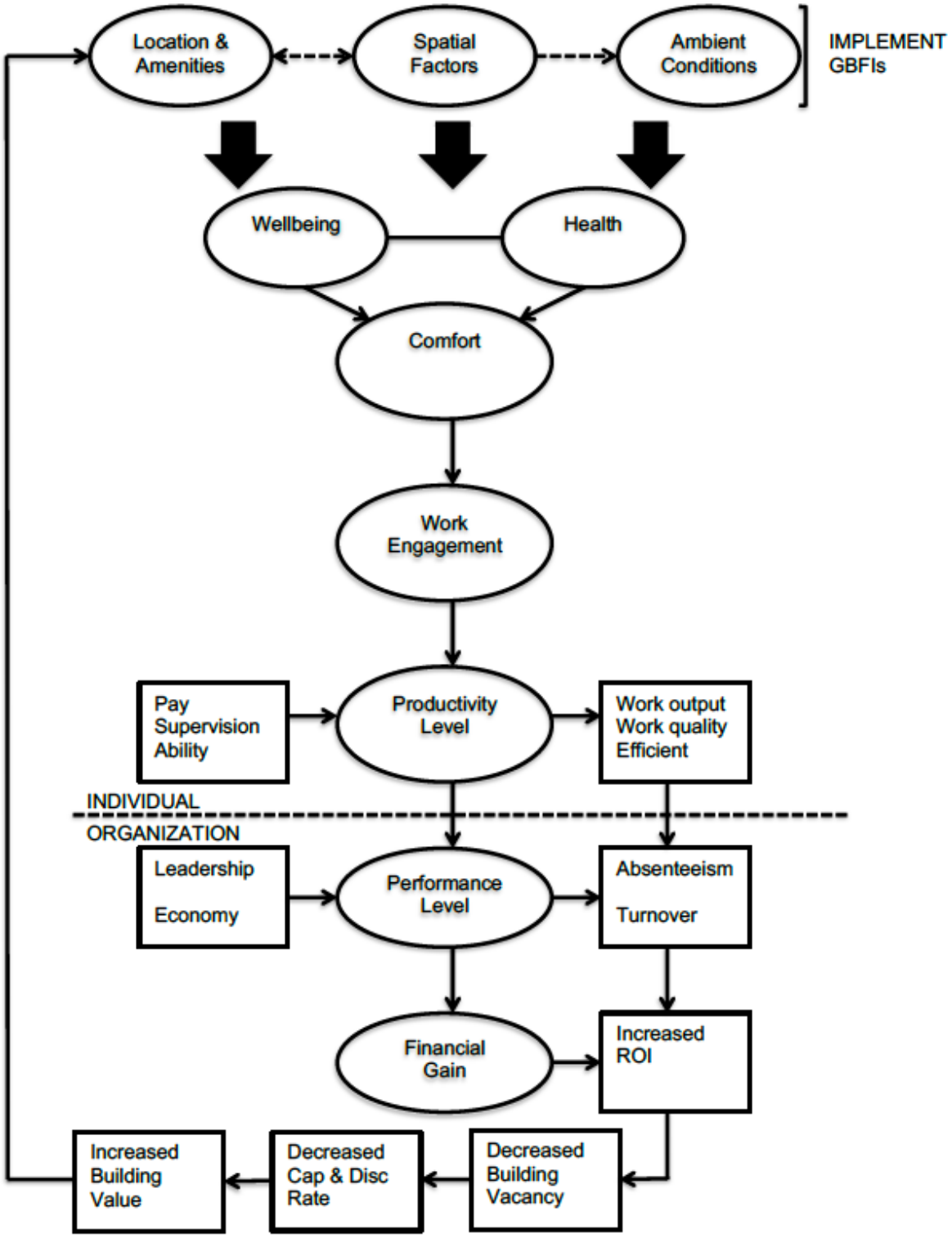


Figure 2.1: Emergent Research Model

Additional Factors to Consider

Chadburn *et al.* (2017) found that quiet workspaces with good ventilation and temperature control tended to result in higher productivity levels within an office environment. This

formed part of a trial study in an office in London, where analysis of the findings indicated that personal productivity was dependent on both the physical and behavioural environments. This type of study suggests that the GBFIs each work cooperatively to produce positive organizational outcomes. However, there are frequently times when the GBFIs interacted in ways that produce negative outcomes. Some of the more obvious interactions are between ventilation rates, temperature, and air quality, e.g. Fang *et al.* (2004). As mentioned in the introduction, one of the main drivers of green buildings is to reduce operating costs through more efficient energy systems. Clearly GBFIs interact in complex and sometimes unpredictable ways. One of the most common ways to reduce energy costs is the installation of energy efficient lighting systems and/or the redesign of space that makes use of more natural light. Often, the introduction of more natural light requires a redesign of the internal space. This might inadvertently have a negative effect on the ambient conditions as the management of natural light can result in indoor thermal challenges, especially for those workers located near large windows, and glare. A re-configuration of an office environment into a more open-plan design can result in an increase in residual noise, which can be exacerbated if the external building façade is predominantly glass (i.e. sound waves reverberate well off glass), thus having a negative impact on individual productivity levels. In order to increase ambient comfort within a naturally lit office environment, interventions such as automated thermal controls and glare controls need to be implemented in order not to undermine productivity levels. Another example would be open-plan offices which, while good for allowing natural light to infiltrate the interior of an office space, often increases noise levels. Office environments containing knowledge workers tend to have typical internal designs that comprise an open-plan layout in conjunction with shared or singular cellular offices for senior members of staff or staff with highly specialized work functions (De Croon *et al.*, 2005; Chadburn *et al.*, 2017). The use of natural lighting can reduce the need for low-quality artificial lighting, which in turn could result in the implementation of high-quality, energy efficient lighting that may reduce computer screen glare.

Newsham *et al.* (2013) stated that improved IEQ in LEED certified buildings resulted in increased satisfaction with the thermal conditions, external views, general aesthetic appearance, less disturbance from heating ventilation and air-conditioning (HVAC) noise, and

an improved workplace image. This led to improved night time sleep patterns, mood, improved physical symptoms, and a reduced number of airborne contagions. In addition, improved IEQ resulted in enhanced building user experience, higher quality light levels, greater access to windows and natural light, better thermal conditions, and a general increase in air quality (Newsham *et al.*, 2013). Tangible benefits of IEQ are relatively easy to measure, however one of the resultant, but more challenging, measurable effects is that of improved productivity as a result of the implementation of GBFIs (Kato *et al.*, 2009). Thompson *et al.* (2014) identified that a relatively minor increase in individual productivity can improve organizational performance by a greater factor than the costs of implementing GBFIs. Finally, Thompson *et al.* (2014) have noted that rarely are the same measures used between studies, and thus there is a need for standardization in order to fully understand how the various components of IEQ impact individual productivity.

Way Forward

At this point, the model in Figure 2.1 is based on a literature review that has been conducted to inform the development of a new theoretical model. Where it exists, empirical data from previous studies is used to support the individual relationships. However, no empirical data has been collected to test the model as a whole. The next step for this research is to empirically test the model by carefully gathering data on GBFIs and comparing buildings with different GBFI qualities. To make equitable comparisons it would be necessary that tenants in different buildings have employees/occupants who are performing roughly similar work. These comparisons would need to look to incorporate a number of metrics, including that of individual productivity, organizational performance, and financial gain, and therefore like-for-like comparisons can be made. It would be necessary to gather three different sets of data. The first set of data would be information about the various GBFI qualities of the various buildings. This information would include determining the exact GBFIs contained in the subject building(s). The second phase would need to be an organization-wide survey of the occupants in each of these buildings assessing satisfaction with GBFIs, comfort, perceived health and wellbeing, work engagement, and some consistent measure of productivity. Length of time in a building is also important to understand as it is likely that the effects discussed in the model would take some time to manifest. This data would be extrapolated

by conducting a POE similar in structure to previous research, although with motivations for standardized measures. This will allow for insight in occupant productivity in relation to GBFIs. The third phase would be to compare the organizational performance of the organizations in the different buildings. For example, if the organizations being compared were in the financial services industry, then organizational performance could be assessed by comparing a generic financial product (e.g. balance investment fund) in the form of comparing annualized returns over a prolonged period of time. This would allow for the fair ranking of different investment firms within the context of a single financial product, as they all operate within the same market and are privy to the same market information. Ultimately, the research model is based on relationships supported by empirical evidence from other studies. The difference being is that the research model will attempt to consolidate these relationships in order to illustrate the GBFI lifecycle from an organizational benefit perspective as opposed to previous green building research that focused on the long-term financial benefit relating to utility savings.

Recommendations for Future Research

This research has the potential to develop into residual studies that incorporate green buildings and the impact on occupants, and their subsequent behaviour. This may include a study on the length of time spent in the building or the foot traffic in a retail building containing GBFIs, i.e. assessing if consumers shop for longer (spend more) in retail building containing GBFIs. There is also a possibility that a similar study could be implemented in a light industrial building containing GBFIs, as this has become a more prevalent real estate asset (superior financial returns) due to the successful emergence of e-commerce (European Public Real Estate Association, 2017).

3. A Scoping Literature Review on Methodologies used in Assessing Individual Productivity and Organisational Performance

3.1 Introduction

The second paper focuses on research methods relating to individual productivity and organisational performance in office buildings containing GBFIs within the framework of a scoping literature review. This was conducted using the Preferred Reporting for Systematic and Meta Analysis (PRISMA) approach, as it has been successfully applied and accepted by the research community (Moher *et al.*, 2009; Levac *et al.*, 2010; Peters *et al.*, 2015; Tricco *et al.*, 2016; Sadick and Kamardeen, 2020). The scoping review is underpinned by the emergent research model (Figure 2.1) that is introduced in chapter 2.

A scoping literature review does not focus on a specific research question, but rather provides a mapping process to identify relevant areas for further enquiry.

This paper serves as the overarching assessment of methods applied when assessing individual productivity and organisational performance within the context of green building. The prominent research design, method of analysis and duration of data collection were used to inform some of the applied methods in the subsequent two empirical papers. It was noted in this paper that the applied research approaches only focused on individual productivity, while there was little focus on organisational performance. This identified a gap in the knowledge that is addressed in the empirical paper that focuses on organisational performance within the context of financial services companies (FSCs) and indoor environmental quality (IEQ) (Chapter 5). The PRISMA approach was applied, where a preliminary (one key word) search resulted in approximately a hundred and twenty thousand possible relevant online records. When more than one key word was applied, the sample of relevant records reduced to n = 225. Further filters were applied, which resulted in final sample of papers comprising the scoping review of n = 39. The overarching results of the scoping review was that it identified common data collection approaches (cross-sectional and

longitudinal), main methods of analysis, which ranged from different statistical approaches, and the main measures and corresponding application by other researchers. These measures included: ambient conditions, spatial conditions, location and amenities, comfort, engagement, individual productivity, and organisational performance.

Contribution by the authors:
Nurick wrote the paper as first author, which included conception, structure and all the associated reading, and PRISMA formulation. Nurick also handled all the correspondence with the *Journal of African Real Estate Research* with regards to submission (including re-submission with a schedule of corrections).
Thatcher provided oversight and input at a theoretical level.

The *Journal of African Real Estate Research* was selected as an ideal venue as it is a local journal (Directory of Open Access Journals) that focuses on theoretical and empirical real estate research conducted by scholars based in Africa. The journal is published by the African Real Estate Society (AfRES). The AfRES is one of the six regional groups that falls under the International Real Estate Society (IRES), who promote real estate education and research.

Enhanced Indoor Environmental Quality and the link to individual productivity and organisational performance: A scoping review

Nurick, S. and Thatcher, A. (2021a) Enhanced Indoor Environmental Quality and the link to individual productivity and organisational performance: A scoping review. *Journal of African Real Estate Research*, **6**(2), 84-116.

Abstract

This paper provides a scoping literature review of research methods that seek to establish the measurement of individual productivity and organisational performance in office buildings containing enhanced green building features and initiatives that specifically focus on indoor environmental quality (IEQ). The paper follows the PRISMA framework and includes thirty-nine academic papers for the period 2000 to 2020. Different research instruments are discussed, which include post-occupancy evaluations (POE), longitudinal surveys, and interviews. Furthermore, a narrative is provided that focuses on specific measures, which include location and amenities, comfort, engagement, individual productivity and organisational performance. This structure provides insight into common research approaches and also highlights where less used research approaches could be applied in the field of GBFIs, including the assessment of individual productivity and organisational performance. The key findings highlighted that in previous research individual productivity was measured via self-assessment, while there has been no research that has successfully measured organisational performance within the context of GBFIs. Gaps have been identified in the literature with regards to the relationship of knowledge-based building occupants and measuring/monetising the implementation of GBFIs. Implications of this research indicate there are common approaches, which have highlighted both strengths and more importantly weaknesses with regards to linking GBFIs to individual productivity and organisational performance. Addressing the weaknesses that predominantly encompass measuring organisational performance creates opportunity for future research in this field.

Key words: green building features and initiatives (GBFIs), indoor environmental quality (IEQ), post-occupancy evaluation (POE), productivity, performance

Introduction

Rationale

Office workers comprising lawyers, bankers, management consultants and financial services specialists tend to be in A-grade or Prime grade buildings containing GBFIs. The success of the businesses that occupy prime office space is underpinned by individual productivity and organisational performance. Productivity in offices has shown to be difficult to accurately measure where a variety of researchers have attempted many different methods (Nurick and Thatcher, 2021b). Organisations themselves assess individual productivity through interviews or surveys either self-assessed or from a superior or subordinate. Organisational performance is comparatively easier to measure. This can be done by comparing reporting periods, and/or by comparing competing companies that offer similar products. This paper examines the research methods used to measure individual productivity and organisational performance in office buildings that contain green building features and initiatives (GBFIs). In order for a building to be certified green it must contain some form of GBFI. The key GBFIs that pertain to this paper are centred around indoor environmental quality (IEQ), which focused on air quality, temperature, lighting, office layout, ventilation, and noise levels. The relationship between GBFIs and individual productivity and organisational performance requires further scrutiny as green building advocates (councils and building owners) often maintain that green buildings, more specifically the GBFIs linked to IEQ, yield enhanced productivity and performance. According to the literature reviewed in this paper this is not an entirely accurate statement, as there are findings that suggest that certain enhanced IEQ features can actually hinder individual productivity (Thatcher and Milner, 2012). The main thrust of this paper is to review the literature that examines the link between GBFIs, in the form of enhanced IEQ in green buildings, and individual productivity and organisational performance. For the purposes of this paper the definition of individual productivity is underpinned by pay, motivation, supervision and individual capability. All of these attributes contribute to organisational performance, which can be defined as the overall financial performance of the organisation (Nurick and Thatcher, 2021b). The paper aims to review research approaches that address both individual productivity and organisational performance of tenants and/or owner-occupiers of office buildings containing GBFIs. This will be done by assessing the literature that collects empirical data in office contexts. The justification for a scoping

literature review is that it provides a concise approach to organise previous research so that commonalties and gaps become easily identifiable in order to generate a set of hypotheses (Tricco *et al.*, 2016).

The emergence of the green building movement appeared relatively recently in Africa, as there only two established green building councils (South Africa and Kenya) on the continent. The Green Building Council of South Africa and the Kenya Green Building Society was established in 2007 and 2017, respectively, while green building councils in North America, Europe and Australia were formed in the late 1990s and early 2000s, respectively. Many green building advocates within Africa have claimed, with only anecdotal evidence, that green buildings result in improved productivity. Therefore, research on linking enhanced IEQ to both individual productivity and organisational performance plays a pivotal role in justifying the implementation of GBFIs within the African office market. Past research on the performance of green buildings has used a variety of approaches, with post-occupancy evaluations (POE) arguably being a popular technique where quantitative and qualitative data are gathered. POE are one of the preferred methods for determining building user satisfaction levels with regards to specific building elements in relation to GBFIs. This is because POE are viewed as diagnostic tools that assist in isolating specific building related problems so that they can be addressed timeously without further compounding building user problems (Prieser, 1995). According to Tagliaro and Ciaramella (2016), POE are considered to be beneficial mechanisms for collating data in order to support the refinement of real and perceived performances. There have been very few, if any, longitudinal studies with a central focus on establishing a coherent link between GBFIs and employee and organisational outputs.

There are three main types of POE: (1) the building user survey (BUS) is a standardised instrument that assesses building occupant's perceptions of their work environment; (2) POE that focus on building operations such as water, electricity, and waste; (3) POE that focus on the financial performance of the building, which can be linked to variety of line items that contribute to a building's income and expenses. The main gap that is identified is that although past research is focused on the link between individual productivity and IEQ in the form of GBFIs, there is little research (and thus evidence) to link organisational performance to enhanced IEQ as the result of the implementation of GBFIs in the workplace. The

theoretical model (figure 3.1) developed by Nurick and Thatcher (2021b) will be used, as it was based on the consolidation of earlier models, and thus represents the most up-to-date model. Figure 1 shows the possible linkages between GBFIs which lead to individual productivity and organisational performance. If an organisation is satisfied with their rented space and are performing well financially due to improved individual productivity (increased ROI), then there is a low chance of them seeking new rental premises upon lease expiration. If an office building experiences lower vacancies, then this reduces the building's risk profile, which will reflect in lower capitalisation and discount rates, thus resulting in enhancing the building value (Nurick *et al.*, 2015). Figure 3.1 provides a framework that underpins the identification of the key methods used, and measures assessed in the scoping literature review.

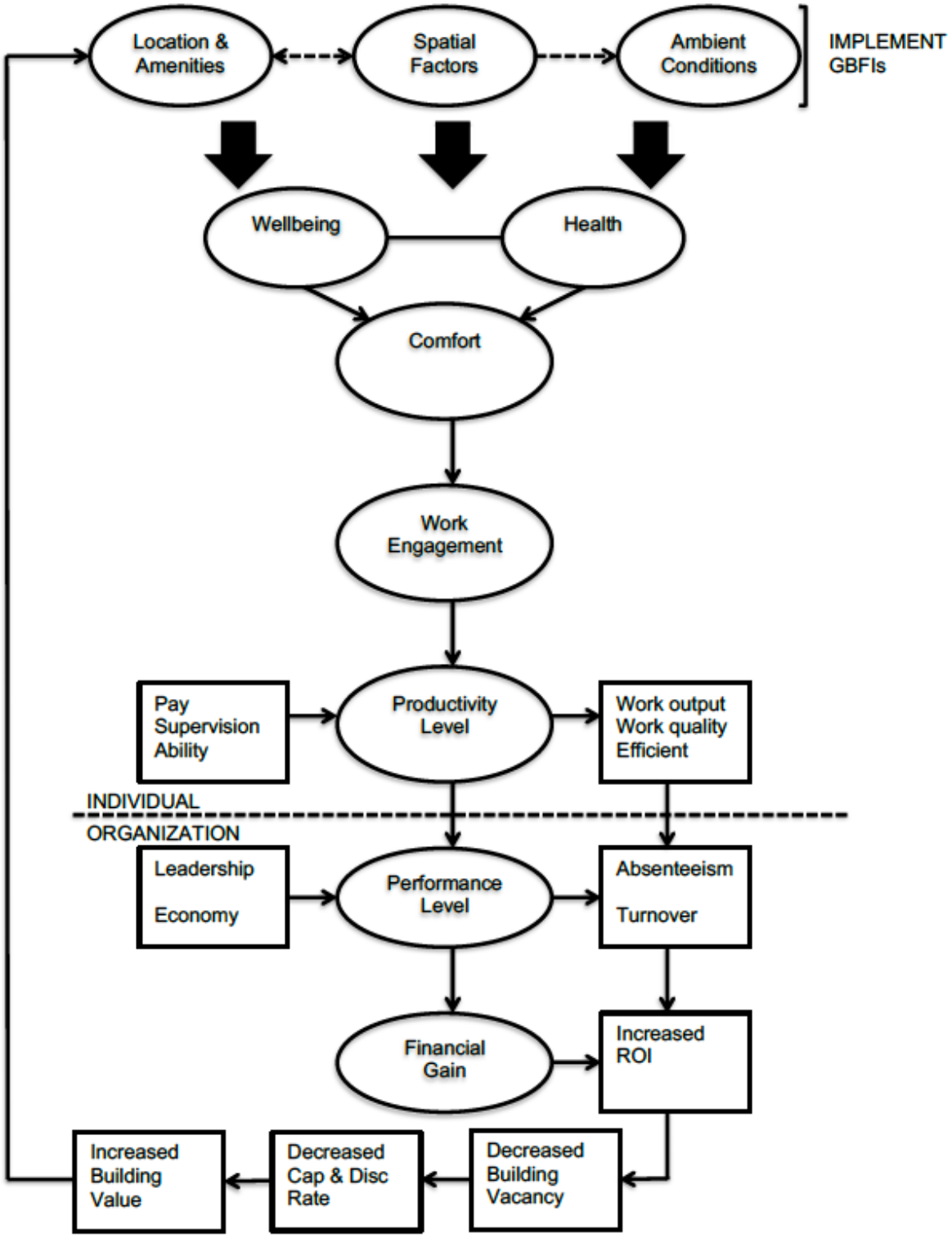


Figure 3.1: Linkages of GBFIs to Productivity and Performance (Nurick and Thatcher, 2021b: 29)

Methods

The Preferred Reporting Items for Systematic Reviews and Meta Analysis (PRISMA) (Moher *et al.*, 2009) framework was applied, involving the four steps of identification, screening,

eligibility, and inclusion. A scoping review was utilised as it provides a mapping process (Levac *et al.*, 2010; Peters *et al.*, 2015) used to identify relevant areas for further enquiry in an area where there is only emerging evidence in order to provide clarification for key concepts and gaps (Tricco *et al.*, 2016). A systematic review on the other hand, provides a more detailed approach that focuses on a specific research question in an area which is relatively mature, while a meta-analysis only refers to the statistical analysis that is encompassed within a systematic review. The application of the PRISMA framework allows for a transparent logical approach that exhibits the manner in which articles were classified as included. A traditional literature review seldom provides this logical approach for the reader.

The process of identifying articles was relatively broad, where the key words of green building features and initiatives, post-occupancy evaluation, office productivity, organisational performance and indoor environmental quality were entered in Scopus and Google Scholar for the period 2000 to 2020. The key words were selected as they covered a relatively wide spectrum that could be encapsulated within the scoping literature review. Additionally, some of the keywords corresponded to the theoretical framework exhibited in figure 3.1. It should be noted that a limitation of this scoping literature review is the exclusion of articles that only focus on a single GBFI, as there is potentially an exhaustive list of individual building components/features, which do not directly, or at best, very loosely link to IEQ. The reason for the twenty-year period is due to the key words being prominent in research areas in developed markets in the first decade of the twenty-first century. This is due to the establishment of green building councils in North America, Europe, the United Kingdom and Australia in the late 1990s and early 2000s, while green building councils became more prominent in Africa and Asia from circa 2010.The search criteria were refined by intentionally focusing on peer reviewed academic articles that specifically focused on methods for determining the impact of GBFIs on office workers. These academic papers included a variety of methods for assessing the impact of enhanced IEQ on office building occupants. Some papers applied methods that were slight variations of previous methods, while other papers attempted to apply new approaches to measuring a change in individual productivity and organisational performance.

Over a hundred and twenty thousand journal articles were found using Google Scholar and Scopus, which contained at least one of the key words. Two hundred and twenty-five articles that contained more than one of the key words were identified with one hundred and eighty articles excluded at this point since they only focused on the building, not the occupants. Forty-five academic articles were screened as they contained more than two of the key words and examined building occupants. Four articles were removed because they were literature reviews. The remaining forty-one articles were considered eligible and focused on building components and/or people within simulated or natural settings. However, two articles were excluded because they only focused on IEQ and not people. This resulted in two groups of included articles (*n* = 39) of people within offices (experiments, *n* = 11, non-experiments, *n* = 28). Figure 3.2 provides a flow diagram of the PRISMA process used in the scoping literature review.

