Operational performance and delivery structure of hospital facilities

Empirical relationship analyses in Ontario, Canada

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Abstract

While expending large amounts of scarce public funds on social infrastructure, including hospitals, governments globally apply increasingly diverse delivery mechanisms. Across Canada, particularly the province of Ontario, policy shifts favour the use of Public-Private Partnerships (P3s). Yet little empirical understanding exists of the implications these delivery structures have on operational outcomes like energy and labour use, major contributors to Facility Management (FM) budgets and climate change, as well as facility user satisfaction. In order to further investigate concepts surrounding a positive theory of P3s (Vining and Boardman, 2008), the three articles within this thesis pragmatically employ qualitative and quantitative methods to explore diverse aspects of the relationship between variations in facility delivery structure and operational performance among hospital facilities in Ontario, Canada.

Article 1 applies a cross-sectional analysis of 2016 energy use data for all 286 operational hospitals in Ontario. Results show facilities delivered through P3 contracts including an operating term had lower energy intensity than those delivered conventionally or via P3 contracts without an operating term. Article 2 uses a comparative, longitudinal Case Study of two P3 facilities with an operating term to further investigate preliminary findings in Article 1 of a strong relationship between energy intensity and contractual approach to energy management. The facilities studied were identified in Article 1 as having among the highest and lowest energy intensities of all Ontario hospitals. Initially both facilities had poor energy performance. Then, while the facility applying a Regression Analysis Model to set annual targets and payments maintained only modest improvements over the operating period, the facility applying a Bid Energy Model achieved dramatic improvement in energy use and associated environmental performance over the same period. Supporting findings of Article 1, the facility using a Bid Energy Model capitalised on risk transfer mechanisms unique to delivery structures bundling design, construction and operating phases.

In Article 3, a second Case Study investigates energy use and FM labour utilisation at a conventionally procured and operated hospital and an early P3 hospital with an operating term. Both facilities are part of the same public health care corporation in Ontario and studied in Article 1. The P3 facility was also included in Article 2 as the site applying a Bid Energy Model for energy management. Using empirical data on labour and energy use - supplemented by facility user surveys, interviews of key stakeholders and contractual study - findings show consistently better performance at the P3 facility, though after a short bedding-in period for energy use. Stakeholders reported that, despite transferring many best practices from the P3 facility to improve data tracking and reporting across the organisation, internal accountability remained a challenge at the conventionally procured facility and budgeting factors negatively affected its operations. Strong financial penalties and incentives within the P3 contract are identified as drivers for high performance for energy use and maintenance directly, and facility user satisfaction levels indirectly.

The evidence from this study reveals that delivery structure is a potentially useful tool to drive operational performance, and thereby address recognised performance gaps in public buildings, but that effectiveness is highly subject to contractual details with respect to risk transfer. The studies within are unique in their use of empirical data collected from mature operational facilities under a variety of delivery models. The work helps to describe how key actors interact and respond to policy decisions that have intended and unintended consequences to hospital facilities, their stakeholders, regional economies and the broader environment. To date the author has presented findings in multiple conferences, published in conference proceedings, submitted one article for journal publication and applied these findings within his professional duties.

Declaration

No portion of the work referred to in this thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.

Copyright Statement

Dedication

This thesis is dedicated to my family, particularly the endless and reluctant support of my darling wife Dr Elena Tonti *PhD* through health issues, job changes and the birth of our two beautiful children, Ian Dante and Francesca Erica. I gratefully acknowledge the invaluable input from my doctoral co-supervisors Professor Pamela Stapleton and Professor Anne Stafford and for their understanding through the various ups and downs of life. In addition, I want to extend my fulsome appreciation to my employers at Plenary Americas, and the Toronto Terminals Railway before, my interviewees, the University of Manchester, its faculty and staff, and my cohort of classmates for enabling this enriching journey.

Author

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1 Bridge Introduction

The purpose of this thesis is to empirically investigate relationships between variations in facility delivery structure and operational facility performance. Applying data from hospitals in Ontario, Canada, the associated research was conducted to address associated gaps noted in the literature with respect to empirical studies on the topic (Chen et al., 2015), particularly related to Public-Private Partnership (P3) facilities. The following research question guides the thesis as a whole: *Is there a relationship between variations in delivery structure of hospital facilities in Ontario, Canada and the associated operational performance of the infrastructure, as measured by multiple specific facility resource use metrics relating to energy and labour?* Following an Alternative Format, the thesis includes three publishable papers that address the above research question from different perspectives and applying a variety of methods.

The integrated studies summarised in the articles support the overall thesis through inclusion of the following components identified through an initial literature review process. Firstly, all studies are of public hospital facility infrastructure in the province of Ontario, Canada. This includes facilities delivered under a variety of structures, including multiple P3 models. Secondly, the studies focus on the relationship between infrastructure delivery and the operational performance of the infrastructure. The quantitative analysis of operational performance is conducted from multiple perspectives as measured by the following site data: facility management labour use, facility user satisfaction, energy use and associated Greenhouse Gas (GHG) emissions. Facility management labour use and energy use are major components of facility management budgets (Adams et al., 2010) and together serve as a proxy for facility operational expenditure, a metric that was unavailable for analysis directly. Thirdly, all research uses empirical data collected in the field to conduct analyses and generate findings. Much of the data generated for this research is not publically accessible, with such detailed data made available through the author's embedded role in the field. This approach is rare among the related academic and industrial literature currently available.

For the remainder of this Bridge Introduction, Section 1.1 provides an overview of public health facility delivery approaches; Section 1.2 highlights the objectives and motivations of the research; Section 1.3 outlines the key literature supporting this research; Section 1.4 outlines the research design including my epistemological influences, research phenomenon, thesis development and methodology; and Section 1.5 summarises the prior sections and provides a roadmap to the remainder of the thesis.

1.1 Research Initiation - Public Health Facility Delivery

Infrastructure ownership, management and financing trends vary throughout the development life cycle and over time (Jacobson and Tarr, 1995). Scarcity of funds and expertise, as well as risk mitigation, has long led governments and the private-sector to cooperate on infrastructure development (Albalate et al., 2014) with private investment in European public infrastructure traced back to the 17th and 18th centuries (Tang et al., 2010). Notable examples include the UK's turnpike road system in the late 1600s (Bogart, 2005) and Paris's first concession for provision of drinking water in 1777 (Kerf et al., 1998). The trend expanded beyond Europe in the 19th century with private delivery of the Suez Canal, Trans-Siberian Railway and numerous other Asian and American canals, roads and railroads (Kumaraswamy and Morris, 2002).

While the above examples include Civil Infrastructure, Social infrastructure are defined by Chan et al. (2009) as "physical assets that support the social development of a community, including education, health and public housing facilities". Historically, hospital facilities, the form of social infrastructure that is the subject of this thesis, have been provided both publicly and privately along with the services performed within. However, since government-funded universal health insurance programs were established in many Organisation for Economic Co-operation and Development (OECD) countries – beginning with Germany (1883), United Kingdom (1911) and Canada (1957) - public financing and provision of these facilities became the norm (Canadian Museum of History, 2010).

Private companies' roles have broadened to all aspects of public infrastructure development including financing and ownership as well as management, design, construction, maintenance and/or operation (Akintoye et al., 2016) and these practices evolved further through the emergence of P3s in the late 1990s (Winch, 2000, Grimsey and Lewis, 2002a). Due to the variety of project forms and situations around the world, P3s have been defined in a number of ways (Hodge et al., 2010), including contracting out of public services to private firms, such as garbage collection (Sindane, 2000) and even full privatisation of formerly state-owned industries (Ng, 2000). In a definition adopted by the Canadian Council of Public Private Partnerships (CCPPP), a P3 is any "cooperative venture between the public and private-sectors, built on the expertise of each partner, which best meets clearly defined public needs through the appropriate allocation of resources, risks and rewards" (Henk, 1998, CCPPP, 2015).

Noting the context of an increasingly diverse range of infrastructure delivery structures being used globally, hospital facilities in Ontario, Canada were identified as a prime example available for study as part of this thesis. Canada, and particularly the province of Ontario, is one of the highest-volume P3 markets in the world; of these the majority are social infrastructure and many are health deals (Inframation Deals, 2019). The 286 hospitals in the province are delivered using a variety of structures (Infrastructure Ontario, 2019b) classified throughout the thesis into the following groups:

1) Conventional delivery: Publically owned and operated, typically constructed using a Design-Bid-Build model.
2) Mix of conventional and P3 (no operating phase) delivery: Since the mid-2000, major additions or reconstructions of existing hospitals facility in Ontario were delivered as P3s without an operating phase.
3) P3 delivery without an operational phase (e.g. Build-Finance, Design-Build-Finance)
4) P3 delivery with an operational phase (e.g. Build-Finance-Maintain, Design-Build-Finance-Maintain)

As noted above, little empirical research has taken place with respect to delivery approach, including the use of P3s, and the operational performance of facilities. This is particularly true with respect to use of resources such as energy and labour, the focus of this research.

1.2 Objectives and Motivation

The primary objective of the research associated with this thesis is to investigate empirically whether relationships exist between variations in facility delivery structure (e.g. conventional versus P3) and operational performance of the facilities. This aim is substantiated by noted gaps in the literature with respect to empirical studies on the topic (Chen et al., 2015). With the intended audience of public policy-makers the intent is to provide guidance to maximise public infrastructure investment efficiency. With a lack of available expenditure data directly available to compare the delivery structures' operational performance, the author targeted proxy values representing key facility management expenditures. These resource use values – namely energy and labour – allowed the study of other aspects of operational facility performance that have great global significance. In particular, this includes environmental performance of the facilities.