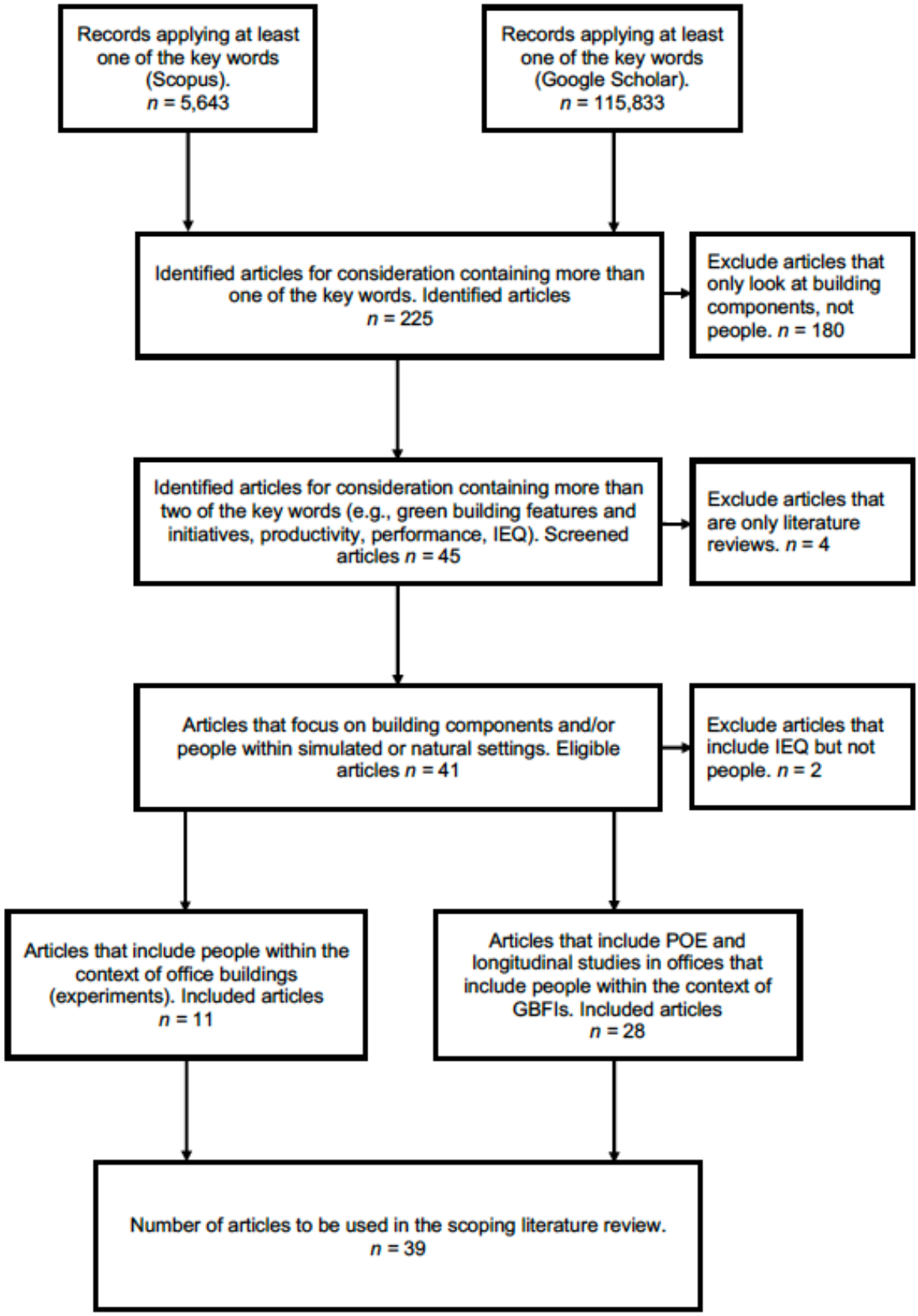


Figure 3.2: PRISMA Flow Diagram adapted from Sadick and Kamardeen (2020)

Selection of Studies for Review

The thirty-nine journal articles comprise this scoping literature review used a variety of research designs. The overall breakdown of the research design for the sample comprised 26 (67%) articles use some form of survey only (i.e., conventional survey, POE or BUS), 8 (21%) articles use both surveys and simulated experiments, 3 (8%) articles only use simulated experiments, and 2 (5%) articles applied interviews as a form of data collection. The sample size used by the selected articles ranged from a few hundred to several thousand. There was a variety in the measures that were chosen for analysis. As per table 3.1 the data collection techniques were either cross-sectional (19 articles, 49%) or longitudinal (20 articles, 51%). However, there were some commonalities across the majority of the selected studies. This included studies that focused on IEQ of buildings that contain GBFIs and how this impacted on the user experience, including satisfaction levels. Methods of analyses exposed a group of common approaches, including ANOVA (13 articles, 33%), descriptive statistics (20 articles, 51%), multivariate analysis (2 articles, 5%), non-parametric statistics (2 articles, 5%) and Spearman's rank-order correlation (2 articles, 5%). Many of the findings highlighted thermal comfort, temperature, ventilation, indoor air quality (IAQ), personal control of one's environment, building aesthetics, acoustics (both general and internal partitioning) and office configuration (open plan vs shared offices vs individual cellular offices) as the common GBFIs in the selected studies. The details of each journal article are given in Table 3.2. The order of the articles is chronological, starting in the year 2000.

Table 3.1: Method of Analysis and Duration of Data Collection (*n* = 39)

Method of Analysis	Number	Percentage
ANOVA	13	33%
Descriptive Statistics	20	51%
Multivariate Analysis	2	5%
Non-Parametric Statistics	2	5%
Spearman's Rank-Order Correlation	2	5%
TOTAL	39	100%
Duration of Data Collection	Number	Percentage
Cross-sectional	19	49%
Longitudinal	20	51%
TOTAL	39	100%

A further geographical analysis of the included articles indicated that the research was conducted across seventeen countries. Most of the countries (14) are located in the northern hemisphere, while the remaining countries (3) are in the southern hemisphere. Most of the studies were conducted in one country, however two of the studies conducted research in buildings located in two countries, resulting in a total of forty-one separate country specific occurrences. The geographical spread of the research in the included articles occurred seven (17%) times in the United Kingdom, and five times (12%) for both China and the United States, respectively, Figure 3.3 shows the geographical spread of all seventeen countries.

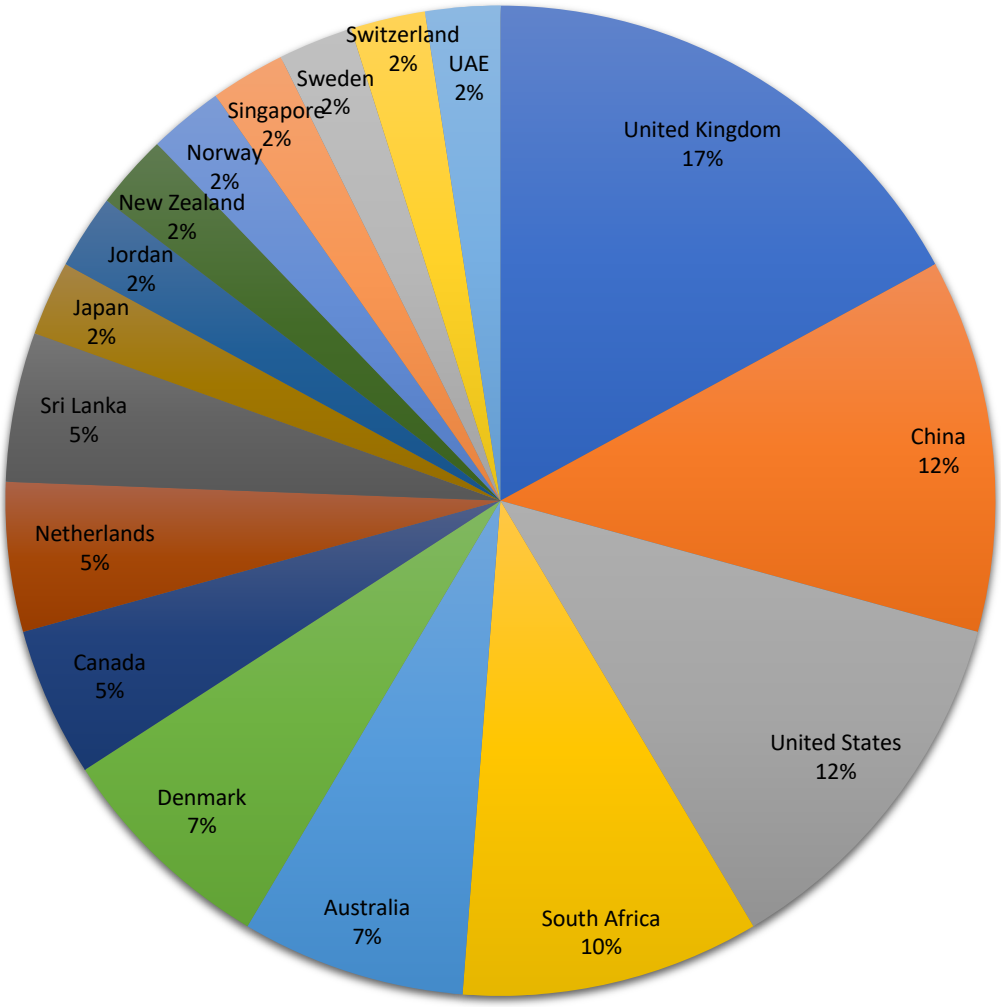


Figure 3.3: Geographical Spread of Research in Included Articles

The Results

The results in Table 3.2 are derived from research conducted in different geographical locations (North America, Europe, Asia and Africa). Table 3.2 provides a breakdown for each of the thirty-nine papers in terms of research design, subject and setting, method(s) of analysis, duration of data collection, and results. This indicates that similar findings should be considered robust and somewhat conclusive, as each of these locations experience different climatic conditions, which contribute to office building occupant comfort levels.

There were eleven articles that were conducted in simulated, laboratory conditions that included people but not specifically within the organisational context of GBFIs. These experiments indicated that improving the office environment could result in improved productivity (Clements-Croome and Baizhan, 2000). These results can be extrapolated in

more detail, such as the removal of air pollution positively impacting health and work productivity (Wargocki *et al.*, 2002; Wyon, 2004) and high temperatures and humidity adversely affect concentration levels (Fang *et al.*, 2004).

It was established by Vischer (2007) that comfort comprised three elements: physical, psychological and functional, where all three elements contribute to individual productivity. This was confirmed by Wiik (2011) who found that both physical and psychosocial environments had a significant impact on productivity in an office building. Additionally, it was also found that behavioural components had a greater influence on productivity than physical components in an office environment (Haynes, 2008b). Loftness *et al.* (2009) found that POE are a beneficial tool for building occupants with regards to assessing building control, health and productivity. In terms of office design, results indicated that there were higher levels of productivity with individual and shared offices when compared to open-plan offices (De Been and Beijer, 2014). Haynes *et al.* (2017) partially agreed but noted that the configuration of open-plan offices was the main contributing factor that influenced productivity levels. However, Byrd and Rasheed (2016) stated that methods measuring perceived productivity were not sufficiently conclusive to substantiate the link between productivity and enhanced IEQ.

Results from the twenty-eight articles contained POE, interviews and longitudinal surveys. All of these included people within the context of GBFIs. Leaman and Bordass (2007) conducted research that focused on comfort in terms of IEQ and their impact on health and productivity, with a specific focus on satisfaction. The findings indicated that generally, occupants of green buildings were satisfied with IEQ when compared to conventional buildings, however not all occupants were satisfied with enhanced IEQ, specifically the influence of comfort and control in buildings containing GBFIs.

According to Schwede *et al.* (2008) the physical attributes of an office environment that most influenced productivity were the acoustic and visual environments. The impact of green buildings on organisations and individuals researched by Kato *et al.* (2009) found that organisations tried to link GBFIs to productivity, employee retention and corporate environmental awareness. However, employees cited enhanced company image and

environmental awareness as the factors that influenced their perceptions regarding GBFIs. Research by Singh *et al.* (2010) supported the notion that green buildings with enhanced IEQ resulted in superior health and perceived productivity of office building occupants. Gou, Lau and Chen (2012) found that subjective satisfaction with IEQ resulted in improved health and productivity, however objective building measurements indicated that green buildings were uncomfortably cold in winter, thus highlighting a possible design flaw.

Gou, Lau and Zhang (2012) found that occupants of green buildings were more satisfied with the IEQ when compared to a conventional building. The green building occupants perceived that they were healthier and more productive (Niewenhuis *et al.*, 2014). This was contrary to research by Gou *et al.* (2013) who found mixed results for occupant satisfaction for green buildings. Gou and Siu-Yu Lau (2013) found that green building occupants were generally satisfied with the thermal environment, however contrasting indoor temperatures in relation to the season was a source of discomfort. Therefore green building design needs to ensure satisfactory ventilation in order to meet occupant comfort requirements, as there was a relationship between perceived thermal satisfaction and measured individual productivity (Tanabe *et al.*, 2015).

Gou *et al.* (2014) stated that it was difficult to measure the impact of IEQ on office building occupants, where the main priorities were perceived health and productivity when comparing green and conventional buildings. It was established that there were many variables that affected work productivity, especially for occupants located in open-plan office spaces (Guerin *et al.*, 2012). Research conducted by Thatcher and Milner (2012) indicated contrary results, which highlighted that occupants of green building did not show improvements in psychological and physical wellbeing, or perceived productivity. Research produced by Agha-Hossien *et al.* (2013) showed that enhanced IEQ resulted in an increase in productivity that was based on individual self-assessment. Further research by Feige *et al.* (2013) stated that there was a relationship between the actual building and comfort levels, however the link between comfort levels and work productivity was not fully confirmed.

Additional research is required to link individual productivity to organisational performance, specifically with regards to financial gain. Hedge and Dorsey (2013) and Thatcher and Milner (2014a) reported that IEQ factors alone did not result in occupant satisfaction. Both sets of

authors continued by stating that ergonomics (i.e., physical workplace design) needs to be considered in combination with IEQ (specifically thermal comfort and ventilation) in order to positively impact occupant satisfaction, health and productivity. Research by Thatcher and Milner (2014b) stated that although green buildings may positively impact occupant wellbeing there was not sufficient evidence to conclusively prove that green buildings result in improved health and productivity.

Activity based work (ABW) environments/collaboration spaces requires IEQ that focuses on air quality and building aesthetics, which can result in perceived enhanced productivity, health and building satisfaction (Candido *et al.*, 2016). This was supported by Thatcher and Milner (2016) who stated that enhanced IEQ resulted in an increase in perceived productivity and physical wellbeing. A different set of results were published by MacNaughton *et al.* (2016) in that green buildings must give the impression to building occupants of a high performing building in order to influence the perceptions and impact of IEQ on occupants. Mallawaarachchi *et al.* (2016), Mulville *et al.* (2016), Chadburn *et al.* (2017) and Mallawaarachchi *et al.* (2017) all, to a greater or lesser degree, highlighted individual system control as a factor that influenced IEQ satisfaction.

Green buildings generally resulted in higher job satisfaction and superior individual productivity assessments when compared to conventional buildings, however there were some conventional buildings that outperformed some green buildings regarding these metrics (Newsham *et al.*, 2017). Elnaklah *et al.* (2020) compared green and conventional buildings in terms of various IEQ factors and found that comfort was superior in green buildings, however individual productivity was slightly higher in conventional buildings, and there was no significant difference in absenteeism and presenteeism in either building type. Finally it was established by Lee *et al.* (2020) that regardless of a green refurbishment or a new green building, the results were the same in IEQ user satisfaction and experienced health symptoms.

Measures and Variables

Table 3.3 unpacks the key measures and where they have been used by previous researchers. The last measure, organisational performance has not been analysed in any of the chosen journal articles cited in table 3.2.

Critique

Although the office environment seems to have been researched extensively in terms of ambient environment and its impact on individual productivity, there are still areas that are either continuously re-examined or neglected altogether. The majority of the journal articles used for this scoping literature review focused on the impact of IEQ on individuals in terms of their perceived productivity, thermal comfort, health and wellbeing. The overarching methods that were applied were POE, longitudinal studies, cross-sectional studies, and interviews.

The trends that appeared with regards to measures included: user satisfaction of IEQ features such as temperature, thermal comfort, humidity, air quality, ventilation, noise, lighting, office configuration, and individual control of the ambient environment. Other non-building measures that appeared were: physical and mental wellbeing (Singh *et al.*, 2010), perception of working conditions (Thatcher and Milner, 2012), job satisfaction, absenteeism, presenteeism and perceived productivity (Thatcher and Milner, 2014b).

The most prevalent methods of analyses were descriptive statistics or some form of multiple regression. While all of the journal articles either focused on the building or individuals operating within the building, there were no studies that predominantly focused on the organisation and how GBFIs may impact the organisation as whole in terms of financial performance. This was a result of past researchers not attempting to link the impact of enhanced IEQ at an organisational level or in the case of Feige *et al.* (2013) not being able to conclusively link improved individual productivity to an improvement in organisational performance that was measured by financial gain to the company, which was hypothesised but not definitively proven.

A challenge that needs to be acknowledged is that productivity may also be influenced by non-GBFIs factors within an organisation, such as the implementation of new executive leadership, which may drastically change strategic and operational policies, for example IT and HR regulations. One of the main weaknesses of previous studies is that individual productivity is self-assessed by the individual and/or their supervisor, which seldom results in a fully quantifiable set of comparable outputs over a period of time. Quantitative data has been collected via laboratory studies, which artificially simulates the office environment. This approach has its disadvantages, as the research subjects are generally aware of the purpose of the experiment, which can result in skewed data.

Ideally measuring individual productivity needs to occur over a relatively long period of time in the actual office environment, which normally occurs through longitudinal studies. The main challenge with longitudinal studies is that when an organisation moves from an old to a new green building, the buildings are not identical, which can also distort the data. The differences in buildings tend to occur as a result of physical elements that are not directly linked to GBFIs, such as new internal configurations for working and resting stations (e.g., cafeteria and toilet locations). The location of the new building will impact commuting times. Additional amenities that are close or offered in the new building may to a greater or lesser degree impact individual productivity.

One of the challenges that has become apparent as a result of conducting a scoping literature review is the inconsistency with regards to the variables that are assessed. Many variables tend to be analysed in isolation in relation to productivity. This is often done without much consideration of the impact of other variables within the greater context GBFIs and individual productivity. These variables tend to include ambient conditions, spatial conditions, location, amenities, comfort and engagement. The majority of studies listed in table 1 did not have a theoretical model that provides a foundation for their chosen variables. An example of such a model is exhibited in figure 3.1, which shows the relationships between the variables.

There seems to be a lack of standardised approaches in which the variables are measured. These approaches include POE, BUS, close-ended questionnaires, environmental monitoring systems, different types of simulated office experiments and longitudinal studies. This

inconsistency with regards to approach also creates difficulty when attempting to compare results across a number of studies. There is additional inconsistency within the types of surveys that have been used across the different studies. This is mainly due to the time span, i.e., cross-sectional vs. longitudinal. A major challenge is the inability to compare many studies, as each study seems to, at most examine one or two GBFIs. Therefore, it may be beneficial to switch the focus solely from GBFIs to IEQ, as this would allow for a more high-level comparison across studies.

Another challenge is the inability to ascertain if there are commonalities across industry sectors, as most of the included studies chose not to disclose the company type to maintain anonymity. A final problem is the manner in which building(s) are incorporated into various studies. Some studies solely focus on one building containing GBFIs, while other studies attempt to compare conventional and green buildings. When comparisons are conducted there is additional difficulty to define the sufficient and accurate criteria that are able to generate data that can result in meaningful conclusions. Therefore, measuring individual productivity within the context of organisational performance over a period of time in relation to competing organisations may result in a data set that can assist in linking individual productivity to organisational performance by providing quantifiable data to support to the proposition that the implementation of GBFIs pertaining to IEQ in an office building increases individual productivity thus leading to an enhancement in organisational performance.

When comparing what has been done within the identified journal articles to the model linking GBFIs pertaining to IEQ to productivity and performance (figure 3.1) there are gaps that require further research. There needs to be specific focus on how knowledge-based building occupants can measure and/or monetise the implementation of GBFIs. This is a vital point, as capital expenditure by real estate companies is usually linked to some form of long-term return on investment (ROI). One of the variables that influences ROI is the vacancy rate, which is underpinned by the tenant's satisfaction with the space and/or the financial success of companies occupying the space in order to re-new leases upon expiration. This will also impact valuation variables (discount and capitalisation rates), as is shown in figure 3.1. A comparison of companies located in buildings containing GBFIs against similar companies

located in conventional buildings could provide an insight into linking GBFIs to organisational performance.

Discussion

The benefit of a scoping literature review within this field of research is that it has provided a systematic approach to identifying specific journal articles that encapsulate office buildings, occupants, GBFIs, enhanced IEQ, and the resulting impact of a number of measures and variables on occupant comfort, wellbeing, and productivity. There appears to be commonalities with regards to conducting research in measuring productivity in office space where IEQ has been enhanced.

Additionally, there seems to be similar trends with regards to the results in terms of the emerging variables that have the strongest links to productivity and the indoor environment. The main findings still revolve around occupant's satisfaction or comfort with the ambient environment and control thereof, with a specific focus on air quality and temperature. The measurement of productivity is either through the supervisor (Newsham *et al.*, 2017) or in most cases, self-assessed (Schwede *et al.*, 2008; Kato *et al.*, 2009; Agha-Hossien *et al.*, 2013; Mallawaarachchi *et al.*, 2016; Haynes *et al.*, 2017) when conducted in an organisation.

There are a variety of research designs, where the majority were cross-sectional studies, longitudinal studies, BUS, and/or POE. Most of the results highlighted office building occupants' wellbeing, comfort, and perceived productivity as the main findings across the majority of articles classified as eligible/included. None of the studies managed to successfully link individual productivity to organisational performance, nor has this been a core research objective for the majority of the researchers in this field of study. There was one study that attempted to find this link as a secondary component to their research (Feige *et al.*, 2013), however the results were inconclusive. Therefore, there remains a gap in this research field, as the impact of the implementation of GBFIs, specifically enhanced IEQ on individual productivity and its link to organisational performance (figure 3.1) has yet to be established.

Conclusion

There is minimal focus on how specific organisations or industries are impacted by GBFIs. Although individual employees underpin organisations, there has yet to be research that links GBFIs to individual productivity and then to organisational performance within an office environment. The majority of the sample of journal papers have indicated that enhanced IEQ is positively received by office building occupants, as there is to a greater or lesser extent an improvement in self-assessed productivity, which has been influenced by both physical and non-physical measures. It should be noted that the main limitation of this scoping literature review includes the assessment of academic research conducted only within the last twenty years, which may indicate a bias towards certain types of research designs and methods of analyses.

Implications for Further Research

The next step in this research area would be to quantitatively assess the impact of GBFIs, specifically enhanced IEQ on organisational performance by comparing the same tenant type (e.g., financial services companies) located in green buildings and cross mapping their organisational performance against IEQ scores. There are several financial institutions that offer products for long-term investment. Typically, these products are categorised as low, medium, and high-risk investment options. Depending on the financial institution, the asset allocation that comprise these investment categories differ depending on the asset managers. Financial services companies located in green buildings with different IEQ ratings can be compared in terms of the annualised return. A further study could be conducted to determine if there is a relationship between specific IEQ attributes (GBFIs) and annualised return (organisational performance), as this would provide further insight in linking individual productivity and organisational performance to GBFIs. This analysis will hopefully provide further insight into the strategy of implementing GBFIs within an office environment.

Appendix

Table 3.2: Selected Sample of Journal Articles (Included *n* = 39)

Author(s)	Research Design	Subject and Setting	Method(s) of Analysis	Duration of Data Collection	Results
Clements-Croome and Baizhan (2000)	Occupational Stress Indicator (OSI) Survey.	Focus on crowded offices/physical environment, which impacts job satisfaction and productivity.	Spearman rank - correlation coefficient, multiple regression, F-test.	Cross-sectional	Improving the office environment could result in improved productivity.
Wargocki *et al.* (2002)	Experiment of removing air pollution source in two buildings, where thirty subjects participated in each building.	Comparison of perceptions of work performance in an office environment when air pollution loads are changed.	Descriptive statistics, t-test, Wilcoxon test, chi-squared.	Cross-sectional	Removal of air pollution positively impacted health and work performance in an office building.
Fang *et al.* (2004)	Experiment and simulated office work of thirty female subjects.	Impact of indoor temperature and humidity on SBS and performance.	Descriptive statistics, ANOVA, Wilcoxon rank test.	Cross-sectional	Uncomfortably high temperatures (gender specific) and humidity levels adversely affect concentration levels.

Wyon (2004)	Experiment of up to five hours of where sources of air pollution was removed in a simulated office. The experiments took place in two offices, n = 26 for each office.	Investigation on indoor air quality (IAQ) on occupant behaviour and productivity.	Multivariate analysis, Wilcoxon test.	Two separate eight week experiments.	Air quality and sufficient ventilation is positively linked to occupant behaviour and productivity in an office building.
Vischer (2007)	Survey, n = 520 from five office buildings.	Investigating the relationship between comfort and performance in an office environment.	Descriptive statistics	Cross-sectional	Environmental comfort comprises three elements: physical, psychological and functional comfort. Personalising space is linked to psychological comfort, which can impact performance.
Leaman and Bordass (2007)	POE from 177 buildings, which focused on comfort, temperature, air quality, lighting, noise, configuration, health and perceived productivity.	Dissatisfaction with green buildings, tolerance of green buildings.	ANOVA, Pearson's correlation	Cross-sectional	Generally, occupants are more satisfied. However some of the granular data indicates some dissatisfaction with certain GBFIs.
Haynes (2008b)	Analysis of two data sets. n_1 = 996, n_2 = 422. Data sets focused on comfort, office layout, interaction and distraction.	Impact of the office environment on perceived productivity of occupants.	Descriptive statistics, Factor analysis/Cronbach's alpha.	Cross-sectional	Behavioural components have a larger impact on productivity than the physical components for office occupants.

Schwede *et al.* (2008)	Analysis of 48 surveys of over 5,000 occupant self-assessments.	Occupant satisfaction of new and old workplace designs.	Descriptive statistics of quantitative and qualitative data.	Cross-sectional over four years	Physical attributes of the workplace impact productivity, which are not properly addressed by designers. The acoustic and visual environment are the most influential factors for building occupants.

Loftness *et al.* (2009)	National Environmental Assessment Toolkit (NEAT) - assesses the efficacy of POE.	Value add of POE for building occupants and facility managers.	Descriptive statistics, ANOVA, Pearson's correlations.	Cross-sectional	POE offer many benefits to building occupants with regards to building control, health and productivity.

Kato *et al.* (2009)	Analysis of two data sets, where *n* = 128. There were two surveys, one targeted management and the other employees.	Perceptions of office buildings occupants located in green buildings.	Descriptive statistics	Cross-sectional	Green building affect an organisation and individuals differently. Organisations cited productivity, employee retention and environmental awareness. Employees cited enhanced company image and environmental awareness.

Singh *et al.* (2010)	Longitudinal study (surveys) involving case studies where building occupants moved from a conventional building to a green building. Case study 1, *n* = 56, case study 2, *n* = 207.	Investigation into the perceived effects of a green building on occupant health and productivity.	t-test	Eight months	The data supported the notion that green buildings with enhanced IEQ result in superior health and perceived productivity of office building occupants.
Wiik (2011)	Questionnaire that converts data into an indoor productivity index (IPI). Survey included twelve companies. Three companies moved premises, nine companies refurbished premises, where *n* = 484.	The development of a model that predicts the economic benefits of refurbishing or moving premises in terms of productivity.	Analysis of Variance (ANOVA), t-test, Pearson's correlation, Cronbach's alpha.	Pre-occupancy surveys. Post-occupancy survey - six, elven and twenty months after moving into new premises.	Both the physical and psychosocial environments have significant impact on productivity in an office building.

Gou, Lau and Chen (2012)	Post-occupancy study in the form of a BUS, where n = 182.	Subjective and objective evaluation of the thermal environment of a green building.	Pearson's correlation	Data collection occurred at the end of summer and mid-winter, each for six days.	Subjective satisfaction with and control of IEQ resulted in improved health and productivity. Objective measurement indicated that the building was uncomfortably cold in winter, thus highlighting some design flaws of the green building.
Gou, Lau and Zhang (2012)	Post-occupancy study in the form of a BUS for two case studies, where n_1 = 57, n_2 = 42. The survey focused on IEQ attributes.	IEQ comparison of two green buildings and a conventional building.	Case study, descriptive statistics and t-test.	Data collected in summer and winter.	Perception of the green building occupants was that they were more satisfied with the IEQ than the occupants of the conventional building. Green building occupants perceived that they were healthier and more productive.
Guerin *et al.* (2012)	POE, where two samples were applied - calibration sample (n = 101), validation sample (n = 102). Survey focus was on occupant satisfaction and performance.	Evaluation of building occupants work performance and satisfaction that focused on IEQ criteria for green buildings.	Descriptive statistics, t-test.	Cross-sectional	There are many variables that affect occupants work performance, specifically for occupants located in open-plan office space.

Thatcher and Milner (2012)	Longitudinal study comparison of two groups, where *n* = 240. One group moved into a green building and the other group that remained in a conventional building.	An investigation to determine if green buildings actually result in enhanced physical and psychological wellbeing.	Descriptive statistics, t-test. Seven measures were analysed.	Time 1 - before employees moved into a green building. Time 2 - six months after employees moved into a green building.	Results were contrary to the industry narrative regarding green building. The green building group did not produce consistent result that indicated that a significant improvement in psychological and physical wellbeing, and perceived productivity.
Agha-Hossien *et al.* (2013)	POE, where *n* = 162.	Employee satisfaction regarding energy performance can be used as predictor for perceived productivity.	Self-assessment of productivity and analysis of absenteeism data.	Pre and Post OE six months apart.	Employee were satisfied with the new work environment that focused on space configuration and quality. Employee self-assessed productivity increased.

Feige *et al.* (2013)	Questionnaires, structured interviews, and physical measurements inside office buildings. The research comprised 18 office buildings where *n* = 1,500 employees.	The relationship of sustainable office buildings occupant's comfort, self-assessed performance and work engagement.	Descriptive statistics, correlation analysis.	Questionnaire and measurements occurred twice over summer and winter.	There is a relationship between building and comfort levels. The link between comfort and work performance is not fully confirmed. Linking work performance and financial gain to the company still requires research.
Gou *et al.* (2013)	BUS focused on comfort and satisfaction. The sample included 9 green buildings and 5 conventional buildings, with total occupants of *n* = 1,251.	Comparison of green and conventional building with a specific focus on occupant satisfaction and comfort.	Case study, descriptive statistics and t-test.	Data collected in summer and winter.	Mixed results for occupant satisfaction and comfort for green buildings.

Hedge and Dorsey (2013)	POE where *n* = 35 for two green certified office buildings. Research focused on ergonomic and IEQ measures.	Investigating the impact of ergonomics and IEQ factors on health, performance and satisfaction.	Chi-squared, t-test, Pearson's correlation, factor analysis, stepwise linear regression.	Cross-sectional	IEQ factors alone do not result in occupant satisfaction. Ergonomics needs to be considered in combination with IEQ in order to positively impact occupant satisfaction, health and performance.
Gou and Siu-Yu Lau (2013)	POE as a BUS conducted in an office building, which comprised a survey (*n* = 182) and physical measurements.	POE of thermal environment in a green building.	Descriptive statistics	Data collection occurred at the end of summer and mid-winter, each for six days.	The majority of occupants were satisfied with the thermal environment. Contrasting indoor temperatures in relation to the season was a source of discomfort for building occupants. Green building design needs to ensure satisfactory ventilation in order meet occupant comfort requirements.

De Been and Beijer (2014)	WODI Light online questionnaire across 87 case studies, which spanned across different sectors, where *n* = 11,799.	Measuring employee satisfaction with the working environment, with specific focus on office type.	Regression analysis	Five and half years.	Results indicate a higher level of productivity with individual and shared offices versus larger open-plan offices.
Gou *et al.* (2014)	BUS comprising 14 buildings where *n* = 1,251 occupants. Survey focused on temperature, light, noise, perceived health and perceived productivity.	Green building IEQ satisfaction which can impact office occupant comfort, health and productivity.	Analysis of Variance (ANOVA), F-test, Pearson's correlation.	Data collected in summer and winter.	Difficult to measure the impact of IEQ on office building occupants. Perceived health and productivity is highest when compared to conventional buildings for occupants located in highly rated green office buildings.
Niewenhuis *et al.* (2014)	Longitudinal study, which focused on workplace satisfaction, concentration, air quality and subjective productivity. A sample of *n* = 67.	The introduction of green features in an office building. Measuring the difference in occupant in terms of wellbeing and productivity.	Analysis of Variance (ANOVA), chi-squared.	Three weeks	Green features contribute to employee welfare and organisational output in terms of productivity.

Thatcher and Milner (2014b)	Longitudinal study comparison of two groups. One group moved into a green building and the other group that remained in a conventional building, with n = 41.	The determine whether a green building results in a healthier more productive office environment.	Descriptive statistics, t-test, F-test, chi-squared.	Time 1 - two months prior to moving to the green building. Time 2 - two weeks, six months after moving into the green building. Time 3 - three weeks, one year after moving into the green building.	Results suggest that green building may positively impact wellbeing of occupants. The results do not conclusively prove that green buildings result in enhanced health and productivity for the occupants.
Thatcher and Milner (2014a)	Longitudinal study (POE) involving moving from conventional buildings to three green buildings. The sample was: n_1 = 161, n_2 = 56, n_3 = 108. Survey focused on psychological and physical wellbeing, job satisfaction, propensity to continue working at the organisation, productivity, absenteeism, presenteeism.	Focus on ergonomics for green building that contributed to the design of the interior design rating tool.	Descriptive statistics, t-test.	Pre-occupancy survey - three months prior to moving into a green building. Post-occupancy survey - six months after moving into a green building.	Ergonomic has a role to play in green building design, with specific focus on thermal comfort and ventilation.

Tanabe *et al.* (2015)	Survey of office workers n_1 = 105. The survey focused on health, indoor environment, fatigue, self-assessed performance, and usage of cooling items. Experiment and simulated office work, n_2 = 11 for the chamber.	Investigating changes in the thermal environment with regards to the impact on individual productivity in an office building.	Descriptive statistics and correlation tests.	Phase 1 - four months, Phase 2 - two months.	There is a relationship between perceived thermal satisfaction and actual measured (Phase 2) individual productivity.
Byrd and Rasheed (2016)	Review of measuring productivity. Two surveys - the first focus on self-assessed productivity. The second survey included twenty-one factors that focused on environmental and social aspects in an office environment. Both surveys had *n* = 49.	Measuring productivity of green buildings within the context of IEQ.	Review of measuring productivity and a survey.	Cross-sectional	Methods of measuring perceived productivity are not conclusive to substantiate the link between productivity and enhanced IEQ.

Candido *et al.* (2016)	POE, time-lapse surveys, IEQ measurements for 65 buildings with 7,000 responses. Nine IEQ measures and four satisfaction measures:	Workplace layout and occupant satisfaction with IEQ components for activity based working (ABW).	Analysis of Variance (ANOVA), Cohen's *d*	Cross-sectional	Building occupants were satisfied with IEQ regarding air quality, building aesthetics, perceived productivity, building satisfaction, health and collaboration space for ABW layout.
MacNaughton *et al.* (2016)	Environmental monitoring system (phase 1 and 2), survey (phase 2). Sample comprised *n* = 30 (phase 1) and *n* = 24 (phase 2).	Environmental perceptions and health before and after moving to a green building.	Univariate and multivariate analysis	Two weeks (phase 1), six days (phase 2).	Building occupants in green building experienced enhanced IEQ. A green building must exhibit high performance and give the perception of high performance (IEQ) in order for it to influence building occupants.

Mallawaarachchi *et al.* (2016)	Survey and semi-structured interviews. Measures comprised self-assessment of productivity, thermal conditions, visual quality, IAQ and acoustic quality, where n = 65.	Examining the relationship between IEQ and enhanced productivity of green buildings occupants.	Non-parametric statistics, Spearman's correlation.	Cross-sectional	Several IEQ factors influenced individual productivity, such as air quality, acoustics and system control.
Mulville *et al.* (2016)	Survey, n = 95. Measures comprised ambient environment, air quality, temperature, humidity, noise, lighting, occupant behaviour, health, wellbeing and proximity to windows.	Examines the ambient environment on perceived comfort, health, wellbeing and productivity in an office building.	Spearman's correlation	Five weeks during the summer months.	Certain environmental factors have a greater influence on productivity, such as noise level, access to systems control.
Thatcher and Milner (2016)	Longitudinal study (POE) involving moving from conventional buildings to three green buildings. Treatment group - employees moved from conventional to green building. Contrast group - employees remained in the conventional building. Samples comprised n_1 = 97, n_2 = 41, n_3 = 73.	Investigation into whether green office buildings results in enhanced user experience due to improved IEQ.	Review of academic literature, descriptive statistics, t-test, F-test, chi-squared.	Pre-measures taken three months before moving to a green building. Post-measures taken twelve months after moving into a green building.	There was an increase in perceived productivity and improvement in physical wellbeing.

Haynes *et al.* (2017)	Survey, where *n* = 220. Self-assessment of productivity and an evaluation of the office environment. Focused on lighting, temperature, cleanliness, interruptions and work interaction.	Investigation into the open-plan offices focusing on if productivity benefits outweigh productivity penalties.	Descriptive statistics, Factor analysis/Cronbach's alpha.	Cross-sectional	The configuration of open-plan offices is the main contributing factor regarding influencing levels of productivity.
Chadburn *et al.* (2017)	Close-ended questionnaire of employees in professional companies, where *n* = 213. Survey focused on seven aspects of productivity.	Drivers of individual productivity of knowledge based workers, focusing on the physical and social environment.	Descriptive statistics	Cross-sectional	Individual productivity is dependent on the physical and social environment. Main drivers of productivity is an office with good ventilation and temperature control.

Mallawaarachchi *et al.* (2017)	Survey and semi-structured interviews used to test two hypotheses, where *n* = 65.	Examining the relationship between built environment and productivity of green buildings occupants.	Spearman's correlation	Cross-sectional	There is a statistically significant relationship between green buildings and occupant productivity in terms of: air quality, system control, acoustical partitioning, amount of space and open-plan office design.

Newsham *et al.* (2017)	Analysis of office building occupants (*n* = 14,569) in green and conventional buildings. Occupant productivity measures: great place to work, external value, management, happy to be here, manager assessed performance, HVAC complaints.	Analysis of green and conventional buildings. The main focus is organisational performance across the data set.	Building level - non-parametric Wilcoxon signed rank test. Employee level - multivariate analysis of variance with covariates (MANCOVA).	Cross-sectional	Generally green buildings scored higher with regards to job satisfaction and value to clients. Green buildings also tended to yield higher job performance assessments conducted by managers. Note: not all green buildings outperformed all conventional buildings.
Elnaklah *et al.* (2020)	POE of five green buildings and eight conventional buildings, *n* = 502 building occupants. Focus of the study was measurement of air temperature, humidity, CO_2 concentration, individual productivity measured by absenteeism and presenteeism.	Investigation into the comparison of IEQ quality of green buildings versus conventional buildings.	Descriptive statistics, t-test, Cohen's d	Longitudinal study, where data was collected over three campaigns over approximately 18 months.	Thermal comfort in green buildings is superior to conventional buildings. Individual productivity was slightly higher in the conventional buildings with no significant difference between absenteeism and presenteeism.

Lee *et al.* (2020)	POE of occupants (*n* = 367) in office buildings (*n* = 14). Main measures comprised: windows view from desk, temperature, humidity, lighting level, daylight, air quality and indoor environment.	Investigation into satisfaction and health symptoms experienced by users of green refurbished office buildings compared to new certified green buildings.	Multivariate analysis, pairwise analysis	Cross-sectional across the sample of buildings that took approximately two years.	Both categories of building had superior IEQ compared to conventional buildings. Refurbished conventional buildings to green certified buildings exhibited similar satisfaction and health symptoms relating to IEQ to that of anew certified green building.

Table 3.3: Measure and Corresponding Application by Other Researchers

Measure	Application by previous researchers
Ambient conditions (IEQ/IAQ)	Multiple approaches to measuring IEQ/IAQ. Hedge *et al.* (1996) focused on temperature, lighting, glare, ventilation, internal drafts, insufficient air movement, dryness, humidity, ambient noise distraction, unpleasant air odour, stale air, dusty air and electrostatic shock in a questionnaire to assess perceptions of the IEQ in a sick building syndrome (SBS) study. This questionnaire was used by Thatcher and Milner (2012, 2014b, 2016). Another popular application for measuring IEQ/IAQ is the BUS, (Gou *et al.*, 2013; 2014) that focused on comfort, including assessing perceptions of temperature, light, noise, and air quality.
Spatial conditions	Scale developed by Thatcher and Chunilal (2015) - comparison of workspace type and quality was conducted when an organisation moved from a conventional building to a green certified building. This scale consists of 13 items which showed good discriminant validity and internal consistency reliability (Thatcher & Chunilal, 2015). The items were underpinned by ergonomics theory that includes frequency-of-use, functionality, personal space, privacy and collaborative space (McCormick, 1970; Orborne, 1982). Candido *et al.* (2016) conducted a study that somewhat focused on spatial comfort and individual space containing seven items, based on the BOSSA Time-Lapse IEQ questionnaire. Mallawaarachchi *et al.* (2017) partially looked at spatial quality, where the focus was personal control workstations, distractions, privacy, office instrumentality, space arrangement, office orientation and space flexibility, based on similar items that were identified by Heerwagen (2000).
Location and amenities	Currently no validated scale exists to assess satisfaction with location and amenities. A scale will therefore be developed and pilot-tested that assesses the important amenities as identified by Alker *et al.* (2014). A draft version of possible questions was included as an Appendix to the Alker *et al.* (2014) report, but this has not been empirically tested. The questions that focused on location pertained to the proximity of the office to different transport routes, nodes and commute times. The questions that focus on amenities include showers, storage facilities for bicycles and clothes, quality of food at the office, and proximity of external amenities such as shops.
Comfort	A POE was deemed an appropriate tool for assessing comfort by Bordass and Leaman (2005a) as it provided a feedback mechanism. Therefore the following researchers listed in table 1 applied a POE and/or a BUS: Leaman and Bordass (2007); Gou,

	Lau and Chen (2012); Gou and Siu-Yu Lau (2013); Gou *et al.* (2013); Thatcher and Milner (2014a); Elnaklah *et al.* (2020). Another method of measuring comfort was to conduct simulated experiments that intentionally changed the indoor environment (Wargocki *et al.*, 2002; Fang *et al.*, 2004). Feige *et al.* (2013) assessed comfort by applying questionnaires, structured interviews and conducting physical measurements within an office. Mulville *et al.* (2016) and Chadburn *et al.* (2017) both used questionnaires that included comfort as a measure. According to Vischer (2007) and Laughton and Thatcher (2018), discomfort is categorised as a physical or psychological. Psychological comfort was assessed through Laughton and Thatcher (2018) self-developed 6 item scale. This scale showed good internal consistency reliability in a previous study. Physical comfort was measured using the SBS questionnaire from Hedge *et al.* (1996). There were 15 items on this scale, and it was assessed using a 4-point scale ranging from never (4), 1-3 times per month (3), 1-3 times per week (2), and every day (1). Good internal consistency reliabilities have been reported on subsequent administrations of this scale.
Engagement	Feige *et al.* (2013) attempted to measure work engagement using descriptive statistics and multiple regression by trying to identify a correlation between engagement, environmental features, IEQ, SBS, work performance and organisational citizenship behaviour. This was based on the mental state of employees, which is underpinned by vigour, dedication and absorption (Demerouti and Bakker, 2008). Scale created by Schaufeli *et al.* (2006) focused on vigour (high energy levels and mental resilience), dedication (high involvement levels and enthusiasm) and absorption (high concentration levels). Utrecht Work Engagement Scale (short version), 9 items (3 each for vigour, dedication, and absorption) measured on a 7-point Likert-type scale from “never” to “always”. These scales were based on a previous study by Schaufeli *et al.* (2002) using the Maslach-Burnout Inventory-General Survey (MBI-GS) where engagement and burnout were analysed.
Individual productivity	Absenteeism and presenteeism are viewed as potential indicators of productivity (Roelofsen, 2002; Danielsson and Bodin, 2008; Thatcher and Milner, 2012; Agha-Hossien *et al.*, 2013; Thatcher and Milner, 2014b; 2014a; Elnaklah *et al.*, 2020). Self-assessed productivity is another approach to determining productivity levels, where respondents were asked to rate their perceived productivity on a scale from 0-100% within the context of their full capacity (KPIs) (Thatcher and Milner, 2012). Another more structured measure of productivity is by conducting psychometric tests, which use different types of reasoning tests, containing quantitative and qualitative

	assessments (Byrd and Rasheed, 2016). The BUS also requires self-rating of productivity which used a scale ranging from decrease (-20%) to increase (+20%) (Gou *et al.*, 2013). Another version of the BUS measured perceived productivity using a 7-point likert-scale ranging from “less productive” to “more productive” (Gou *et al.*, 2014).
Organisational performance	There are no previous researchers that were able to establish a link between GBFIs to both individual productivity and organisational performance. Therefore, there are no commonly used items to assess this measure within a knowledge-based office environment.

4. Linking IEQ and Individual Productivity

4.1 Introduction

This is the first of the two empirical papers, which specifically focused on individual productivity.

This paper investigates individual productivity of knowledge workers based in investment teams within financial services companies (FSCs) in South Africa. This paper focused on the individual component (above the dotted line) of the emergent model presented in Nurick and Thatcher (2021b). Two FSCs located in a four and a six green star certified building, respectively, participated in the study. In-depth semi-structured interviews were conducted across the two FSCs, comprising fifteen respondents, with at least five years' experience at their specific FSC working in the green building. The over-arching findings indicated that location and amenities played a substantial role in contributing towards organisational culture, collaboration spaces, and employee attraction and retention. Furthermore, another factor that is unique to South Africa is safety at both a personal level and an asset level (e.g., building occupants' motor vehicles). This resulted in the modification of the theoretical model that was initially presented in Nurick and Thatcher (2021b).

Contribution by the authors:
Nurick wrote the paper as first author, which included conception, structure and all the associated reading, and model development. Nurick also handled all the correspondence with the *Journal of Corporate Real Estate* with regards to submission (including re-submission with a schedule of corrections).
Thatcher provided oversight and input at a theoretical level.

The research has been submitted to the *Journal of Corporate Real Estate*, as it is deemed to be an ideal (Scopus rated) international journal. The journal is published by Emerald Insight, which houses numerous reputable journals across multiple research disciplines. The research has been through one round of review, where a schedule of corrections has been drafted in response to the review. The amended paper has been re-submitted for further review.

Examining the Impact of Indoor Environmental Quality on Individual Productivity of Knowledge Workers in Green Certified Buildings

Abstract

Purpose: This paper investigates green buildings and individual productivity, specifically within the context of indoor environmental quality (IEQ) within green certified office buildings. The purpose of the research was to determine how self-assessed productivity levels were influenced by the indoor environment of the office building.

Methodology: Qualitative data analysis was conducted via semi-structured interviews in two financial services companies (FSCs), both based in green certified office buildings in South Africa. Thematic analysis was conducted to extract common themes from the data. Furthermore, the data were compared to previous research to identify new potential pathways or provide support for existing pathways.

Findings: The main findings were that physical components, such as temperature, lighting, ventilation and noise contribute depending on the respondent to individual productivity, engagement, organisational commitment and psychological wellbeing. Safety, underpinned by location and amenities, was a new component not previously considered that subtly contributed to individual productivity.

Originality: The research provides valuable insight into the contributing factors that impact individual productivity within a green certified office building, as previous researchers have yet to reach a consensus on the relationship between individual productivity and IEQ in green certified office buildings.

Key words: indoor environmental quality (IEQ), financial services companies (FSCs), productivity, engagement, comfort, wellbeing

Introduction

The emergence of green building since the 1990s in developed real estate markets has mostly focused on the financial benefits (Milne, 2012), specifically building materials during

construction and utility costs (water and electricity) during occupation. Indoor environmental quality (IEQ) is a category that is found in most mainstream green building tools (Green Building Council Australia (GBCA), 2015; Green Building Council of South Africa (GBCSA), 2015a; United Kingdom Green Building Council (UKGBC), 2015; United States Green Building Council (USGBC), 2015), which has anecdotally resulted in green building advocates claiming that occupants based in green certified office buildings are more productive than their contemporaries located in conventional (non-green) buildings. There have been previous researchers that have attempted to link green building features and initiatives (GBFIs) to productivity to office building occupants. This has yielded mixed results due to the variety of methods (Nurick and Thatcher, 2021a). Some researchers have found that certain GBFIs do enhance individual productivity (Harter *et al.*, 2003; Schwede *et al.*, 2008; Vischer, 2008; Singh *et al.*, 2010; Fisk *et al.*, 2011; Wiik, 2011; Gou, Lau and Chen, 2012; Gou, Lau and Zhang, 2012; Alker *et al.*, 2014). Other researchers have found mixed results (Thatcher and Milner, 2012; Feige *et al.*, 2013; Byrd and Rasheed, 2016; Bortoluzzi *et al.*, 2018). Furthermore, Haynes (2008b) states that the nature of human interaction (or distraction) in an office environment has the greatest direct impact on productivity. Additionally, research by Newsham *et al.* (2017) indicated that some conventional (non-green certified) buildings outperformed some green certified buildings in terms of organisational productivity metrics.

Rationale

Typically, the implementation of green building features and initiatives (GBFIs) underpinned green building certification. GBFIs focused on both structural (materials and design) and operational (utilities) components of the building. Furthermore, some GBFIs are linked to IEQ in the form of location and amenities, spatial factors and ambient conditions, which impact user experience of the building. Figure 4.1 developed by Nurick and Thatcher (2021b) exhibits the relationship between the implementation of GBFIs to wellbeing, health, comfort, work engagement and productivity. The aforementioned factors that influence productivity are inter related, and therefore do not sit in isolation. Wellbeing (individual mental status) and health (individual physical condition) contribute to overall comfort (satisfaction with physical working environment), which in turn has an impact on work engagement (ability to

concentrate on a task), and thus productivity (ability to efficiently perform a work related task)(Ildiri *et al.*, 2022). This theoretical model (figure 4.1) indicates that if individual productivity is enhanced due to the implementation of GBFIs, then this could be transferred into improved organisational performance. The latter question about organisational performance was tested within the context of FSCs based in green and non-green buildings by examining returns of South African financial products (Nurick, 2022), which indicated that there was improved performance in a group of FSCs located in green buildings compared to FSCs in non-green buildings in terms of the five-year annualised returns. The measurement of individual productivity within an office environment is somewhat challenging as output is not linear as would be the case in a factory/assembly line environment. Therefore, one of the common approaches to assessing individual productivity is to interview or survey office workers to ascertain their perceptions of what influences productivity in terms of physical and psychological comfort, engagement, organisational commitment and the ability to perform their work. This is either conducted via longitudinal or cross-sectional studies, which involve interrogating many of the aforementioned factors in relation to the physical building components that relate to IEQ (Wyon, 2004; Roulet *et al.*, 2006; Akimoto *et al.*, 2010; Fisk *et al.*, 2011; Chadburn *et al.*, 2017). It should be noted that much of the prominent research attempting to link individual productivity and organisational performance was conducted in the period between 2000-2020 as indicated by Nurick and Thatcher (2021a). This is due to uptake of green buildings in the late 1990s and early 2000s where advocates claimed that enhanced IEQ resulted in improved individually productivity, which resulted in many researchers investigating this claim with varying levels of success. However, generally, there were no categorical results that either supported or refuted the proposition that there was a direct link between enhanced IEQ and improved individual productivity and organisational performance. The relatively small number of peer reviewed papers that have been published in the last five years have attempted to re-address this link, with a different theoretical lens, which takes a more philosophical approach in the form of developing theoretical models and the compilation of systematic and scoping literature reviews (Browning *et al.*, 2020; Mirzaei *et al.*, 2020; Sadick and Kamardeen, 2020; Bueno *et al.*, 2021; Colenberg *et al.*, 2021; Zitras *et al.*, 2021).

This paper addresses the following research question:

What theoretical and empirical pathways link GBFIs to individual productivity and organisational performance within an office building?

This paper focuses on individual productivity, as the organisational performance component of the research question is addressed in Nurick (2022). The unit of analysis in this study is the individual office worker located in a green certified building.

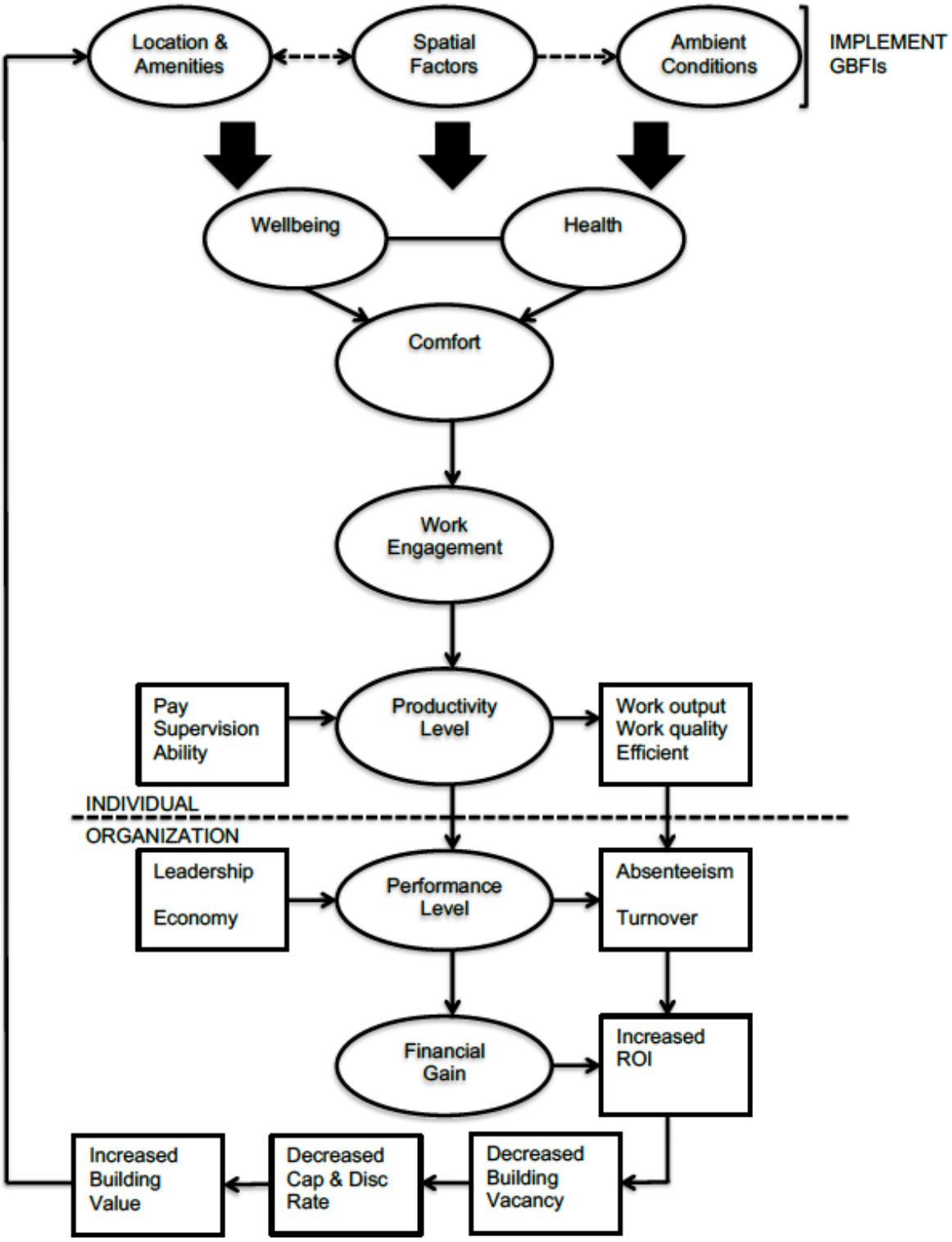


Figure 4.1: Linking GBFIs to Individual Productivity and Organisational Performance (Nurick and Thatcher, 2021b: 29)

Method and Research Question(s)

Method

Data was collected via semi-structured interviews across two financial services companies (FSCs), which occurred over a two day period for each FSC in 2022. Semi-structured interviews were deemed to be the optimum data collection method as this allowed for in-depth discussions with respondents in order to extract their thought process with relation to GBFIs and the impact on their individual productivity levels. The respondents, all skilled (i.e., university graduates) were purposively selected, as the overall sample comprised individuals across different age ranges, and levels within the respective FSCs. Furthermore, the sample was selected based on their specific skills that placed them within the investment division in each of the FSCs for at least five years. An email was sent to each FSC requesting respondents that met these specific criteria, as this was aligned with the quantitative research conducted by Nurick (2022) using FSCs. The engagement regarding the respondent's thought processes and their reasoning would not have been possible using surveys. Case study 1 (CS1) is an investment company located in a Green Star South Africa (GSSA) six star rated building in Cape Town, and received its as-built rating in 2014. The headline GBFIs are the double-skinned glazing that cover the entire external façade of the building, where there are two layers of windows, which are one meter apart as a form of thermal insulation, and the HVAC system that makes use of sea water and the associated built-in floor air flow reticulation system. Case study 2 (CS2) is a bank located in a Green Star South Africa (GSSA) four star rated building in Johannesburg, which obtained its certification in 2009, as a result of its 'campus' design in a heavily urbanised commercial area. The main GBFIs associated with CS2 are the water and electricity management systems that future proof the building from infrastructure failures which tend to occur more often in Johannesburg. These systems also contributed to the centralised control of temperature and ventilation in the building. Figure 4.2 provides an insight in the interior fitout and external glazing of CS1, while figure 4.3 is an image of the atrium of CS2. The main GBFIs and externalities for both cases are listed in table 4.1. CS1 and CS2 comprised eight and seven respondents, respectively. Qualitative data was acquired and analysed using NVivo in the form of thematic analysis.

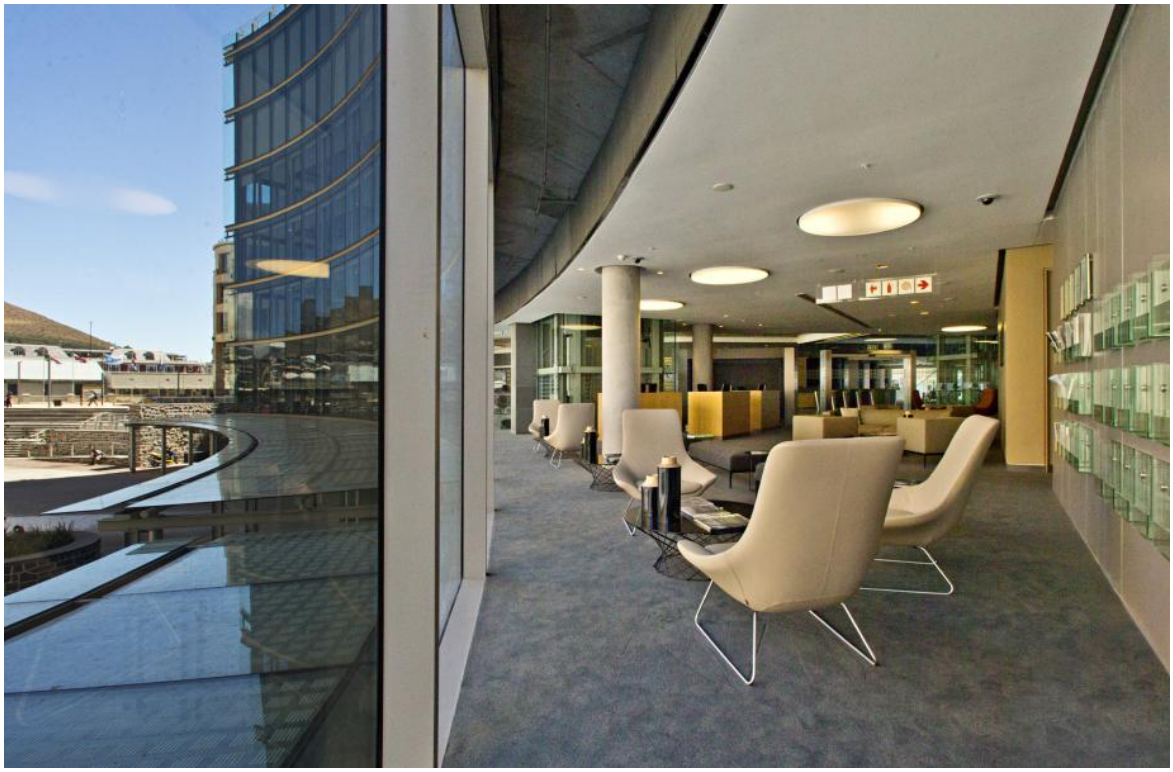


Figure 4.2: CS1 Interior Fitout and External Glazing (Collaboration, 2014)



Figure 4.3: CS2 Atrium (Solid Green Consulting, 2011)

Table 4.1: Key GBFIs and Externalities of CS1 and CS2

Case Study 1	**Case Study 2**
Double skinned glazed that covers the entire external façade.	Water and electricity management systems.
HVAC system using sea water and linked to built-in floor air flow reticulation system.	Centralised control of temperature and ventilation.
Internal atrium, which provides large amounts of natural light.	Atrium, which provides large amounts of natural light and can be used for corporate functions.
Green roof for functions and breaks from work with views of nature.	Green spaces within the campus design of the building.
Walkable access to a mixed use urban precinct, comprising shops, thus reducing the carbon footprint of the building occupants.	A shopping centre across the road that contains grocery stores, thus reducing the carbon footprint of the building occupants.
Showers and bicycle storage facilities, thus reducing the carbon footprint of the building occupants.	Non-opening windows allowing for temperature and ventilation control, in addition to acting as a barrier from traffic related noise pollution.

Interview Schedule and Procedure

The semi-structured interview questions emerged from the sources cited in the literature review conducted by Nurick and Thatcher (2021b). This resulted in questions that focused on the physical indoor working environment (lighting, noise, temperature and ventilation), physical comfort, engagement, psychological wellbeing and presenteeism.

The respondents were volunteers who were purposively selected across the two case studies and had been at their respective organisation from five to twenty two years. The in-depth interviews were conducted at each of the respective office buildings over a period of two consecutive days (total of four days of interviews), where an hour was allocated for each respondent. The actual interview times ranged from thirty to forty-five minutes, where the

older respondents tended to speak for longer, as they had more to draw on from their careers working in office buildings within the context of FSCs. Data saturation occurred relatively quickly at each location, which justified the relatively small sample size, i.e., similar responses were being expressed across the sample of respondents for each of the FSCs prior to the completion of the interview schedule.

Sample

The age range across the respondents was large, and varied from late twenties to early sixties. All of the respondents were university graduates and held positions in their respective organisation that ranged from specialist analyst to executive director, within the investment division. All the respondents were similarly positioned with regards to their work station. In other words, they were each in close proximity to a window, printer, bathroom. However, some of the respondents in CS1 were positioned near a central atrium that runs through the centre of the building, which is a source of natural light. Table 4.2 provides a breakdown for each of the fifteen respondents in terms of their general characteristics. CS1 comprised three female and five male respondents, respectively, with the majority in middle or senior management positions. The tenure of the sample for CS1 ranged from five to twenty-one years ($\overline{x}$ = 10.25, S = 6.04). CS2 comprised three female and four male respondents, respectively, with roles ranging from analyst to executive director. The range of tenure for the respondents from CS2 is five to twenty-two years ($\overline{x}$ = 14.71, S = 6.63). The average and standard deviation for tenure for the entire sample (both case studies) is $\overline{x}$ = 12.60 and S = 6.62, respectively. Each respondent is coded anonymously, which only refers to the case study and respondent number, respectively. For example, the first respondent in case study 1 is coded CS1R1.

Table 4.2: Respondent Characteristics

Respondent CS1	**Gender**	**Position**	**Tenure**
CS1R1	Female	Senior Manager	12 Years

CS1R2	Female	Senior Manager	8 Years
CS1R3	Male	Middle Manager	5 Years
CS1R4	Male	Executive Manager	21 Years
CS1R5	Male	Middle Manager	20 Years
CS1R6	Female	Middle Manager	5 Years
CS1R7	Male	Middle Manager	6 Years
CS1R8	Male	Middle Manager	9 Years
Respondent CS2	**Gender**	**Position**	**Tenure**
CS2R1	Female	Senior Manager	17 Years
CS2R2	Male	Middle manager	6 Years
CS2R3	Male	Executive Manager	22 Years
CS2R4	Female	Analyst	5 Years
CS2R5	Male	Senior Manager	19 Years
CS2R6	Female	Executive Manager	22 Years
CS2R7	Male	Senior Manager	12 Years

Method of Analysis

The chosen data acquisition approach was in the form of semi-structured interviews in order to ascertain the perceptions of respondents with regards to the impact of the indoor environment on their productivity. Due to the differing roles and tenure of the respondents, gauging productivity in an office environment can be somewhat subjective. Thematic analysis was used to analyse the data collected from the semi-structured interviews. Themes emerged from the data and were organised into five global themes, namely: IEQ Awareness,

Productivity Drivers, Productivity Barriers, Access to Nature, and Enhanced Organisational Culture. Thematic analysis is an approach for systematically organising qualitative data into groups (themes) that express consistent meaning (Braun and Clarke, 2012), where themes have a singular focus, linked but do not overlap, but can build on previous themes. Most importantly the consolidation of the data within all the themes should address the main research question (Braun and Clarke, 2012). Thematic analysis comprises several stages, which include: transcribing the interview recordings where the researcher familiarises themselves with the data, coding the data by using specialist qualitative data software, searching for and reviewing potential themes, and identifying the global themes. It should be noted that thematic analysis is not a linear research method with one correct answer, but rather an iterative approach where the researcher can review the data to infer results that are not quantifiable, which is considered a robust approach in the field of both deductive (based on a philosophical framework) and inductive coding (themes emerging from interviews) (Fereday and Muir-Cochrane, 2006; Braun and Clarke, 2021). This form of data collection results in obtaining thick descriptions, which comprises one or more of the following attributes: interpretation of data within a certain context, capturing thoughts and emotions, assigning motivations and intentions, rich account of details, and the meaningfulness of a given situation(s) in detail (Drew, 2022).

Results and Discussion

IEQ Awareness

Two sub-themes emerged from the global theme of IEQ awareness, namely ambient conditions and the age of respondents. These two sub-themes are inter-related as the respondents' engagement with the ambient conditions or lack thereof was underpinned by their age.

Ambient conditions

Elements of ambient conditions that are commonly found in the literature tend to focus on IEQ and/or sick building syndrome (SBS) in terms of perceptions of office building occupants.

This was typically conducted using a building user survey (BUS) (Thatcher and Milner, 2012; Gou *et al.*, 2013; 2014; Thatcher and Milner, 2014b; 2016), which lacked in-depth data in the form of thick descriptions. All the respondents across the two case studies had some form of awareness of the GBFIs that contributed to their indoor environment, as they were all aware that their respective company was located in a green certified building. The main IEQ components that were highlighted formed part of the ambient conditions - ventilation and temperature. The main challenges with these two components is that due to the 'smart design' of the green building occupants did not have individual control. Building occupants were required to log a call with the facilities management team if there was a problem or modification to air flow and/or temperature was requested. A secondary IEQ component that was raised by some of the respondents was the quality of natural and artificial light, where it was only deemed a problem if there were power outages. These timed electricity outages (known as load shedding in South Africa) could cause disruptions to the working environment. However, both the green buildings had uninterrupted power supplies, resulting in a minor disruption to the power, as there was a very small time delay (approximately a minute) when converting from the national grid to on-site power generation.

Age of respondents

The age of the respondent underpinned their IEQ awareness (CS2R3). Respondents that had careers spanning more than twenty-five years were very aware that they were in a high quality building, as they had spent the bulk of their careers in lesser quality (non-green) buildings where many IEQ factors were not adequately addressed. One respondent recalled when smoking was permitted in office buildings and how this would be considered intolerable today. On the contrary, respondents (in their late twenties to mid-thirties) were relatively less aware of the level of indoor environmental quality of their office. This is due to them not being exposed to the office environments of the 1980s and 1990s, and therefore taking for granted good quality ventilation, temperature management, and lighting to the point where these building attributes were considered to be the norm and hardly considered important by these participants.

Productivity Drivers

There were two sub-themes that underpinned drivers of productivity, namely the physical office environment in terms of spatial factors and ambient conditions, and physical comfort.

Spatial Factors and Ambient Conditions

Although ambient conditions were cited as a contributing factor to productivity, spatial factors also played a vital role in impacting individual productivity levels. Previous research on spatial factors predominantly applied longitudinal studies, however these approaches all applied high-level survey type data collection instruments, which lacked in-depth engagement with office building occupants (Heerwagen, 2000; Thatcher and Chunilal, 2015; Candido *et al.*, 2016; Mallawaarachchi *et al.*, 2017). The main drivers of productivity related to GBFIs cited by the majority of respondents across both CS1 and CS2 were access to dedicated work space, ambient noise levels in an open plan office environment (not too loud), quality lighting (natural and artificial), temperature control (or lack thereof), the physical quality of the office environment (furniture), building management support services (e.g., a broken light), access to break away zones and refreshment stations (location and amenities) that can be used as informal collaborative space, physical comfort in terms of having the option of sitting versus standing desk, knowing that there are external amenities within walking distance (e.g., groceries), access to privacy when required. A combination of spatial factors and ambient conditions in terms of the aforementioned GBFIs influence individual productivity. When one or more of these GBFIs is deemed to be unsatisfactory by the building occupants then productivity is negatively impacted. Due to the nature of the type of employee (skilled knowledge worker) in both case studies and the calibre of the FSCs (blue chip companies), there was a high expectation in terms of both spatial factors and ambient conditions.

Comfort

Comfort has been heavily researched within the context of structured interviews, likert-type scales, and physical measurement, however all of these approaches lacked in-depth engagement with office building occupants (Hedge *et al.*, 1996; Wargocki *et al.*, 2002; Fang

et al., 2004; Bordass and Leaman, 2005b; Leaman and Bordass, 2007; Feige *et al.*, 2013; Mulville *et al.*, 2016; Chadburn *et al.*, 2017; Laughton and Thatcher, 2018; Elnaklah *et al.*, 2020).The aforementioned spatial factors and ambient conditions were directly linked to comfort, and thus these productivity drivers could also be associated with psychological wellbeing, for example a well maintained and clean office environment with efficient facilities management support could enhance work engagement (concentration) and reduce residual frustration (distractions), which indirectly improves productivity (CS1R1, CS1R4, CS2R3, CS2R4, CS2R6, CS2R7).

"…psychological aspect in that, okay, I am at work, this place is well looked after and that also means I want to bring my best in terms of work and personal interactions…" CS1R1

High levels of natural light also enhanced psychological wellbeing, as different shades of natural light improved mood and potentially work engagement.

"…not having the feeling like I am working in a casino and they just want you to work not knowing whether it is day or night." CS1R2

A main factor cited by respondents in both CS1 and CS2 that contributed to psychological wellbeing, which underpinned productivity was safety. This was defined as personal safety in the building, i.e., high quality access control and security, and safety regarding personal assets, for example employees cars. The issue of safety is prevalent social factor, both within domestic and corporate environments as South Africa experiences relatively high incidents of crime. Therefore, all respondents (especially women) highlighted safety as a contributing factor to both psychological wellbeing, which impacted overall comfort in the office environment.

"Am I worried about getting to my car, no. Am I worried that my car is still going to be there, no…" CS2R1

Unique to South Africa, is the reliability of the associated services such as water and electricity. CS2R1 and CS2R4 noted that their organisation ensured uninterrupted power and water regardless of temporary service outages that do occur relatively regularly. In this regard, the office environment is safer than many of the respondents' domestic

environments, as areas remain well lit, which eliminates potential criminals from entering the premises and/or unassumingly approaching building occupants in the basement parking lot.

Productivity Barriers

Barriers to productivity also related to the quality of the ambient environment in terms of noise levels, temperature variability that can potentially lead to physical symptoms (e.g., headaches and nausea) that can force certain employees to go home (CS1R6) or require more breaks to recover from the temperatures that are too hot or cold (CS2R3). Physical SBS symptoms that are commonly found in green certified buildings are throat irritation, lethargy/tiredness, stuffy nose, dry/irritated throat and dry skin (Tham and Willem, 2010; Tham *et al.*, 2015). Lighting in private rooms is motion sensitive which often switches off especially if they have been sitting still for long periods of time. Older office furniture that would not be considered ergonomic in a modern office environment was also considered to reduce productivity. The location of the office building geographically was also viewed as a potential barrier to productivity (CS2R4), as this may require excessive commuting times. Psychological wellbeing was negatively affected if the building's IEQ standards were not maintained (CS1R7, CS1R8). The aforementioned barriers to productivity were consistent with the literature, and were partially or fully related to SBS, which can still occur in green certified buildings (Ghaffarianhoseini *et al.*, 2018).

Access to Nature

Access to nature was a prominent feature for the majority of respondents in relation to productivity. Access to nature was defined by respondents in CS1 as views of natural features (i.e., a view of the ocean or the mountain), as these respondents were located in a building which only had glazing as the material for the external envelope. Respondents from CS2 defined access to nature as the ability to take a break from work in one of the green spaces located as central outdoor atria, where there was a lawn, benches and barbeque facilities. This is an important feature as CS2 was located in a heavily built up urban precinct, and these green spaces were shielded from urban noise pollution, for example traffic. Access to nature

was cited by several respondents as a positive contributing factor to their psychological wellbeing (CS1R6, CS1R8).

"…my desk right next to the ocean window is quite nice, the light that comes from that is excellent…" CS1R8

Enhanced Organisational Culture

Organisational activities that make use of the building enhance psychological wellbeing. For example, CS2 used their indoor atria to host musical performances and formal company functions. Spatial factors, such as informal collaborative spaces in the form of noise reducing meeting pods and tea/coffee areas allowed for relatively short face-to-face interaction. Formal spaces were designed in the form of making all the office spaces open plan (CS1) and the majority of the office spaces were open plan (CS2), where only executive directors were given private offices, in the latter. This resulted in more meeting rooms being provided that each contained smart technological amenities, e.g., flat screens for presentations and conference calling capabilities (CS2R2). The location of the building (CS1) also fed into the organisational culture, as building occupants had walking access to a nearby urban precinct (CS1 and CS2), which hosts other blue chip companies, thus permeating an ambitious and professional ethos outside of the building. This greater urban environment provided another subtle contributing factor to the organisational culture. CS2 was located on what many respondents refer to as the 'campus', which has outside green areas – a rarity in their urban node. This allowed employees to enjoy each other's company during a short break or at an organised outdoor event (CS2R3), which subtly re-enforced the organisation's culture.

Cross-Case Analysis

Both cases exhibited similar high level findings across the five main emergent themes. Physical indoor attributes, such as lighting noise, temperature and ventilation were highlighted as important to a higher or lesser degree in their relation to impacting individual productivity, physical comfort, engagement, and psychological wellbeing. A finding that was

consistent across both cases studies, which is very important within a South African context due to the relatively high crime rate, is safety – both personal safety and protection of assets. There were some minor differences, which were underpinned by location, organisational culture, and access to certain amenities. Presenteeism (physically being at work but mentally drifting off) was not a major finding, as this did not occur often nor for long periods of time. Many of the findings were consistent with foreign literature, with regards to self-assessed productivity (El Tohamy *et al.*, 2018) in relation to an indoor environment of an office building, and also in terms of reaching data saturation relatively quickly.

3.7 Re-visiting and Revising the Theoretical Model

The majority of the findings from the semi-structured interviews can be linked back to the theoretical model (figure 1). Some of the components from figure 1 were more prevalent than others, for example, ambient conditions, which led to health, comfort, work engagement, and the subsequent impact on individual productivity. Location and amenities were also referred to by respondents in both case studies, which contributed to psychological wellbeing and convenience, thus also having a positive impact on individual productivity. One respondent (CS2R7), explicitly stated that employee retention was underpinned by the relationship, or lack thereof, with one's line manager. However, CS2R5 stated that employee attraction was somewhat influenced by the building's location and amenities.

"…the garden spaces. As well as the easy location. And almost a sense of park-like atmosphere and it is called a campus site so, I think it is it definitely used to attract a lot of staff." CS2R5

Personal safety and security of personal assets were also cited as a new contributing factor that indirectly influenced productivity, especially within the context of South Africa, and perhaps also within the realm of financial services, as these knowledge workers were relatively well remunerated. Safety was also defined as reliable infrastructure services to the building (i.e., water and electricity) when compared to the domestic environments of some of the respondents.

Components of figure 1 that received direct minor attention were spatial factors and overall wellbeing, which were represented as shrunken ovals, when compared to the original theoretical model. This was partially due to both cases studies having relatively flat hierarchical structures, i.e., most working spaces were open-plan. Furthermore, most respondents acknowledged that external factors, not related to work, were the major influences on their psychological wellbeing.

"…concerned about what is happening at home or my baby…" CS2R4

The finding have resulted in a revision of the theoretical model (figure 4.1), to a new model (figure 4.4) that more accurately reflects the main components linked to IEQ that have a major (solid red line) and minor impact (dotted red line) on individual productivity in this study. The revised components of figure 4 are indicated in red with updated one-way and two-way relationships. Furthermore, those components that have a minor impact on productivity have been reduced in size (wellbeing, special factors and health) relative to other components, when compared to their respective roles/positions in figure 1. Additionally, the solid green lines represent confirmation of components and linkages from the original model (figure 4.1), while black components and links were those addressed in Nurick (2022).

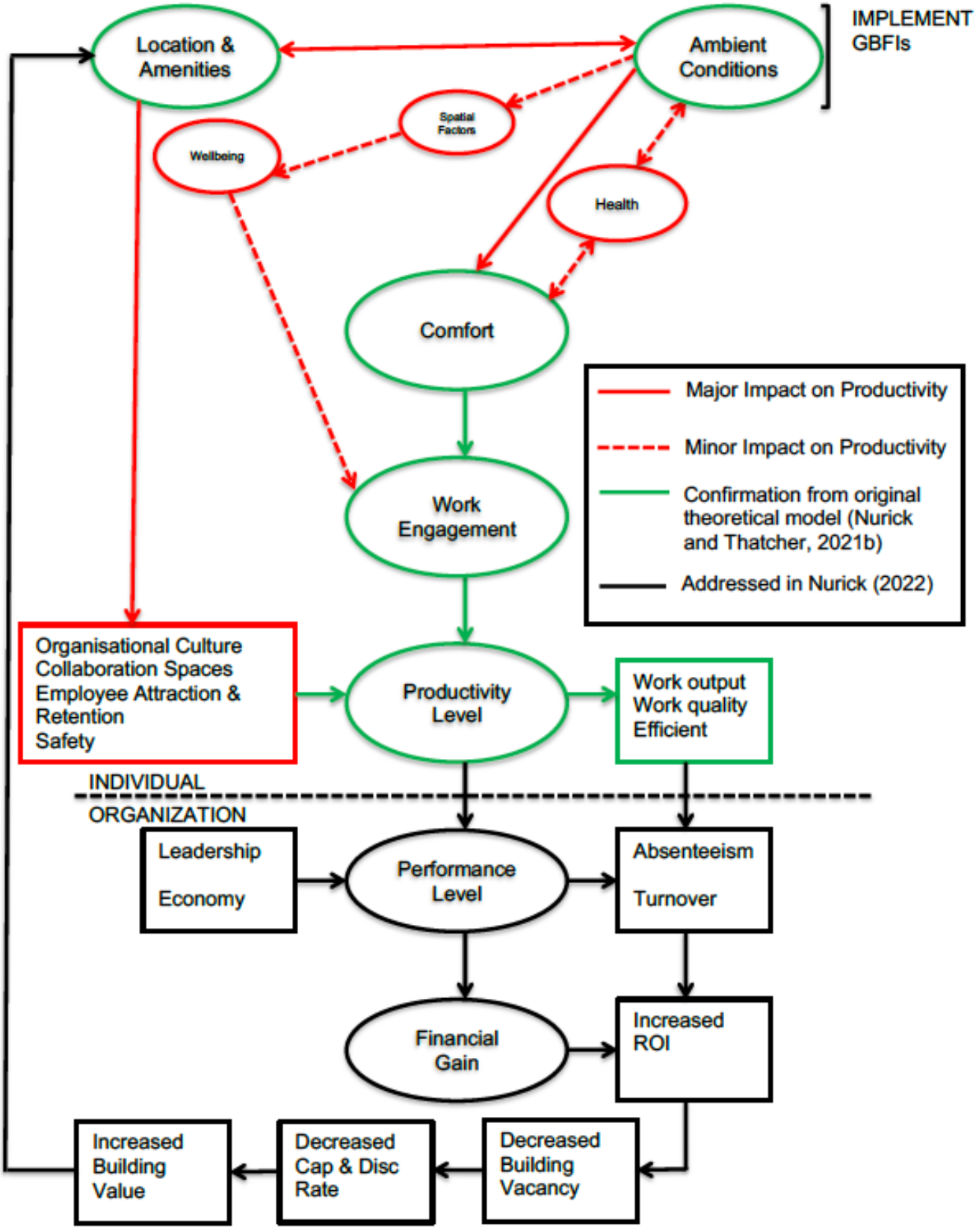


Figure 4.4: Revised Theoretical Model

Conclusions

Assessing individual productivity of knowledge-based workers in relation to the office indoor environment is not an exact science, and therefore relies on self-assessment, which is underpinned by a level of subjectivity. This form of data gathering in this field of research is deemed acceptable, as previous researchers have applied this same approach (Feige *et al.*, 2013; Mallawaarachchi *et al.*, 2016; 2017). A theoretical model (figure 4.1) was used as a framework to explore the relationships between various components that potentially impact individual productivity. The findings provided more clarity with regards to which components played a major and minor role on the impact on productivity in FSCs. Ambient conditions that directly influenced physical comfort (Gou *et al.*, 2013; Gou and Siu-Yu Lau, 2013; Thatcher and Milner, 2014b; Elnaklah *et al.*, 2020) and work engagement (Schaufeli *et al.*, 2002; Schaufeli *et al.*, 2006; Demerouti and Bakker, 2008) were the major contributing components of the indoor environment. Additionally, location and amenities also influenced the organisational culture, collaboration spaces, employee attraction and retention, and general safety of personnel and their associated assets. All of these new factors that are presented in figure 4 were commonly mentioned by respondents across both case studies to impact their individual productivity, to a greater or lesser degree. Due to the research being conducted in South Africa, there were unique findings, which can be linked to a green building market that is still in its infancy, when compared to developed real estate markets in North America, Europe and Australasia. South Africa's socio-economic climate makes it a relatively unsafe country, and therefore safety is a major consideration when designing modern office spaces. Another finding that seems to be more prevalent in South Africa with relation to green buildings is employee attraction and retention, where the former plays a larger contributing role, as many South African graduates come from previously disadvantaged backgrounds (due to the legacy of apartheid) where they aspire to work in a modern office buildings, which is often the antithesis of their domestic environment in their formative years. Graduates from previously disadvantaged backgrounds could possibly be hampered by a variety of factors when not in a supported office space, for example: poor internet connectivity, unreliable electricity supply, crowded/noisy households containing cross-generational occupants, and a lack of access to office hardware such as scanners and printers. It should be noted that the legacy of apartheid still exists in South Africa. This impacts the domestic and professional lives

of knowledge workers, especially those who are descendants of the historically marginalised segment of the population. Aspiring to work in modern premium grade buildings is often seen as a sign of early success for contemporary university graduates whose parents did not have access to quality tertiary education, and therefore the opportunities offered for employment in blue chip firms were limited, which could potentially result in lucrative corporate career progression. This was mentioned by CS2R1, a senior manager that is directly involved in recruitment across the organisation. The research is limited to FSCs occupying green certified buildings located in South Africa. The chosen research method does not require a relatively large sample. Qualitative research in the form of semi-structured interviews is typically an in-depth data collection method, which yields thick descriptions (Drew, 2022). Therefore a large sample size is not required, as would be the case for survey based research (Yin, 2012). Furthermore, given the focus on FSCs in South Africa, the generalisability of these findings to other countries or industries is questionable.

Opportunities for further research in this area could potentially be targeting knowledge-based workers in a different sector, for example auditors, lawyers, physiotherapists and architects etc. In closing, the reason that knowledge workers based in FSCs were selected for this research, is that it was the qualitative continuation of the quantitative research conducted by Nurick (2022) where the organisational performance component of figure 1 was tested at an organisational level, which focused on FSCs. The main reason for selecting employees at FSCs is that these types of workers are typically office bound. Other graduate roles, which are not fully office bound, due to the nature of their job, would be less likely to have their individual productivity levels impacted by the quality of the IEQ at their corporate headquarters. Therefore, this may provide similar and/or different findings due to nature of the work of these different professionals. Future research could also include investigating individual productivity of workers located in different property sectors, such as retail, industrial and educational buildings. Furthermore, research into the impact of COVID-19 on knowledge based workers is also warranted, as these types of workers have re-evaluated if they need to go into the office every day, which reduces the tension resulting from commuting and exposure to the physical working environment. In addition, organisations have re-assessed the need for the employees to be in the office every day. Thus, a reduction in daily on-site work could potentially dilute the impact or increase awareness of the quality

of IEQ (when compared to their domestic environment) and the impact of individual productivity within an office environment.

5. Linking IEQ and Organisational Performance

5.1 Introduction

This is the second of the two empirical papers, which specifically focused on organisational performance.

This paper examines organisational performance within the context of financial services companies (FSCs) located in green certified and conventional (non-green) certified buildings in South Africa. This paper focused on the organisational component (below the dotted line) of the emergent research model (Figure 2.1) presented in Nurick and Thatcher (2021b). Three financial products, namely an income fund (low risk), balanced fund (moderate risk) and South African equity fund (high risk), where used to track the organisational performance of FSCs based in green certified and conventional (non-green) buildings. Desktop research was conducted by analysing annualised returns of financial products in relation to several green building attributes, such as the overall rating and IEQ score. The sample comprised ten FSCs located across nineteen green certified buildings, and ten FSCs located across thirteen conventional (non-green) buildings. Furthermore, return projections were conducted to compare fund performance of FSCs based in green certified and conventional (non-green) buildings. Finally, a new metric, *average green return ratio incremental (AGGRi)* was developed to ascertain the incremental return of FSCs based in green certified buildings compared to their competitors located in conventional (non-green) buildings.

Contribution by the author:
Nurick wrote this paper as the sole author, and developed the overarching concept, structure, conducted the desktop research and empirical tests. Nurick also handled all the correspondence with the *Journal of Sustainable Real Estate* with regards to submission (including re-submission with a schedule of corrections and funding related to final publication costs).

The *Journal of Sustainable Real Estate* was selected as a suitable venue (Scopus listed), as it is an international journal with a key focus on sustainability within global real estate markets.

The journal is published by the American Real Estate Society (ARES). The ARES is one of the six regional groups that falls under the International Real Estate Society (IRES), who promote real estate education and research.

Mind over Mortar: Examining IEQ Scores and Financial Services Companies Performance

Nurick, S. (2022) Mind over Mortar: Examining IEQ Scores and Financial Services Companies Performance. *Journal of Sustainable Real Estate*, **14**(1), 42-56.

Abstract

This paper investigates green buildings and organisational performance, using financial services companies (FSCs) located in green and non-green buildings. Returns of low, moderate, and high-risk investment products were used to underpin organisational performance. FSCs based in green buildings on average outperformed their competitors in non-green buildings. One statistically significant relationship (high-risk fund) was found when assessing returns and IEQ. Average green return ratios (AGRRi) determined the discount/premium of the incremental return per IEQ point of a FSC based in green building(s). However, there were individual FSCs located in non-green buildings that outperformed some of the FSCs based in green buildings.

Key words: indoor environmental quality (IEQ), financial services companies (FSCs), performance, average green return ratio (AGRRi)

Introduction

This research is underpinned by the proposition of Nurick and Thatcher (2021b) that green building features and initiatives (GBFIs), specifically enhanced indoor environmental quality (IEQ), result in increased individual productivity and organisational performance. There is still much conjecture amongst previous researchers regarding the notion that green buildings result in increased productivity, although this outcome is often claimed by the various green building councils. Multiple researchers have debated and struggled to fully establish the relationship between green buildings and individual productivity, and ultimately enhanced organisational performance (Feige *et al.*, 2013; Byrd and Rasheed, 2016; Thatcher and Milner, 2016; Rasheed and Byrd, 2017). Some of the methods that have focused on productivity have applied several approaches, which include *inter alia* building user surveys (BUS), post-occupancy evaluations (POE), longitudinal studies, and simulated office experiments, usually

in laboratories. All these approaches have usually focused on the actual knowledge worker versus the overall organisation, which either performs (or not), based on pre-determined industry defined metrics (Wyon, 2004; Biron *et al.*, 2006; Akimoto *et al.*, 2010; Fisk *et al.*, 2011; Chadburn *et al.*, 2017).

Rationale

The emergence of green building councils started to appear in the late 1990s. One of the mandates of these councils was to develop a tool to measure/assess potential green certified buildings. This required a set of standard categories within green building tools, which included electricity, water, management, transport, materials, land use, emissions, innovation, and internal environmental quality (IEQ) (Green Building Council of South Africa (GBCSA), 2015a; United Kingdom Green Building Council (UKGBC), 2015; United States Green Building Council (USGBC), 2015). The GBCSA uses Green Star South Africa as the tool to measure office buildings, where a building is considered green certified if it achieves four, five, or six stars (GBCSA, 2015a). The benefits of green building, more specifically GBFIs, have been demonstrated from a building operations perspective, in term of utility savings, and how this benefits both the owner and the tenant. Measuring utility savings is relatively simple and therefore it is easy to establish if an individual or group of GBFIs results in a long-term financial benefit. Assessing individual productivity levels of building occupants is more challenging and linking individual productivity levels to organisational performance adds a further layer of complexity. Attempting to link GBFIs (specifically enhanced IEQ) to organisational performance has to date not been fully established within the research community. There have been some researchers (Byrd and Rasheed, 2016) that have debated the accuracy of measuring productivity and these inaccuracies have falsely been attributed to the notion that enhanced IEQ results in improved productivity. Furthermore, a literature review conducted by Rasheed and Byrd (2017) indicated that self-evaluation is not an accurate approach with regards to productivity in an office environment within the context of IEQ. Feige *et al.* (2013) indicated that improved occupant comfort, as a result of enhanced IEQ can reduce the turnover rate of an organisation, which may have a positive impact on the financial performance of the organisation. However, Feige *et al.* (2013) were unable to fully confirm a link between occupant comfort and productivity and were unable to provide evidence that if

occupants were more productive then this would lead to financial gains for the organisation. It should be noted that much of the literature examining office occupants within the context of IEQ use the term “performance” in relation to the individual occupant (i.e., individual productivity as it is defined in this paper) and not in relation to the overall organisation. The research indicates that there is currently very little literature that specifically attempts to establish a relationship between GBFIs (i.e., enhanced IEQ) and organisational performance. Another indicating factor is that past researchers have been unable to link individual productivity to organisational performance (Kampschroer *et al.*, 2007; Flamholtz, 2009; Feige *et al.*, 2013), which further highlights the difficulty of exhibiting direct links of enhanced IEQ to individual productivity through to improved organisational performance.

The rationale underpinning this research is based on the model developed by Nurick and Thatcher (2021b), specifically the section below the dotted line that focuses on the organisation, as shown in Figure 4.1. The focal point of this paper is the link between individual productivity and organisational performance, i.e., cross-over of the dotted line. The reason for highlighting this linkage is due to green building advocates stating, albeit with mixed supporting empirical evidence (Zhang *et al.*, 2010; Park and Yoon, 2011; MacNaughton *et al.*, 2015; Tanabe *et al.*, 2015), that green buildings result in increased productivity. Assuming that this is the case, then increased productivity should equate to enhanced organisational performance. If it could be established that organisational performance was to be enhanced because of superior IEQ, then this would benefit both the building owner (reducing the asset risk) and tenant, which would therefore ultimately justify the implementation of GBFIs (or at least an investment in IEQ features). The model shows that that the performance level also is influenced by leadership and the economy (Prouska *et al.*, 2016; Saleem *et al.*, 2019) and is partially assessed by absenteeism and turnover. Ultimately organisational performance level is measured by financial gain (increased ROI), that if linked to enhanced IEQ, would justify the implementation of specific GBFIs, as this would also add value to the building from an owner/occupier perspective.

While there has been previous research (Clements-Croome and Baizhan, 2000; Heerwagen, 2000; Wyon, 2004; Miller *et al.*, 2009; Akimoto *et al.*, 2010; Singh *et al.*, 2010; Feige *et al.*, 2013; Alker *et al.*, 2014; Thatcher and Milner, 2014b; Garnys and Wargocki, 2015; Mallawaarachchi *et al.*, 2016; 2017; Newsham *et al.*, 2017) that has focused on the

relationship between green buildings and individual productivity, there has yet to be research that links green certified office buildings, more specifically enhanced IEQ, to overall organisational performance. The reason for a lack of research that specifically focuses on organisational performance in the context of GBFIs is that developing a robust generic performance measurement framework for knowledge-based workers has been difficult to develop and be fully accepted by both industry and academia. Office-based companies (knowledge-based/white collar workers) vary depending on the profession and industry. For example, measuring organisational performance in the legal, engineering, and banking sectors would have to done using very different underlying data and tools, and would therefore be a challenge to normalise and compare. Therefore, a new approach is required to isolate organisational performance data that can be potentially linked to the indoor environment. One of the challenges in a knowledge-based environment is the ability to link certain professional outcomes in a financially quantifiable manner. This research uses a bottom-up approach where the researcher intentionally focused on financial services companies (FSCs), as these types of organisations are assessed on their ability to outperform the market, but more importantly to outperform their competitors, in terms of annualised returns. Furthermore, knowledge-based workers employed by FSCs are office bound for the duration of the workday, as access to secure financial systems and confidential data normally occurs within the confines of the office building and other secure firewalls. Additionally, unlike other professions (e.g., engineers, auditors, and lawyers) that are often required to leave the office as part of their work to meet clients.

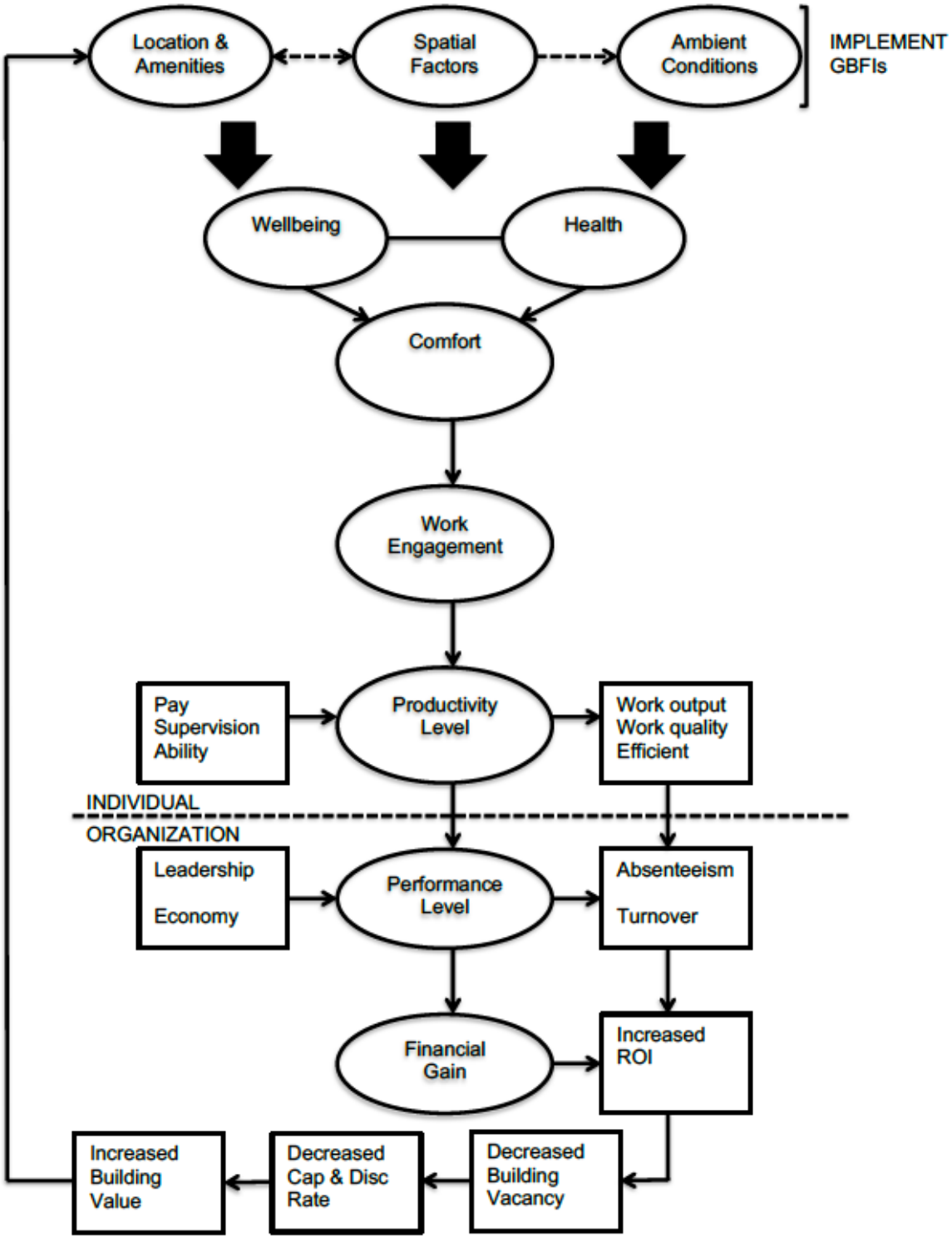


Figure 5.1: Linking GBFIs to individual productivity and organisational performance (Nurick and Thatcher, 2021b: 29)

Method and Hypotheses

Method

The overarching method is a bottom-up approach comprising three phases where twenty FSCs offering three commonly provided investments (i.e., an income fund, a balanced fund, and a South African equity fund) were selected. These three funds are offered by all the FSCs included in this study and can be directly linked to individual productivity, as highly effective (productive) asset managers find investment opportunities that outperform competing FSCs. Financial services tenants are intentionally selected as their inputs and outputs are quantifiable and therefore comparable.

The first phase involved comparing ten South African based FSCs (1-10) located across nineteen green certified buildings with ten FSCs (11-20) located in thirteen non-green buildings. The nineteen green buildings were all owned by the largest South African real estate investment trust (REIT) that own the majority of green certified office buildings in South Africa. These FSCs 1-10 were the only businesses in this REITs portfolio that offer the three main funds (income, balanced, and South African equity). The other ten FSCs were owned by various property-owning companies in South Africa that also offered the same three funds. Not all FSCs operating in the South African market have all three funds with the focus mainly on balanced and South African equity funds, while ignoring low risk/low return funds, i.e., income funds. The FSCs ranged from institutional investors, insurance companies, asset management companies and boutique private equity investment firms. Sixteen buildings were 4-star green certified, while two buildings were 5-star and one building was 6-star certified. Desktop analysis of publicly available data were obtained from downloaded fact sheets of the three funds from FSC websites for income funds (low risk), balanced funds (moderate risk), and South African equity funds (high risk). All the FSCs were managed in-house by a single or multiple asset manager(s). Additionally, all the investment funds were active funds, i.e., not funds of funds or index linked funds. A change in asset management personal was deemed acceptable over the different time periods, as all asset managers make investment decisions based on the same market information and conditions at a given point in time. It is therefore assumed that an asset manager (and their support staff) working in a

green building with superior IEQ would outperform an asset manager (and their support staff) working in a non-green building and this would be reflected in the fund performance.

Hypotheses

For each of the three fund types the asset class allocation was similar across all the FSCs. The annualised returns from inception for each of these investment funds across each of the FSCs was included, assuming the investment fund was established at least five years ago in order to dilute the impact of COVID-19 on the investment markets. It was also assumed that financial services analysts were all exposed to the same market information and fluctuations regardless of the state of the market. Using the annualised return for each investment fund for each FSC, the average return and standard deviation was calculated for both the green and non-green building groups. The average return was used to forecast the projection of R100 over thirty years in order to determine if there was a significant difference in the average of FSCs located in green buildings versus non-green buildings.

Hypothesis 1. FSCs located in green buildings in the long-term on average outperform competing companies located in non-green buildings.

The second phase attempted to establish if there was a relationship between enhanced IEQ and annualised returns. The annualised return since inception were compared to the annualised return since taking occupation of the green building – five years (approximate average for FSCs 1-10). The difference in return - discount/premium (delta – inception/5 year returns) was calculated and then ranking applied to FSCs 1-10 for each of the three funds. It is expected that as the ranking worsens (tending towards 10), so the IEQ score would decrease. Pearson's Correlation analysis was conducted to test this hypothesis, where a negative correlation would support the notion that there is a relationship between IEQ and annualised returns. Length of time (interaction term) was considered as a co-variate in relation to annualised return for FSCs 1-10.

Hypothesis 2. There is a relative improvement (i.e., ranking improves) of annualised returns for FSCs when compared to the number of IEQ points for a green building.

Hypothesis 3. Time in a green building (operationalised as years since occupation) has a positive impact on the relative improvement in annualised returns.

The third phase comprised several calculations. The first calculation determined the difference between the returns for each FSC within one of the investments (income, balanced or South African equity) and the average return of the corresponding non-green building group. For example, in the income fund (low risk) data set, FSC 1 located in a green building has an annualised return since inception of 9%, and the average returns for the income fund in all the non-green buildings is 7.86%. The incremental return was 1.14%. FSC 1 was located across three buildings with IEQ scores of 12, 13 and 19 points, respectively. The incremental return was divided by each IEQ score (to normalise the output), resulting in a green return ratio incremental (GRRi) for each building for the income fund. The same process was repeated for the balanced and South African equity investments, to calculate the GRRi for each building. The GRRi's across all the investments was summed and divided by the number of buildings (3) housing FSC 1, resulting in an average green return ratio incremental (AGRRi) per building. The AGRRi gives an average indication per building for each FSC located in a green building(s) of the premium/discount expressed as an incremental return when compared to average returns against a sample of FSCs located in non-green buildings.

The following formulae were applied:

$$Return\ of\ FSC\ x\ (GBa; b; c) - Average\ Return\ (NGBa; b; c)$$

$$= Incremental\ Return\ FSC\ x\ (a; b; c)$$

$$\frac{Incremental\ Return\ (a; b; c)}{IEQ\ Points\ for\ Building\ x}$$

$$= Green\ Return\ Ratios\ i\ (a; b; c)$$

$$\frac{Green\ Return\ Ratios\ i\ (a) + Green\ Return\ Ratios\ i\ (b) + Green\ Return\ Ratios\ i\ (c)}{Total\ Number\ of\ Buildings\ for\ Fund\ x}$$

$$= Average\ Green\ Return\ Ratio\ per\ Building\ (incremental)\ (y\%)$$

Where:

FSC x = Any FSC 1-10

GB = Green Building

NGB = Non-Green Building

a = Income Fund; b = Balanced Fund; c = SA Equity Fund

Average Return (NGBa;b;c) = NGB average return for each of the three investments (a;b;c)

GRRi =Green Return Ratio incremental (i) for FSC x (a or b or c)

AGRRi = FSC x is incrementally(i) generating on average per building y% discount/premium to the average returns of FSC 11-20.

For FSC 1 located in a green building, the AGRRi was 0.18%. This means that on average FSC 1 incrementally, but slightly, outperformed the control group (FSCs in non-green buildings). FSC 2 had higher incremental returns across all three investment options and a significantly higher AGRRi (1.48%). Therefore, the larger the difference of returns for investment funds of FSCs located in green buildings compared to the corresponding average return of all FSCs for a particular investment, the larger the AGRRi.

Hypothesis 4. Individual FSCs located in green buildings generate superior fund returns compared to the average returns of FSCs located in non-green buildings when IEQ scores are normalised.

Limitations

This research is limited to the South African green certified office market and FSCs that lease space in these buildings, where the FSCs must offer (amongst other financial products) the three main funds (income, balanced, South African equity). Due to the infancy of the green building movement in South Africa, compared to developed real estate markets there is a relatively small sample of as-built green certified office buildings. This results in a further reduced number of FSCs leasing space in green certified office buildings, which offer the three main funds (income, balanced, South African equity) included in the analysis. Furthermore, as stated in the introduction, other office tenants would not be suitable for this study, as it is difficult to provide a more standardised quantification of their organisational performance in

relation to their physical office environment, especially if their employees spend time away from the office to conduct business. It should be further noted that other factors such as the demographic profile (specifically age), political profile (conservative versus liberal/progressive), corporate governance, and access to resources of office tenants were not considered in this study. This is because these are factors that are luxuries within the context of the South African office market and are more applicable to developed economies and property markets. There is demand for South African green office buildings, due to the unpredictability and increasing prices of utilities. Electricity (which the tenant normally pays) has been increasing at above inflationary levels. Added to these increased costs, South Africa has, for at least the last ten years, experienced load shedding (scheduled power black outs). Rental for office green buildings is not charged at a premium due to the relatively weak office market and macro economy in the last five to seven years. Therefore, in South Africa green certified office buildings provide a form of protection (future proofing of business operations) against failures in infrastructure and rising costs in the form of renewable energy sources and/or the use of natural light through efficient design, i.e., there is not a premium for green buildings, but rather a brown discount for non-green buildings that are considered more vulnerable to infrastructure failures. This illustrates the main reason for being in a green certified office building (regardless of industry), as green buildings can have an operational and therefore financial impact on their tenants.

Results

Green Certified Buildings vs Non-Green Buildings

Annualised returns of ten FSCs located in nineteen green certified buildings across the three types of funds were compared to the same return data of ten FSCs located in thirteen non-green buildings. The FSCs ranged from approximately 25 to 37,000 employees, where some FSCs were located across multiple buildings and others were based in a single multi-tenanted building. Table 5.1 provides a breakdown of the buildings for each of the FSCs in terms of green certification (Green Star South Africa), IEQ points, and the period of time (years) that each FSC had been located in a green building. Table 5.1 contains sixteen four (45-59 points), two five (60-74 points) and one six (75-100 points) star green certified buildings, respectively. There is not necessarily a direct link to points scored for IEQ and overall points awarded for

the building. For example, building 1 has an IEQ score of 12 and a total building score of 48, while building 4 has an IEQ score of 4.5 and a total building score of 51, where both buildings are four star green certified. This is because there are several contributing factors to an IEQ score with varying points allocations. The IEQ score in the Green Star rating tool includes the following aspects: indoor air quality; lighting comfort; thermal comfort; acoustic quality; and daylight and views. While IEQ tends to focus on building occupants, there are also other categories within the Green Star South Africa rating tool that carry more points (e.g., electricity and water) and focus directly on the operational capabilities of the building.

Table 5.1: FSC and Building Breakdown

Green Building Number	FSC	Number of Employees	Stars	Green Star Points	IEQ Points	Years in a Green Building
1	1		4	48	12	4
2	1	± 1,200	4	47	13	3
3	1		6	79	19	7
18	2	± 50	4	45	5.5	5
4	3		4	51	4.5	3
5	3		4	53	6.5	4
6	3	± 31,000	4	53	5	6
7	3		4	50	12	4
8*	3		4	46	10	4
9	4	± 8,000	5	73	17	4
10	5	± 1,000	4	48	6.5	4
11	6	± 25	4	50	4.5	5
12	7	± 1,000	4	45	8.5	4
8*	8	± 400	4	46	10	4

13	9		4	49	11.5	4
14	9		4	50	7.5	4
15	9		4	54	11	4
16	9	± 37,000	4	45	7	7
17	9		5	64	14	6
8*	9		4	46	10	4
19	10	± 220	4	46	11.5	3

*FSC 3, FSC 8 and FSC 9 share Building No. 8.

Table 5.2 provides a breakdown for the FSCs (11-20) located in thirteen non-green buildings. The number of employees ranges from approximately 10 to 725.

Table 5.2: FSC (Non-Green Buildings) Breakdown

Non-Green Building Number	**FSC**	**Number of Employees**
1	11	± 725
2	12	
3	12	± 250
4	12	
5	13	± 170
6	14	± 10
7	15	± 25
8	16	± 25
9	17	± 260
10	18	± 25
11	18	
12	19	± 25

13	20	± 335

Income Fund (Low Risk)

An income fund typically comprises interest bearing investments that include South African government bonds, cash investments through several local banks, and possibly individual/corporate money market accounts. Income funds tend to use consumer price index (CPI), i.e., inflation, as a benchmark, and therefore attempt to outperform this benchmark.

Of the ten FSCs located in green buildings, FSC 3 had the highest annualised return since inception (11%), while FSC 7 had the lowest return (3.8%). FSC 1 (9%), FSC 2 (9.14%), FSC 3 (11%), FSC 6 (8.7%), FSC 8 (9.2%) and FSC 9 (9.64%) all yielded returns greater than the average return for FSCs 11-20 ($\overline{x}$ = 7.86%). The average return for FSCs 1 to 10 is $\overline{x} = 8.26\%$, and the standard deviation for the FSCs located in green buildings and non-green buildings is *S* = 1.85% and *S* = 1.16%, respectively. When the average returns ($\overline{x}$ = 8.26%, $\overline{x}$ = 7.86%) for the two groups of FSCs is used to project the future value (FV) of R100, compounded both annually and monthly for thirty years, then this results in FSCs located in green buildings yielding a FV = R1,081 (annually) and FV = 1,181 (monthly), and the FSCs located in non-green buildings generating FV = R968 (annually) and FV (monthly) = R1,049. This means that the difference between the annually and monthly compounded FV is 11.75% and 12.66%, respectively. Figures 5.2 and 5.3 provide a graphical representation of these projections.

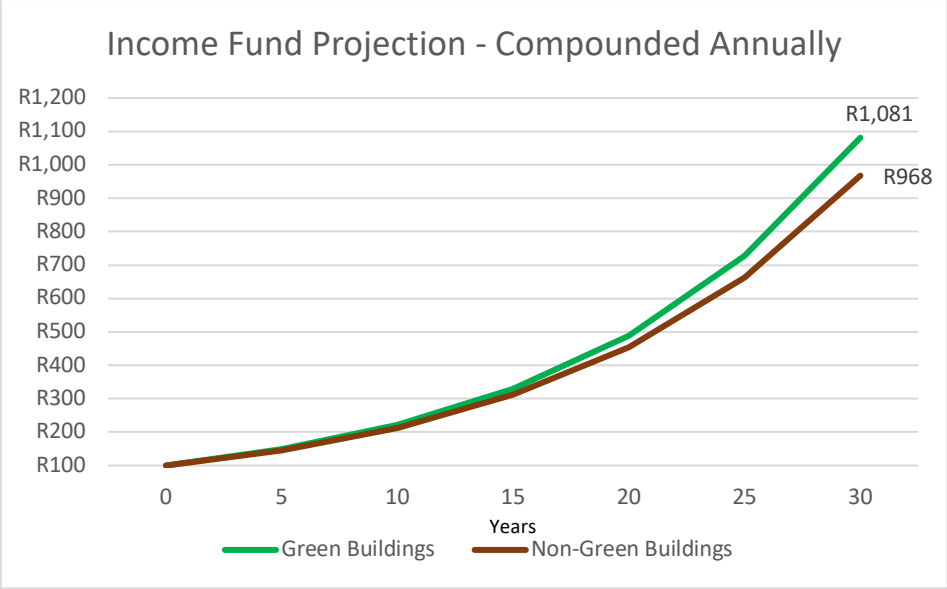


Figure 5.2: Income Fund Projection – Compounded Annually

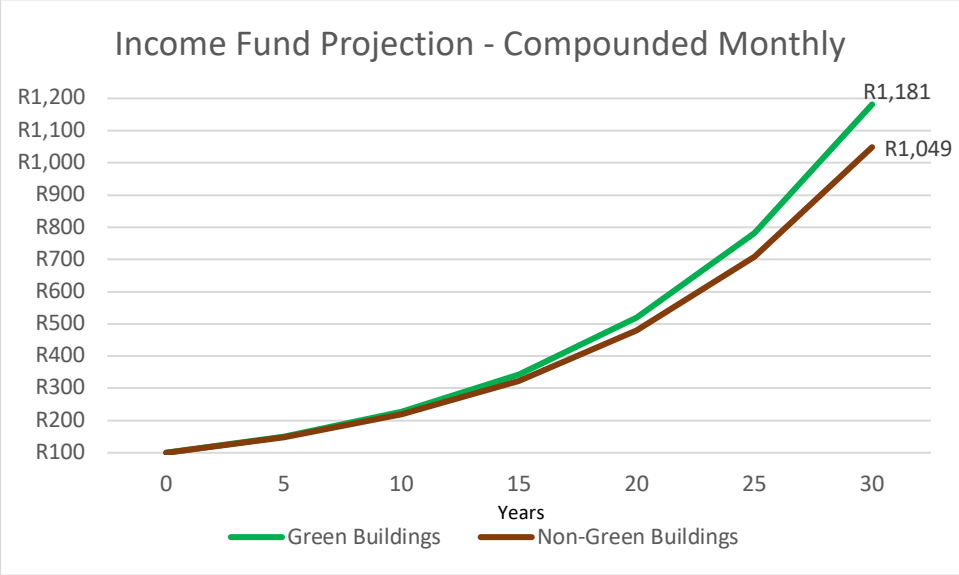


Figure 5.3: Income Fund Projection – Compounded Monthly

Balanced Fund (Moderate Risk)

A balance income fund is considered a moderate risk investment because it typically diversifies across a range of asset classes with varying degrees of risk. This normally comprises a combination of equities (approximately 70% of the fund, with the remaining 30% including property, commodities, bonds, and money market/bank deposits). A small proportion of the

fund (approximately 30%) can be invested off-shore. The benchmark is similar funds in the market and is compared to the market value weighted return of funds in the South African multi-asset high equity category.

The ten FSCs located in green buildings indicated that FSC 1 had the highest annualised return (15.4%) and FSC 10 had the lowest return (8%). Five companies (FSC 1 – 15.4%, FSC 3 – 12%, FSC 5 – 12.45%, FSC 7 – 13.9%, and FSC 8 – 12.3%) all had returns greater than the average return for FSCs 11 to 20 ($\overline{x}$ = 10.62%). The standard deviation for FSCs 1-10 and FSCs 11-20 are *S* = 2.17% and *S* = 3.10%, respectively. The thirty-year compounded annual and monthly FV's of R100 for FSCs 1-10, using the average return ($\overline{x}$ = 11.37%) is R2,530 and R2,981, respectively. The corresponding FV's for FSCs 11-20, applying the average return ($\overline{x}$ = 10.62%) are R2,068 and R2,388, as shown in figure 5.4 and 5.5. The difference between the green building and non-green building groups is 22.34% (compounded annually) and 24.83% (compounded monthly).

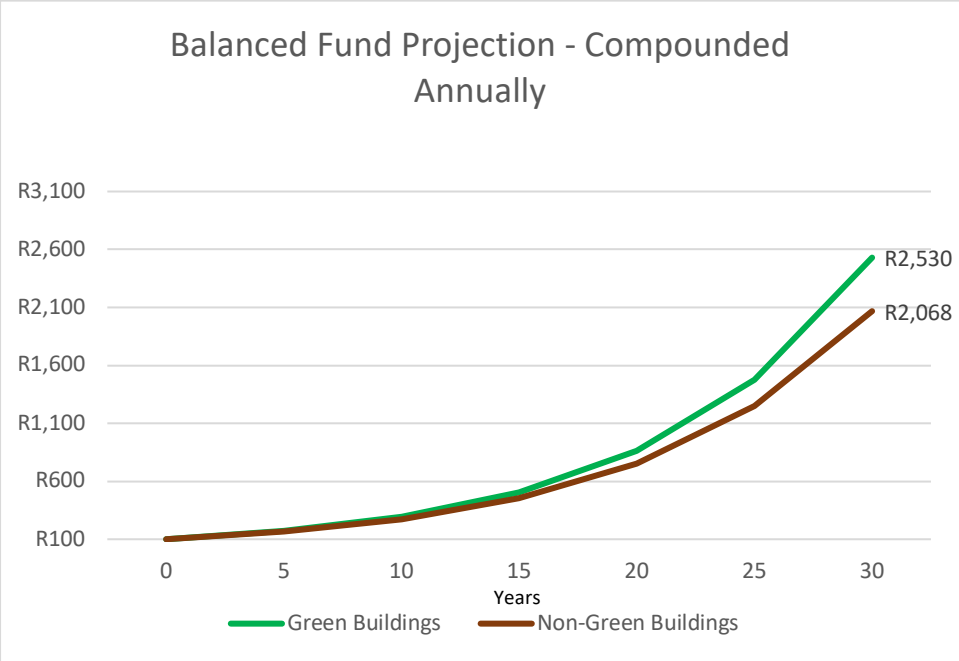


Figure 5.4: Balanced Fund Projection – Compounded Annually

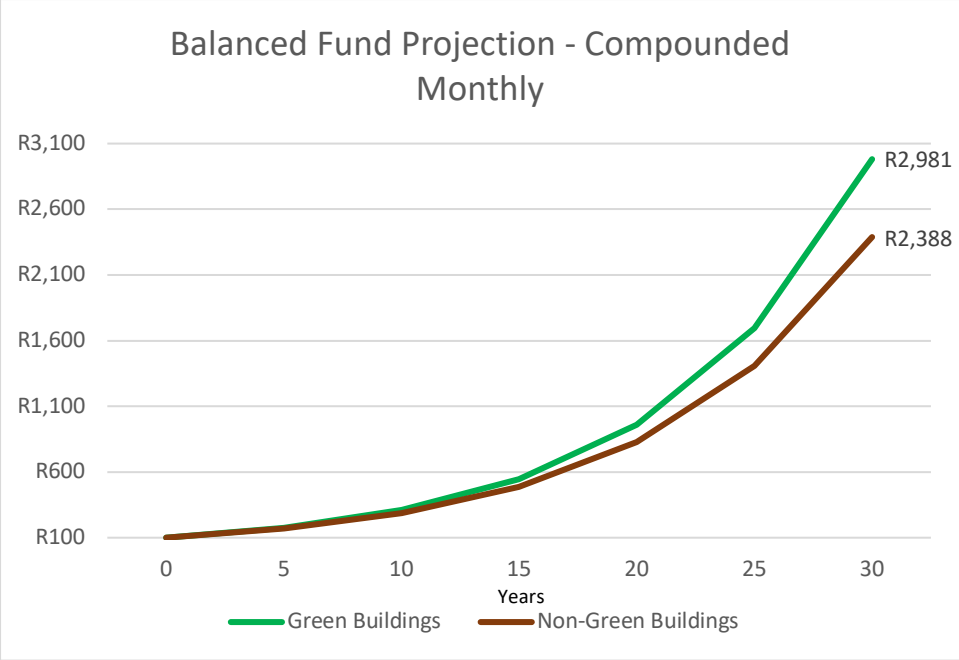


Figure 5.5: Balanced Fund Projection – Compounded Monthly

South African Equity Fund (High Risk)

A South African equity fund is considered a high-risk investment and aims to outperform the equity market over the long-term. A fund of this nature typically comprises at least 90% listed equities, with the remaining 10% including cash and property investments. A maximum of 40% of the assets can be listed outside of South Africa. This type of fund is normally benchmarked against the Financial Times Securities Exchange (FTSE) and/or the Johannesburg Securities Exchange (JSE) All Share Index.

The South African Equity fund results indicate that for FSCs 1-10, the highest and lowest returns were obtained by FSC 7 (16%) and FSC 1 (3.9%), respectively. Only three companies (FSC 1, FSC 4 and FSC 10) were below the average returns of FSCs 11-20 ($\overline{x}$ = 7.3%). The standard deviations for the green building and non-green building groups were *S* = 4.03% and *S* = 4.21%, respectively. When R100 was compounded annually and monthly for thirty years for FSCs 1-10 using the average return ($\overline{x}$ = 10.64%), this resulted in FV's of R2,078 and R2,402, respectively. When the same calculation is conducted for FSCs 11-20, applying the average return ($\overline{x}$ = 7.3%) then the FV compounded annually is R828 and compounded monthly is

R888. The percentage difference between FSCs 1-10 (green building) and FSC 11-20 (non-green building) is 151% (compounded annually) and 170% (compounded monthly), as shown in figures 5.6 and 5.7.

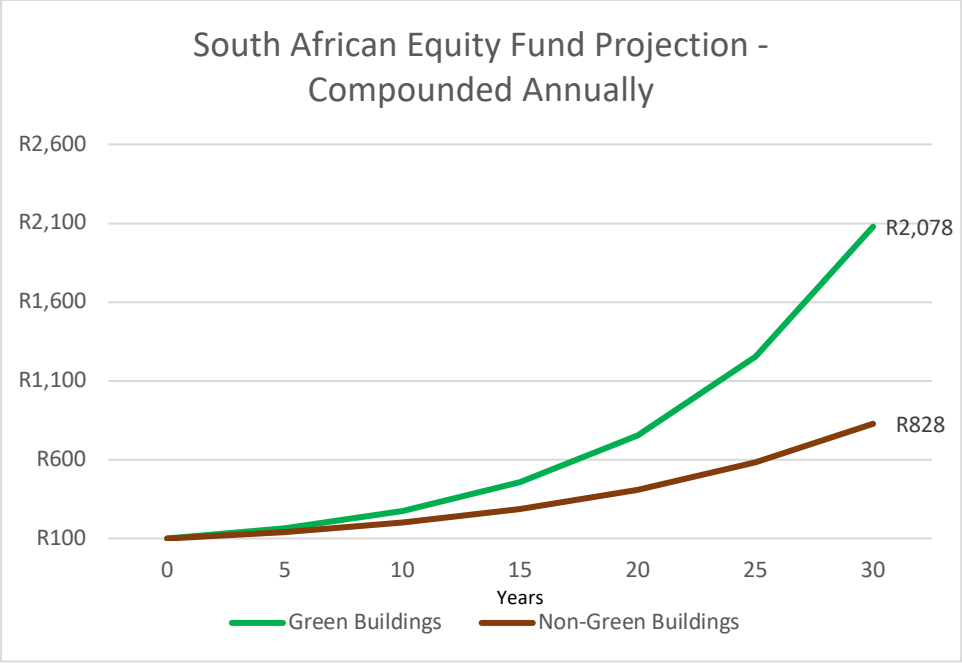


Figure 5.6: SA Equity Fund Projection – Compounded Annually

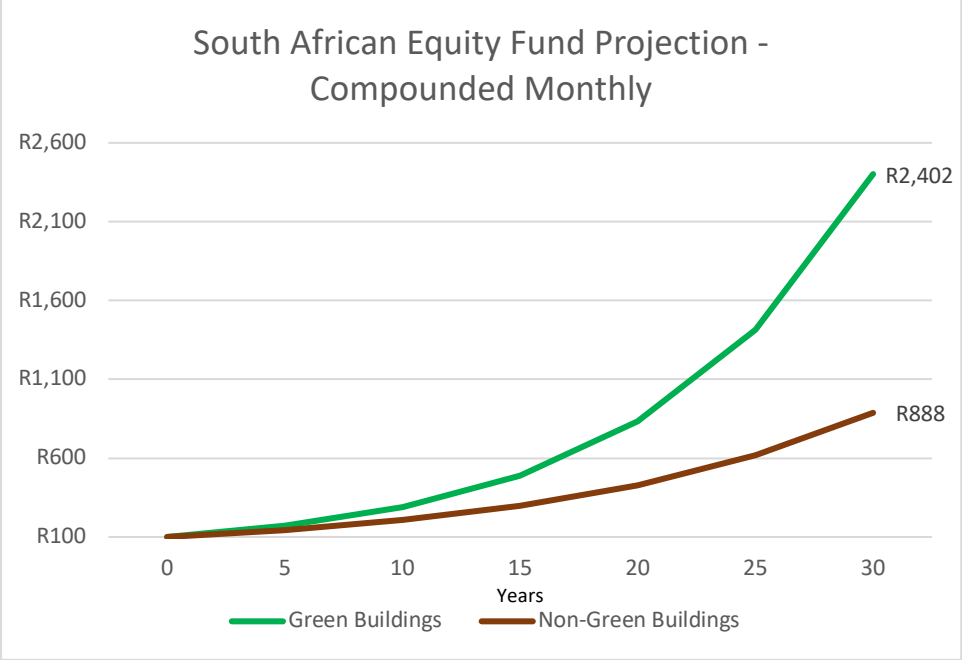


Figure 5.7: SA Equity Fund Projection – Compounded Monthly

IEQ Scores compared to Return

Correlation analyses were calculated to determine if there were any relationships between IEQ scores and annualised return in terms of rank after determining the annualised return delta for each investment vehicle (FSCs 1-10) since inception when compared to the five-year annualised returns. For example, for FSC 1 for the income fund, the annualised return for five years and since inception were 10% and 9%, respectively, resulting in a premium of 1%. For income and balanced investments, the correlation coefficients were r=-0.06 and r=0.14, respectively. The South African equity investment yielded a negative correlation of r=-0.76 (p<0.01), as shown in figure 5.8, while the consolidated correlation (all three funds) was negative, but also not statistically significant, at r=-0.48. Based on these results there was no significant relationship between IEQ score and annualised return in terms of rank, except for South African equity funds.

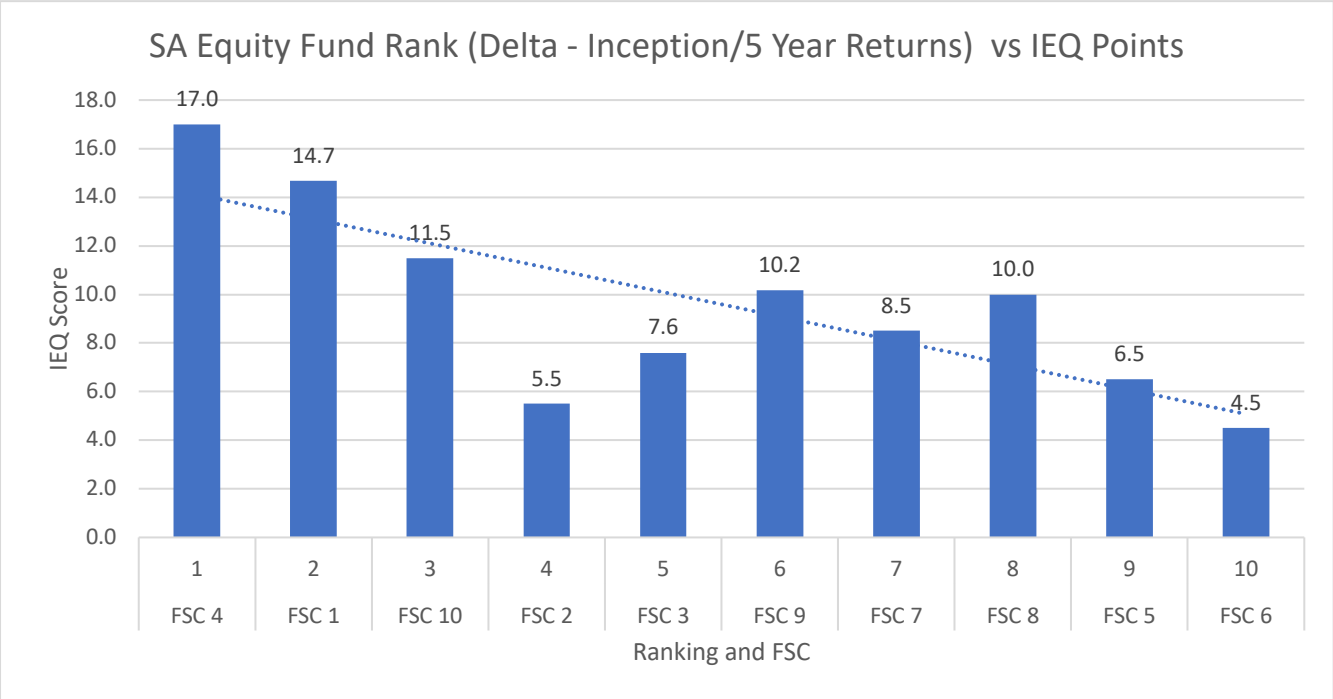


Figure 5.8: South African Equity Fund Rank (Delta – Inception/5 Year Returns) vs IEQ Score

Further analysis of comparing annualised return (without implementing a ranking metric) to IEQ scores indicated there was a sweet spot where FSCs located in building(s) with mid-range

IEQ scores (approximately 7.5 - 10) tend to yield the best returns, as shown in Figure 5.9 (income fund), Figure 5.10 (balanced fund), and Figure 5.11 (South African equity fund). This result may provide an indication that very low IEQ scores do not add value to annualised returns, while very high IEQ scores do not result in a sufficient increase in annualised returns. The extrapolation of the IEQ scores of 7.5 – 10 exhibited some commonalities, which included points for indoor air quality testing, thermal comfort, lighting comfort, conducting an occupant comfort survey, an acoustic audit, and access to daylight.

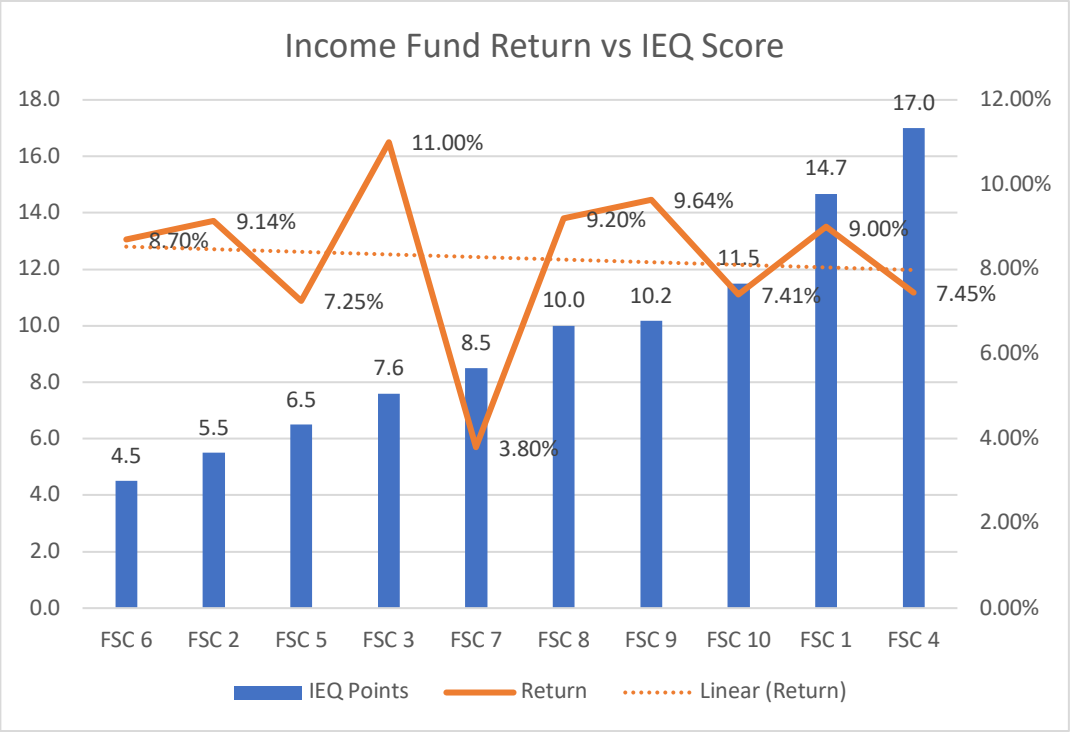


Figure 5.9: Income Fund Return vs IEQ Score

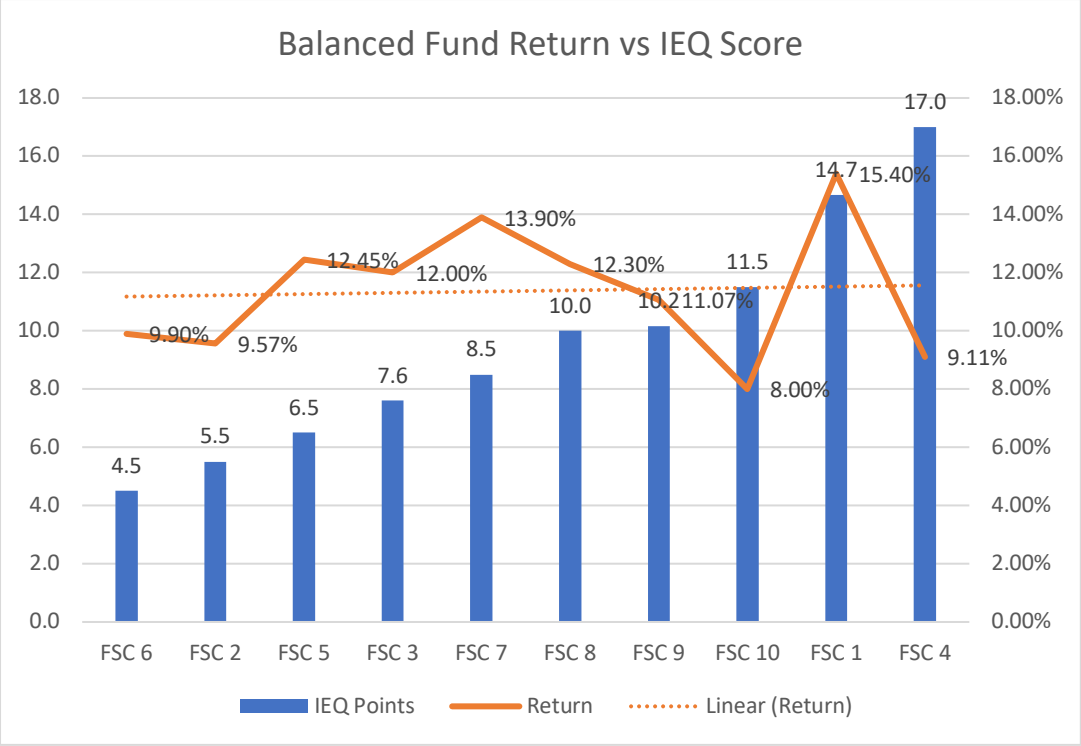


Figure 5.10: Balanced Fund Return vs IEQ Score

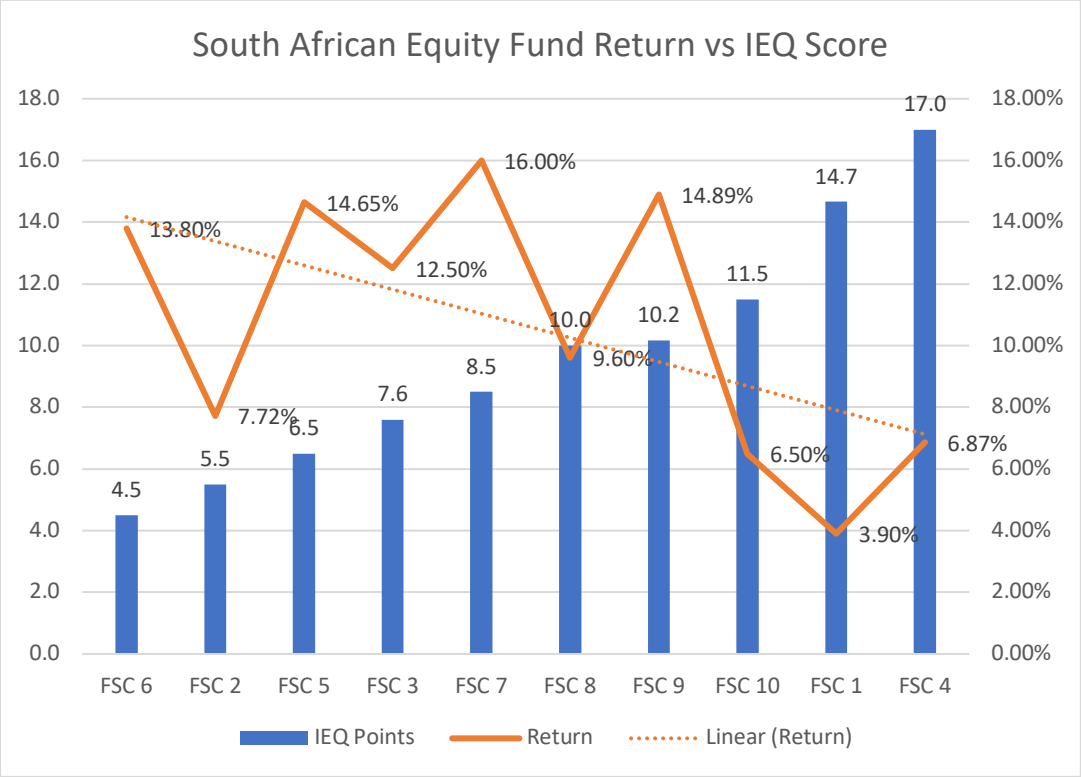


Figure 5.11: South African Equity Fund Return vs IEQ Score

Further analysis was conducted by applying a covariate (time spent in a green building) against annualised return. Due to the average time spent in a green building for FSCs 1-10 was approximately five years, the annualised returns for the last five years were compared to an interaction term. The interaction term is the product of the time spent in a green building and the number of IEQ points. For the income (r=0.06) and balanced funds (r=0.28) there was no correlation between return and the interaction term. There was a moderate negative correlation (r=-0.59, p<0.1) for the South African equity fund. As the interaction term increased the annualised return decreased, however the FSCs with IEQ scores between approximately 7.5-10 yielded the best annualised returns. This could further support the notion that there is a sweet spot for IEQ scores in relation to annualised return.

Average Green Return Ratio (AGRRi)

The AGRRi provides an average indication per building for each FSC located in a green building of the premium/discount expressed as an incremental return when compared to average returns against a sample of FSCs located in non-green buildings. IEQ score per building is embedded in this calculation in order to normalise the green return ratio (GRRi) for each building in relation to the incremental return for each investment vehicle for a particular FSC located in a green building. Nineteen IEQ scores (i.e., one per building) were used to calculate the AGRRi for FSCs 1-10.

FSC 1 was in three buildings where the GRRi for the income, balanced, and SA equity investments was 1.14%, 4.78% and -3.4%, respectively. The sum of the GRRi's was 0.54%. This results in an AGRRi of 0.18% (0.54% divided by 3). Table 5.3 provides a numerical breakdown for FSCs 1-10. FSC 4 and FSC 10 have negative AGRRi's of -0.14% and -0.34% respectively, while the other eight FSCs have a positive AGRRi. The AGRRi for FSC 1-10 was 0.46%, which indicates that as a group FSCs 1-10 marginally outperformed the non-green building group (FSCs 11-20) when an incremental return calculation is conducted taking into consideration IEQ scores.

Table 5.3: Average Green Return Ratio (AGRRi) Breakdown

Building No	FSC	IEQ Points	Incremental Return Income	GRRi - Income Incremental Return to IEQ Points	Incremental Return Balanced	GRRi - Balanced Incremental Return to IEQ Points	Incremental Return SA Equity	GRRi - SA Equity Incremental Return to IEQ Points	Total GRRi TOTAL	AGRRi TOTAL per building
1	1	12		0.10%		0.40%		-0.28%		
2	1	13	1.14%	0.09%	4.78%	0.37%	-3.40%	-0.26%	0.54%	0.18%
3	1	19		0.06%		0.25%		-0.18%		
18	2	5.5	1.28%	0.23%	-10.5%	-0.19%	0.42%	0.08%	0.12%	0.12%
4	3	4.5		0.70%		0.31%		1.16%		
5	3	6.5		0.48%		0.21%		0.80%		
6	3	5	3.14%	0.63%	1.38%	0.28%	5.20%	1.04%	7.38%	1.48%
7	3	12		0.26%		0.11%		0.43%		
8*	3	10		0.31%		0.14%		0.52%		
9	4	17	-0.41%	-0.02%	-1.51%	-0.09%	-0.43%	-0.03%	-0.14%	-0.14%
10	5	6.5	-0.61%	-0.09%	1.83%	0.28%	7.35%	1.13%	1.32%	1.32%

11	6	4.5	0.84%	0.19%	-0.72%	-0.16%	6.50%	1.44%	1.47%	1.47%
12	7	8.5	-4.06%	-0.48%	3.28%	0.39%	8.70%	1.02%	0.93%	0.93%
8*	8	10	1.34%	0.13%	1.68%	0.17%	2.30%	0.23%	0.53%	0.53%
13	9	11.5		0.15%		0.04%		0.66%		
14	9	7.5		0.24%		0.06%		1.01%		
15	9	11	1.78%	0.16%	0.45%	0.04%	7.59%	0.69%	6.14%	1.02%
16	9	7		0.25%		0.06%		1.08%		
17	9	14		0.13%		0.03%		0.54%		
8*	9	10		0.18%		0.04%		0.76%		
19	10	11.5	-0.45%	-0.04%	-2.62%	-0.23%	-0.80%	-0.07%	-0.34%	-0.34%
Average		9.8	0.40%	0.04%	0.75%	0.08%	3.34%	0.34%	0.46%	0.46%

*FSCs 3, 8 and 9 share Building No. 8.

Discussion

The following four hypotheses were stated in the methods section:

Hypothesis 1. FSCs located in green buildings in the long-term on average outperform competing companies located in non-green buildings.

The results of the data analysis indicated that as a group FSCs 1-10 (green buildings) outperformed, on average, FSCs 11-20 (non-green buildings) in terms on annualised return since inception. There were, however, individual FSCs in the non-green building that outperformed FSCs in the green building group. A calculation was conducted using the average returns for the green and non-green building groups to forecast R100 for thirty years, compounded both annually and monthly. For all three investment funds there was a substantial percentage difference in nominal future values. These differences increased as the risk factor of each fund increased, i.e., the income fund had the smallest percentage difference, while the South African equity fund has the largest percentage difference.

Hypothesis 2. There is a relative improvement of annualised returns for FSCs when compared to the number of IEQ points for a green building.

The data indicated that there was no correlation between IEQ scores and annualised return for two of the three investment funds. A return discount/premium was calculated comparing annualised returns since inception to annualised returns for the last five years. This was followed by ranking FSCs 1-10 and mapping them to their corresponding IEQ scores. The income and balanced funds did not exhibit any correlation; however, the South African equity fund indicated a statistically significant negative correlation (r=-0.76) at p<0.01. This meant that as the annualised return premium decreased so the ranking increased (worsened/tended to 10), or in other words FSCs with the highest annualised return premium exhibited the highest IEQ scores. Figure 8 provides a graphical illustration of the relationship between IEQ scores and rank for the South African equity fund.

Hypothesis 3. Time in a green building has a positive impact on annualised returns.

Correlation analysis between the interaction term and annualised return for the last five years did not indicate a relationship between these two variables for the income and balanced funds. For the South African equity fund there was a moderate negative correlation (r=-0.58) at p <0.1, however this was only statistically significant at p=0.10. Due to one fund providing statistically significant results at a relatively high p-value there is an indication that there may be an IEQ sweet spot (7.5-10 points). An IEQ score lower or higher than this range does not add value in terms of annualised returns.

Hypothesis 4. Individual FSCs located in green buildings generate superior fund returns compared to the average returns of FSCs located in non-green buildings when IEQ scores are normalised.

The application of a new indicator, the average green return ratio (incremental) (AGRRi) was used to provide insight into the incremental increase in return for each FSC 1-10 against the average return of FSCs 11-20 for each of the three investment funds. IEQ scores were used to normalise incremental calculations. Eight of the FSCs located in green buildings indicated a marginally positive AGGRi, while the remaining two FSCs had slightly negative AGGRi's. The AGRRi's for each FSC 1-10 were mostly positive, thus providing further support to hypothesis 1 that individual FSCs located in green buildings outperformed a group of FSCs located in non-green buildings. Furthermore, this approach incorporated IEQ scores and adjusted for the three investment funds held by each FSC.

The data indicated that there could be a high-level argument that FSCs located in green buildings do, on average, outperform (based on annualised return) similar companies based in non-green buildings. It could not be conclusively established that there was a significant relationship between annualised return and IEQ scores, both from a ranking and a nominal perspective to IEQ scores, despite the significant finding in support of this relationship for the high-risk South African Equity Fund. Furthermore, using time spent in a green building as a covariate did not uncover a significant relationship between annualised return and IEQ scores. This confirms that the indication of a significant relationship between enhanced IEQ and organisational performance is difficult to establish as was stated by Kampschroer *et al.*

(2007); Flamholtz (2009); Feige *et al.* (2013), but is contrary to many green building advocates (Alker *et al.*, 2014).

A granular analysis of applying the AGRRi equations of return data across the three investment vehicles of each FSC 1-10 compared to the average return of FSCs 11-20 provided a different insight into the incremental return of FSCs located in green buildings. Eight of the FSCs located in green buildings produced a small incremental return per IEQ point when compared to the average return of the companies located in non-green buildings. Two FSCs performed relatively worse when a comparison was made to the sample of FSCs in the non-green building group. This new approach of assessing FSCs located in green and non-green buildings has not been conducted by previous researchers and therefore provides a different lens within a bottom-up approach of assessing organisational performance within the context of GBFIs, specifically enhanced IEQ. The AGRRi method adds value to assessing organisational performance within the financial services sectors in terms of enhanced IEQ, which is underpinned by green building certification.

Analysing organisational performance within the context of green building is a challenge as there are factors that can influence both the productivity of the human resources and the organisation's performance as a whole (Prouska *et al.*, 2016; Saleem *et al.*, 2019). FSCs provide a relatively "clean" output that can be compared against industry benchmarks and competing organisations.

Green buildings in South Africa are classified as P-grade (premium) buildings, while the FSCs (11-20) located in non-green buildings tend to be classified as A-grade buildings, which typically also include high quality finishes and therefore command relatively high rental. There is a possibility that many A-grade buildings do have some GBFIs (including those related to IEQ), but the property owners choose not to opt for green certification, as this would be an additional cost that is not deemed necessary. This could partially explain why there were individual occurrences of FSCs in the non-green buildings outperforming FSCs located in green buildings, as the difference in the actual IEQ of some A-grade and P-grade buildings is often not immediately noticeable.

However, it must be noted that returns are significantly impacted by a number of other external and internal factors. External factors are characteristics that are not in the control of asset manager(s), while internal factors are characteristics that are in the control of the asset manager(s) and the organisation. Examples of external factors include unforeseen socio-political and economic events that result in a sudden market shock (Prouska *et al.*, 2016), such as COVID-19 where global economies were reduced to only essential services during the height of the pandemic. However, examples of internal factors could be investment policies set by executive leadership (Saleem *et al.*, 2019) at an organisational level, which may restrict individual asset manager(s) from fully applying their best judgement in terms of investment decisions. External factors tend to have a longer lasting impact on returns as it generally takes time for an economy to recover or for a political system to change that will benefit the investment community. Furthermore, external factors are more difficult to manage than internal factors and therefore they can have a greater residual impact on an organisation in terms of strategy development in order to pivot appropriately. These factors can distort annualised returns and make it difficult to establish if there is a relationship between IEQ scores and annualised return.

The obvious limitation of this study is that it only focuses on FSCs and therefore cannot be generalised for other office-based industries, or for that matter other FSCs that do not offer the three commonly available investment funds included in this study. These three funds covered a range of investment risk profiles that aided the standardisation of organisational performance of the FSCs located in green and non-green buildings. This study included a relatively small sample of South African FSCs located in green buildings. However, the sample of FSCs was relatively complete as all the companies renting space in South Africa's largest REIT that were in their green building portfolio and operating in financial services were screened and only ten FSCs were found to have income, balanced and South African equity funds that were established at least five years ago. It should be further noted that due to the small and exhausted sample size it is not possible to determine and/or control for staff attraction and retention (salaries and company culture) working for institutional versus boutique FSCs. Another factor that is difficult to determine are other reasons (outside of protection against failing infrastructure) for FSCs to lease space in green certified office buildings. There could be a range of reasons, that may include corporate brand enhancement,

subtle recruiting strategy in the form a superior indoor working environment, and environmental consciousness as part of FSCs core company values, *inter alia.*

Conclusion

The study attempted to determine if there was any benefits for FSCs located in a green building in terms of organisational performance, as measured by annualised return (Hypothesis 1 – partially accepted). There were indications that FSCs located in green buildings did on average yield higher annualised returns to FSCs located in non-green buildings. The difference in performance is not always immediately large but can lead to a large difference when allowed to compound over time, thus benefiting both the FSCs and their clients over the long-term. It should be noted that extrapolating future values is a hypothetical exercise, which is often performed in industry by FSCs with the assumption that current market conditions are relatively stable/predictable over a long period of time. It could not be conclusively established that there was a relationship between annualised return and IEQ scores (Hypothesis 2 - rejected), however there was an indication that there is a moderate IEQ score range where annualised return seems to be maximised relative to the lower returns in the sample. Furthermore, the amount of time in a green building did not provide any insight into the organisational performance of FSCs located in green buildings (Hypothesis 3 - rejected). A new metric (AGRRi) was used to normalise the IEQ score to determine if there was an incremental difference in annualised return for each FSCs located in a green building when compared to the average returns of the FSCs located in non-green buildings (Hypothesis 4 – partially accepted). The AGRRi showed that generally FSCs located in green buildings slightly outperformed FSCs located in non-green buildings. However, it should also be noted that individual FSCs located in non-green buildings did outperform some FSCs in the green building group. This study addressed four hypotheses that focused on organisational performance rather than individual productivity within the context of green building, which yielded mixed results. This was an important step as it provides further insight into whether green buildings, more specifically enhanced IEQ impact the bottom line of FSCs that operate in this space.

There is potential for future research in this area to conduct qualitative data analysis in the form of semi-structured interviews with asset managers of FSCs to determine if there is a perception that their indoor office environment influences their productivity. This data could be used to substantiate the findings of this research and forms part of the model (Figure 1) developed by (Nurick and Thatcher, 2021b) to determine if there is a link between enhanced individual productivity and organisational performance within the context of green office buildings. Furthermore this research could be replicated in other markets where there is a larger sample of green office buildings and FSCs that offer similar funds, that may have different investment challenges to that of South Africa. Additionally, a larger sample would allow for an investigation into FSC performance in relation to company size (number of employees), and create the possibility of analysing other funds that are commonly offered in developed financial markets, which are not widely offered to South African investors. A similar research approach could also be applied to retail property in green buildings, where the financial performance of similar tenants (e.g. anchor tenants such as major supermarkets) could be compared to non-green certified retail buildings. There is also potential for the application of similar type hypotheses within the context of light industrial property (i.e., distribution centres) to determine if an e-commerce type tenant performs better in a green certified industrial building.

6. Conclusion

6.1 Introduction

This chapter provides a conclusion of the pertinent findings across the four articles. The overarching finding from the research is that the relationship between green building features and initiatives (GBFIs) and individual productivity and organisational performance is more nuanced than is commonly stated by green building advocates. The indoor environmental quality (IEQ) within the office building sector is underpinned by various factors, which are physical, psychological, and cultural (depending on the industry). These factors influence both productivity and performance, which need to be separated within the context of GBFIs and IEQ, as improved individual productivity does not necessarily lead to enhanced organisational performance. Productivity was assessed via semi-structured interviews in green certified office buildings containing financial services (FSCs), where these FSCs were also included in the sample of companies that formed part of the organisational performance analysis. Performance was measured using desktop data from FSCs to establish if there was a relationship between annualised returns and IEQ scores.

6.2 Summary of the Literature

The first two papers by Nurick and Thatcher (2021b; 2021a) indicated that there was not necessarily consensus amongst academic researchers in terms of accurately measuring productivity and its meaning within the context of green building research, specifically the impact of IEQ. Several commonalities did become apparent, which included: there were three distinct paradigms for assessing productivity; (1) experimental laboratory studies, (2) field studies, and (3) linking GBFIs to organisational outcomes. The three paradigms each have their own unique advantages, however they were also critiqued, as there are evident flaws in each of these approaches. The three paradigms resulted in the formulation of the emergent research model as shown in Nurick and Thatcher (2021b), which is the basis of the scoping literature review (Nurick and Thatcher, 2021a) and the two empirical papers where the theoretical model is amended to reflect the prominent components and linkages as a result of the qualitative data analysis. The emergent research model addressed three new pathways

not previously found together in the literature; (1) linking GBFIs to wellbeing, health, and comfort, (2) linking comfort, health, and wellbeing to work engagement, and (3) linking work engagement to productivity, performance, and financial gain. The revised model, which focused on the individual perceptions indicated additional pathways that were not immediately evident from previous studies. These were that location and amenities contributed at different levels to the individual productivity within an office environment. Specifically, organisational culture, collaboration spaces, employee attraction and retention, and safety at both a personal and asset level were linked back to the quality of the physical office environment.

6.3 Summary of Applied Methods

There are a variety of methods that have been applied in assessing individual productivity and organisational performance within the context of IEQ. The researcher used the PRISMA framework (Nurick and Thatcher, 2021a) to identify and filter relevant journal papers for the logical sorting of the various methods. Thirty-nine papers were included in the final scoping literature review, in which five statistical methods of analysis were applied in the studies across this sample. These included ANOVA, descriptive statistics, multivariate analysis, non-parametric statistics, and Spearman's rank order correlation. The duration of data collection for the final sample was evenly spread across cross-sectional and longitudinal studies. The main measures that were evident in the final sample were generally congruent with the emergent research model. These included ambient condition (IEQ/IAQ), spatial conditions, location and amenities, comfort, engagement, individual productivity, and organisational performance. A gap that became apparent as a result of the scoping literature review is that there were no studies that primarily focused on the organisation in terms of the link between IEQ and organisational performance within the context of GBFIs, specifically IEQ. Only one previous study (Feige *et al.*, 2013) partially attempted to address this relationship, however they were unable to link individual productivity to organisational performance that could subsequently be measured in terms of financial gain. Another noticeable metric was that only 10% of the sources (approximately four articles) were based on research conducted in South Africa. This indicated that due to the infancy of the green building movement in South Africa compared to more developed green building real estate markets, there is an opportunity to

continue researching the impact of enhanced IEQ on individual productivity and organisational performance within African real estate markets.

6.4 Summary of the Findings

6.4.1 Individual Productivity

Fifteen respondents across two FSCs located in green certified office buildings indicated that there were five overarching themes that impacted their individual productivity in relation to GBFIs, namely: access to nature, IEQ awareness, enhanced organisational culture, a set of productivity drivers, and a set of productivity barriers. The commonly cited drivers of productivity across the majority of the interviewed respondents were: access to dedicated work space, an acceptable ambient noise level in open plan offices, quality lighting (natural and artificial), ability to control temperature, the relatively superior physical quality of the environment, efficient building management support services, access to break away zones for both meetings and private concentration, refreshment stations for informal collaboration, and access to external amenities. The main productivity barriers included: unacceptable ambient noise levels, uncontrollable temperature variability, the onset of SBS symptoms from poor temperature and thermal conditions, motion sensing lighting that switches off when there is little movement from a building occupant, non-ergonomically designed office furniture, and the impact of building location on relatively long commuting times. Based on the analysis of the interviews the main underlying factors that contribute to productivity are ambient conditions, spatial factors and comfort. These three components also play a partial role in psychological wellbeing, although this is also heavily influenced by personal factors that are not work related, such as general personal safety, concern for children and other dependents.

A predominant finding that was highlighted, which appears to be is unique to South Africa is the issue of safety. This encompasses both personal safety (perceived threats of harm to one's self) and the security of personal assets, from cellular phones to vehicles parked in basements. This is due to South Africa's relatively high crime rate, and furthermore due to the type of individuals that work at FSCs (who are generally well remunerated and are relatively wealthy compared to the general population), and therefore potential targets

and/or victims of criminal activity. The buildings in both case studies appeared to play a role in employee attraction, especially relating to attracting junior to middle level staff, and those members of staff that came from previously disadvantaged backgrounds. This is due to the legacy of apartheid and aspirations of a 'born free' (born from 1994 onwards) generation of graduate professionals that typically come from financially modest domestic environments, who aspire to work in high quality buildings as professionals – opportunities not typically afforded to the majority of South Africa's historically marginalised population due the residual effect of the apartheid regime. Furthermore, graduates from previously disadvantaged backgrounds could be additionally hindered by other domestic infrastructure challenges, such as poor internet connectivity, unreliable electricity and water supply, small crowded/noisy households, and lack of access to office hardware (e.g., printers and scanners). Moreover, it is viewed by previously disadvantaged graduates that being offered employment by a company that owns/occupies a premium green-rated building, which is defined in their view as enhanced IEQ, is an indicator of early career success, which has the potential to result in perceived accelerated career progression and thus a relatively early start in the generation of personal wealth.

6.4.2 Organisational Performance

The empirical research conducted by Nurick (2022) provided insight into organisational performance within the context of FSCs based in green certified and conventional (non-green) buildings. This was done by isolating three commonly offered investment products across low-, moderate-, and high-risk levels. The findings indicated that on average FSCs based in green buildings outperformed the FSCs based in non-green buildings in terms of average annualised returns across both groups. The difference in average annualized returns (performance) becomes more obvious to potential clients of the FSCs when the amount (R100) invested today is compounded both monthly and annually in the context of a thirty year forecast to calculate a future value. The performance gap increased as the risk level of the financial product increased, i.e., income funds had the smallest performance gap, while South African equity funds had the largest performance gap. Annualised returns premium/discount (comparing returns from inception to returns for the last five year) of FSCs in green buildings in relation to IEQ score indicated a negative correlation (r = -0.76, p < 0.01)

for the South African equity fund (highest risk). Simply put, the FSCs with highest annualised return premiums exhibited the highest IEQ scores. A new metric was developed, the average green return ratio incremental (AGRRi), which was used to test the incremental return premium/discount per building for each FSC located in green certified buildings. There were ten FCSs located across nineteen green buildings and the AGRRi for the sample was 0.46%, thus indicating that the FSCs in the green certified buildings outperformed the FSCs in the conventional (non-green) buildings across the three funds, taking into consideration the IEQ score for each green building and the odd occurrence when the annualised return of a FSC in the conventional (non-green) building sample outperformed a FSC in the green building group.

6.5 Theoretical Implications

The theoretical implications of determining the relationship between GBFIs, specifically enhanced IEQ, and individual productivity and organisational performance adds a new perspective to the existing body of knowledge. The emergent research model (Figure 2.1) that is presented in Nurick and Thatcher (2021b) comprising the main literature review, exhibited a holistic framework showing the linkages between GBFIs, wellbeing, work engagement, individual productivity, organisational performance, building value, and finally a feedback loop justifying the initial (and potentially continued) implementation of GBFIs within an office building. The emergent research model (Figure 2.1) was underpinned by many previous research studies that attempted to determine the impact of office building occupant productivity when a component(s) of the IEQ is improved in a laboratory study (Veitch and Newsham, 1997; Wyon, 2004; Zhang *et al.*, 2010; Park and Yoon, 2011; MacNaughton *et al.*, 2015; Tanabe *et al.*, 2015), in field studies (Wyon, 2004; Biron *et al.*, 2006; Roulet *et al.*, 2006; Akimoto *et al.*, 2010; Fisk *et al.*, 2011; Tanabe *et al.*, 2015; Chadburn *et al.*, 2017), and studies that attempted to link GBFIs to organisational outcomes (Harter *et al.*, 2003; Kampschroer *et al.*, 2007; Vischer, 2008; Flamholtz, 2009; Feige *et al.*, 2013; MacNaughton *et al.*, 2016).These linkages were examined through the lens of predominantly applied methods by previous researchers, which included *inter alia* (Clements-Croome and Baizhan, 2000; Wargocki *et al.*, 2002; Fang *et al.*, 2004; Vischer, 2008) for the period 2000 – 2020 (Nurick and Thatcher, 2021a). The majority of the previously applied research approaches focused on productivity

by using a variety of statistical analyses through either cross-sectional (Kato *et al.*, 2009; Guerin *et al.*, 2012; Hedge and Dorsey, 2013) or longitudinal studies (Singh *et al.*, 2010; Wiik, 2011; Thatcher and Milner, 2012; Agha-Hossien *et al.*, 2013; Thatcher and Milner, 2014b; 2014a). However, it was also noted that there is opportunity for qualitative approaches to be applied with equal fervour in this research field. Furthermore, limited research was conducted in this field in South Africa and the African continent, as these emerging markets contain less developed green building sectors. Moreover, South Africa and the African region experience different socio-economic challenges compared to developed real estate markets that can drive (or hinder) a customised green building agenda, which is often focussed on green building solutions that address failures in infrastructure, for example, providing re-renewable energy solutions to combat scheduled power black outs and water shortages, so that office buildings occupants may continue to operate efficiently. It should be noted that although many green certified office buildings in South Africa do address energy consumption via renewable energy solutions, these GBFIs are not necessarily sufficient to address the current state of scheduled power black outs. This has resulted in a paradoxical use (fully or partially) of diesel fuelled generators, which are often located in the basement parking lot (to minimise the impact of residual noise) to maintain building operations, and hence individual productivity and organisational performance. It was established that little research had focused specifically on organisational performance, thus identifying a gap in the academic literature. This allowed for specific analysis of an industry (financial services) that is quantitative in nature, where organisations are directly benchmarked by their performance relative to their competitors and the overall market.

The main theory that was addressed in this research was to determine if the implementation of GBFIs, specifically enhanced IEQ resulted in improved individual productivity and organisational performance within an office building. This was the sentiment of green building advocates, however previous empirical research (Gou *et al.*, 2013; Thatcher and Milner, 2014b; Byrd and Rasheed, 2016) did not fully support this notion as some IEQ components can have positive, negative or no impact on productivity or performance. Even if there is an impact (be it positive or negative), it may be too small to measure, and therefore inconsequential to building occupants, and the organisation. Furthermore, differing corporate sectors pose challenges with regards to measuring productivity and performance.

This research focused on one sector (FSCs) that generates quantitative outputs (annualised returns), which are used to benchmark organisational performance. This was a deliberate choice as FSCs products (investment funds) can be used as a direct proxy for determining the top FSCs in the market. Therefore, the office setting of corporate occupiers (FSCs) in both green and conventional (non-green) buildings, combined with the financial services industry provided an optimum environment for testing the theoretical linkages between GBFIs, individual productivity and organisational performance.

Both the empirical papers that focused on individual productivity and organisational performance, respectively, were underpinned by the emergent research model (Figure 2.1). Commonly applied methods that were evident in previous research were the use of a BUS (Gou, Lau and Chen, 2012; Gou, Lau and Zhang, 2012; Gou *et al.*, 2013; 2014), and a POE (Leaman and Bordass, 2007; Loftness *et al.*, 2009; Guerin *et al.*, 2012; Agha-Hossien *et al.*, 2013; Gou and Siu-Yu Lau, 2013; Hedge and Dorsey, 2013; Thatcher and Milner, 2014b; Candido *et al.*, 2016; Thatcher and Milner, 2016; Elnaklah *et al.*, 2020; Lee *et al.*, 2020). Nurick (2022) provided a new method, average green return ration incremental (AGRRi) for assessing organisational performance within the context of enhanced IEQ in green certified buildings. This was done within the context of annualised returns, which is represented as financial gain (increased ROI) in Figure 2.1. The AGRRi is an output that results from a combination of annualised returns of three funds with different risk profiles (compared to the average return of the corresponding fund for the sample of FSCs located in conventional buildings) for each FSC located in one or multiple green certified buildings. The IEQ score(s) are used to normalise the green return ratio incremental (GRRi), which is finally used to calculate the AGRRi. This is a unique approach to isolate organisational performance within the context of attempting to determine if FSCs located in green certified buildings outperform their industry competitors located in conventional (non-green) buildings.

The emergent research model (Figure 2.1) was used to underpin the semi-structured interview questions. The interview data resulted in some modifications to the emergent research model, which highlighted new factors and associated linkages. The qualitative research resulted in a revised theoretical model (Figure 4.4), which provides further insight into the contributing factors and linkages that were consistent with the emergent research

model (Figure 2.1), which were the role and linkages of comfort (Gou *et al.*, 2013; Gou and Siu-Yu Lau, 2013; Thatcher and Milner, 2014b; Elnaklah *et al.*, 2020), work engagement (Schaufeli *et al.*, 2002; Schaufeli *et al.*, 2006; Demerouti and Bakker, 2008) and productivity (Clements-Croome and Baizhan, 2000; Wyon, 2004; Schwede *et al.*, 2008; Singh *et al.*, 2010; Wiik, 2011; Agha-Hossien *et al.*, 2013; Niewenhuis *et al.*, 2014; Tanabe *et al.*, 2015; Candido *et al.*, 2016; Mallawaarachchi *et al.*, 2016; Mulville *et al.*, 2016; Thatcher and Milner, 2016; Chadburn *et al.*, 2017; Mallawaarachchi *et al.*, 2017) that resulted in work output, work quality and efficiency. However, the impact of spatial factors, wellbeing, health and comfort were not as prevalent as predicted, with linkages that also indicated weaker overall relationships. This is contrary to the research conducted by Alker *et al.* (2014) on behalf of the WGBC, who stated that spatial factors in offices has a material impact on the health, wellbeing and productivity of occupants. There were new linkages that indicated a three-way major impact on individual productivity between location and amenities and ambient conditions and comfort. The emergent research model (Figure 2.1) was the result of a literature review (Nurick and Thatcher, 2021b), which was an advanced version of the model developed by Feige *et al.* (2013). The empirical research highlighted gaps in the emergent research model (Figure 2.1), with regards to individual productivity. The modified model (Figure 4.4) highlighted new findings pertaining to amenities and safety, which related to reliable service delivery (electricity and water) and personal and asset security, respectively, while located in a green certified office building. These new findings are unique to South Africa due to both public infrastructure challenges and the legacy of apartheid, and as such create a context for how green certified buildings can alleviate these types of hurdles for office workers. Green certified office buildings provide an IEQ that promotes a physical working environment and overall corporate culture that is deemed to be aspirational for many South African graduate professionals.

From an organisational performance perspective, the emergent research model seemed to be robust, within the context of FSCs and the analysis of annualised returns. The perceived linkages between organisational performance and financial gain leading to increased ROI were supported. Furthermore, average outperformance in terms of annualised returns of investment funds provided by FSCs located in green buildings versus conventional (non-green) buildings indicates that FSCs would remain in their current premises, thus reducing

building vacancies. This would result in the de-risking of the office building, lowering capitalisation and discount rates, which would increase the building value. This would finally culminate in the justification and continuous implementation of GBFIs.

6.6 Re-visiting the Research Question and Hypotheses

This sub-section re-visits the research questions and hypotheses that are stated in the Introduction, sub-section 1.9.

Research Question

What theoretical and empirical pathways link GBFIs to individual productivity and organisational performance within an office building?

The impact of GBFIs on individual productivity and organisational performance varies according to the type of research approach, and thus the type of data that is being analysed (Gou *et al.*, 2014; Thatcher and Milner, 2014b; Byrd and Rasheed, 2016) . The qualitative research indicated that GBFIs contribute to the quality of the location and amenities in green certified office buildings. This resulted in the research respondents identifying that this contributed to their overall experience of the building, and certain GBFIs and other amenities contributed positively towards their individual productivity levels. Nurick (2022) attempted to address the difficulty of assessing organisational performance using quantitative data analysis, where the results are encompassed in the partial acceptance and rejections of hypothesis 1, 2 and 3, respectively. Therefore, the over-arching research question was sufficiently addressed by separating individual productivity (qualitative data analysis) and organisational performance (quantitative data analysis), which was conducted within a robust consolidated approach that fully encompassed the emergent research model (Figure 2.1), developed by Nurick and Thatcher (2021b).

Hypothesis 1

Financial services companies (FSCs) located in green buildings in the long-term on average outperform competing companies located in non-green buildings.

Hypothesis 1 was addressed by conducting calculations to determine the average future value of R100 forecasted over a period of thirty years, compounded both monthly and annually, based on the average returns of the FSCs in the green certified versus conventional (non-green) buildings. The FSCs located in green certified buildings outperformed the FSCs located in conventional (non-green) buildings across all three funds (income, balanced and South African equity). The performance gap increased as the risk of the fund increased. Therefore, this hypothesis is accepted.

Hypothesis 2

There is a relative improvement (i.e., ranking improves) of annualised returns for FSCs when compared to the number of IEQ points for a green building.

The results linked to addressing hypothesis 2 indicated that there was no correlation between IEQ scores and annualised results for the income and balanced funds. However, results, which were statistically significant (Pearson's Correlation analysis), indicated that for the South African equity fund there was an IEQ sweet spot of approximately 7.5-10 points. This indicated that FSCs located in green certified buildings that obtained relatively high and relatively low IEQ scores did not yield superior and inferior annualised returns, respectively when compared to the relatively higher annualised returns of the FSCs located in green certified buildings that obtained IEQ scores in the sweet spot (7.5-10 points). It could not be conclusively established if there is a relationship between IEQ scores and annualised returns. It should be noted that there could be multiple reasons for a lack of correlation between IEQ scores and annualised returns. These could include vagueness of the overall IEQ score, which does not at a high level inform which IEQ credits were obtained in the final certification. There is a further possibility that certain IEQ components are not included in the current GSSA office rating tool, which has the potential to not accurately reflect the full IEQ status of a green certified office building. Therefore, this hypothesis was rejected.

Hypothesis 3

Time in a green building (operationalised as years since occupation) has a positive impact on the relative improvement in annualised returns.

The amount of time spent in a green certified building by a FSC did not provide any indication into the performance in terms of annualised returns when compared to fund inception to five-year annualised returns. The South African equity fund did indicate moderate (r = -0.58, $p < 0.1$) negative correlation, however this was at a relatively large (p = 0.10) significance level. This indicated that FSCs did not exhibit improvement in annualised returns when analysed in isolation (i.e., comparing a FSC to itself over a period of time), especially within the context of time spent in a green certified building. However, FSCs in green certified buildings did generally outperform their industry counterpart that were based in conventional (non-green) buildings. Therefore, this hypothesis was rejected.

6.7 Studies Limitations

The empirical component of this study was limited to office buildings owners and tenants that operate in the financial services sector. Only FSCs were selected for this study, due to fund managers generally being completely office bound, which is not normally the case for other industries based in offices, such as auditors, engineers, and lawyers, who often operate outside their company's office when liaising with clients. This would therefore reduce the exposure for these types of professionals to the IEQ of their company's office, which could distort the impact on productivity and performance when compared to other corporate and/or domestic working environments. All the data was gathered within the South African commercial property market. The green certified buildings included in this study were all assessed using only the GSSA office tool, which means the buildings were rated four, five, or six stars. Individual productivity was measured via self-assessment via in- depth semi-structured interviews, where data saturation occurred relatively quickly due acquisition of thick descriptions. This data collection approach is not always considered to be entirely accurate as there is an element of subjectivity, which can result in a bias factor (Thatcher and Milner, 2014b; Byrd and Rasheed, 2016; Mulville *et al.*, 2016), however this form of assessment was still considered to be sufficient as it is a commonly applied approach, which was exhibited in Nurick and Thatcher (2021a). Limitations regarding the assessment of individual productivity that are not building related may include: lack of job stimulation, poor organisational support systems regarding supervision, lack of ability to competently complete tasks, and personal challenges that may acutely affect productivity (Clements-Croome, 2005).

Only FSCs that offered an income, balanced, and South African equity funds, with similar asset class allocations across each of the three fund types were included in the quantitative analysis. This resulted in a relatively small sample of FSCs, which was underpinned by not all FSCs offering the three funds required in the quantitative analysis and due to South Africa having relatively fewer green certified office buildings compared to other developed real estate markets. A local analysis of FSC performance was conducted to avoid complications with regards to comparison of financial products developed and sold in foreign capital markets, where different macroeconomic factors contribute to annualised return performance. Due to annualised returns being the focal point of analysis with regards to organisational performance, the size (number of employees) would not be a factor, as returns are measured as a percentage. Therefore, the quantum (Rand amount) invested on behalf of clients due to the size of the FSC is normalised, regardless of whether a FSC is an institutional investor or a boutique private equity firm. Furthermore, it should be noted that many FSCs are located in high quality office buildings that contain GBFIs but the building owners have not obtained green certification (most likely due to cost). Moreover, not all FSCs located in green certified buildings are owner occupied, which means that the landlord (not the FSC) provided the capital for the implementation of the GBFIs and the subsequent green certification. A further limitation, due to the timing of the research was the impact of Covid-19 on the productivity component. Many large FSCs did not agree to the mass surveying of their staff, as they had been exposed to several internal surveys that were related to Covid-19. The inability to conduct a large scale survey limited the manner in which work engagement was assessed. Fortunately, this resulted in a targeted approach where a relatively small sample of specialist respondents participated in the semi-structured interviews, who provided thick descriptions as the qualitative data set. Furthermore, respondents that participated in the semi-structured interviews did mention the impact of the IEQ on their ability to engage with their work, which was consistent with the emergent research developed by Nurick and Thatcher (2021b). Moreover, Covid-19 has resulted in changes to interactions with the working environment, for example hybrid working is considered acceptable, while before 2020 this approach was considered by many organisations to be a radical policy.

6.8 Directions for Future Research

The emergent research model (Figure 2.1) could possibly be tested within other professional office-based industries to determine whether similar or different relationship exist between GBFIs and individual productivity and organisational performance. This may result in the further refinement of the emergent and revised theoretical models, which may be specific to certain industries. The study designs could also provide more clarity in terms of exactly which IEQ components require further investigation in relation to individual productivity and how these link to organisational performance. Further research will also be required to test individual productivity in a natural office environment versus an artificial laboratory type environment. Based on previous research (Veitch and Newsham, 1997; Wyon, 2004; Zhang *et al.*, 2010; Park and Yoon, 2011; MacNaughton *et al.*, 2015; Tanabe *et al.*, 2015), this was one of the predominant methods for testing productivity when IEQ components were modified as part of a simulation. There is an opportunity for more in depth examination of the relationship between individual productivity and organisational performance to establish to what degree enhanced productivity can be converted (if at all) to enhance organisational performance, thus yielding a competitive advantage for an owner/occupier of a green building. This provides an opportunity to establish if GBFIs (specifically the IEQ components) do positively impact the profitability of businesses operating in green buildings. If future empirical data could strengthen this argument, then this would result in a higher uptake of green office buildings for reasons outside of operating cost savings or possibly green washing to maintain a certain corporate reputation.

There is another avenue for future research, which could focus on unpacking the term organisational performance. This may take a more holistic view of an organisation in terms of environmental, social, and governance (ESG) issues (Maji and Lohia, 2023). It could be hypothesised that a company with a solid ESG framework may attract and retain top talent across different job entry levels, which in turn could result in enhanced organisational performance. Each component of ESG could be examined to determine how the environmental, social, or governance objectives contribute to sustainable organisational performance. ESG is becoming a more prevalent area of research (Wang *et al.*, 2023) due to a combination of environmental and governance failures by some blue-chip companies that occupy office space both in South Africa and internationally. Furthermore, the built

environment's impact on society, especially in developing countries is garnering increased attention by decision makers at the executive level. Evidence of this, is that some boards are now explicitly appointing executive directors that manage a company's ESG portfolio, as the development of and adherence to certain ESG benchmarks may impact a company's rating, which can impact the cost of capital amongst other financial line items.

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Appendix 1: Ethics Clearance Approval

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Research Office

HUMAN RESEARCH ETHICS COMMITTEE (NON-MEDICAL)
R14/49 Nurick

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER: H21/04/28**
PROJECT TITLE	Perceived Impacts of Green Building Features and Initiatives on Productivity within an Office Building
INVESTIGATOR(S)	Mr S Nurick
SCHOOL/DEPARTMENT	Human & Community Development/
DATE CONSIDERED	16 April 2021
DECISION OF THE COMMITTEE	Approved Permission letters are required before data collection can commence Risk Level: Minimal
EXPIRY DATE	16 May 2024

DATE 17 May 2021 **CHAIRPERSON** _____
(Professor J Knight)

cc: Supervisor : Professor A Thatcher

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10004, 10th Floor, Senate House, University. Unreported changes to the application may invalidate the clearance given by the HREC (Non-Medical)

I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to submit an amendment of the protocol to the Committee. **I agree to completion of a regular progress report. For Minimal and Low studies, this is due annually on 31 December. For Medium and High Risk studies, this is due twice annually on 30 June and 31 December.**

_____ 17 / 05 / 2021
Signature **Date**

PLEASE QUOTE THE PROTOCOL NUMBER ON ALL ENQUIRIES

Appendix 2: Informed Consent Letter



University of the Witwatersrand,
Department of Psychology
School of Human & Community Development

RE: CONSENT TO PARTICIPATE IN SEMI-STRUCTURED INTERVIEWS

PERCEIVED IMPACTS OF GREEN BUILDING FEATURES AND INITIATIVES ON PRODUCTIVITY WITHIN AN OFFICE BUILDING

Dear Sir / Madam,

My name is Saul Nurick and I am a PhD student in the Department of Psychology at the University of the Witwatersrand, Johannesburg. As part of my studies, I have to undertake a research project, and I am investigating the impact of green building features and initiatives on individual productivity and organisational performance under the supervision of Professor Andrew Thatcher.

As part of this project, I would like to invite you to take part in a semi-structured interview. This activity will involve a recorded conversation underpinned by approximately five broad questions. The interview will take approximately 45 minutes.

There will be no personal costs to you if you participate in this project, You will not receive any direct benefits from participation, but there are no disadvantages or penalties if you do not choose to participate or if you withdraw from the study. You may choose not to answer any question and you may withdraw at any time, including after the interview has concluded. The identity of the interviewees will remain anonymous in any reports or papers and their responses will be confidential for the purpose of this research project. Please note that the interview will be recorded and direct quotes may be used for the purpose of this research project.

If you have any questions during or afterwards about this research, feel free to contact me on the details listed below. This study will be written up as an academic publication and will form part of my thesis. If you wish to receive a summary of this research, please let me know. The data collected from this research project will be stored in a password protected computer. With your permission the data collected from this research project may be used by other researchers in an anonymized format. If you have any concerns or complaints regarding the ethical procedures of this study, you are welcome to contact the University Human Research Ethics Committee (Non-Medical), telephone +27(0) 11 717 1408, email hrecnon-medical@wits.ac.za

Appendix 3: Informed Consent Form – Respondent

Informed Consent Form

Title of project:

PERCEIVED IMPACTS OF GREEN BUILDING FEATURES AND INITIATIVES ON PRODUCTIVITY WITHIN AN OFFICE BUILDING

Name of researcher: Saul Nurick

I, ……., agree to participate in this research project.

I agree to the following:

(Please circle the relevant options below)

The research study was explained to me. I understand what this study is about.	YES	NO
I understand that I can withdraw from the study at any point.	YES	NO
I agree that the interview may be audio recorded.	YES	NO
I agree that direct quotations from my interview may be used by the researcher in their research report and/or manuscript.	YES	NO
I agree that my participation will remain anonymous (my name will not be used by the researcher in their research report and/or manuscript).	YES	NO
I agree that other researchers may use the information I provide in my interview (depending on their own ethics clearance being obtained) but my name and any personal information will not be used or passed on.	YES	NO

…… (signature)

…… (name of participant)

…… (date)