This study's research basis and methods approach stem from my professional experiences, education, pragmatic epistemology and motivation to improve public infrastructure's economic, social and environmental sustainability through policy interventions. Emphasis within is placed on hospitals, unique social infrastructure assets with broad impacts on their communities, serving as anchor institutions that often hire local workers and contractors, purchase through local suppliers and increasingly provide facilities and services outside of their core health care functions (Hacke and Deane, 2017). Governments around the world spend large sums of public money annually to provide social infrastructure

(Woetzel et al., 2016), including hospitals. In the Canadian province of Ontario, as with most provinces, the health sector is the largest expense item in the provincial budget with hospital operations the largest program area. Roehrich et al. (2014) identified an increasing diversity of delivery structures used for health facility projects, yet little empirical evidence of their long-term implications on effectiveness and cost in the academic and industrial literature. Across Canada, and the province of Ontario in particular, this disconnect is marked by a notable policy shift favouring the use of P3s, often positioning them as a means to encourage innovation across the life cycle of major infrastructure projects (Regan et al., 2011).

When I began the DBA programme I worked at the Toronto Terminals Railway working with operational rail infrastructure. The facilities had passed through various phases of private, public and jointly public-private ownership and I was interested in studying the effects of these changes in ownership on operational performance from an environmental and economic perspective; reflective of my prior environmental engineering and development economics training and experience. I have dedicated over a decade of postsecondary education and my career to advancing infrastructure projects and am motivated by the integral role I believe infrastructure provides in modern society and to the health and wellbeing of its citizens. An established global infrastructure deficit affects billions of people through inadequate provision of the facilities that enable water and sanitation, transport, energy, information, health, education and other services (Dobbs, 2013). Many challenges exist in finding the new sources of investment required and any efficiencies identified through my research would help facilitate the task.

My initial professional work on P3 projects was a transformative experience due to the apparent benefits to long-term, efficient decision-making associated with the bundling of design, construction and operating terms with maintenance, life cycle and energy management services. Through my research at the time (pre-DBA), it was apparent that much of the existing literature on the subject was lacking in empirical *ex post* analyses and that my position in industry would enable information sharing and analysis to inform future decisions of policy-makers to the benefit of society as a whole. Upon entering the DBA programme and completing the initial literature review, it was evident that, while Ontario is a leader in P3s globally, most mature operational projects were in the social infrastructure sector, specifically hospitals. In 2014 I changed jobs to work for a P3 developer on hospital projects to gain access to data and insights in support of the research. The focus on health infrastructure operations in this study is due to the leading role it has taken in experimenting with delivery forms, particularly in North America, and the limited research about their outcomes. The recent flux makes it a particularly interesting area to study. As well, access to data resulting from my role in industry positions me to make a significant contribution through my research. This is a notable advantage of the DBA approach to such research.

1.3 Key literature

Though the subjects included in this thesis are within the health sector the research is of a highly multidisciplinary nature. As such, the literature covered includes a broad selection of academic articles and industry reports selected through extensive review using a variety of methods. Emphasis was placed on identifying formative articles on the related topics as well as recent academic and industrial work within contributing fields including accounting, economics, finance, engineering, health care, management, operations research, public policy, environmental science and urban and regional planning. Literature from most fields touch on themes such as risk management and financial performance while some fields emphasise specific themes, such as engineering articles' focus on technical performance of specific maintenance cycles, medical articles on clinical practice and accounting articles evaluation of Value for Money models. The remainder of this section summarises the key literature identified in these fields emphasising infrastructure delivery, private-sector participation within, the emergence of P3s and associated research contexts and forms of performance evaluation.

This literature review continues with Section 1.3.1 introducing various approaches to infrastructure delivery – including sub-sections on the growth of P3s generally and specifically health P3s in Ontario, Canada. Section 1.3.2 provides an overview of methods to evaluate the infrastructure performance including from a financial and technical perspectives as well as specifically in the operational phase and with respect to energy use. Section 1.3.3 summarises the prior sections and how they relate to the remainder of the thesis.

1.3.1 Approaches to Infrastructure Delivery

To meet growing needs globally (Dobbs, 2013), governments spend over a trillion dollars of public money a year on social infrastructure alone (Woetzel et al., 2016). This infrastructure enables the social and economic activities through the physical structures and systems that provide the necessary spaces and services to communities. An increasing diversity of ownership and management structures are being used to deliver it, with little empirical evidence of their long-term implications on effectiveness and cost (Stafford and Stapleton, 2017, Hodge and Greve, 2018, Roehrich et al., 2014). This attention has spurred growth of the body of research in the field of infrastructure development, generally, with academic, institutional and industrial literature available to cover the many aspects and phases of the process. Aspects include: development history and theory, such as how public infrastructure investment decision making changes with respect to developmental, environmental, and democratic values (Altshuler and Luberoff, 2003); policy formation, evaluation and planning phases of projects (Priemus et al., 2008); and the various infrastructure management tools and techniques available over the asset life cycle (Hudson et al., 1997) from the planning, design and construction phases through operations and maintenance, rehabilitation and renovation as well as decommissioning.

Governments finance public infrastructure investments through the following: 1) upfront raising of taxes or cutting other expenses, which can lead to political hostility and economic costs; 2) public borrowing, which can generally be done more cheaply than private entities but at restricted amounts; and 3) private financing, which can allow for accumulation of liabilities off the official balance sheet and paid back through annual cash flows (Fernandes et al., 2015, Finnerty, 2013). Political and commercial rhetoric often states that private-sector efficiency should maximise infrastructure value (Avishur, 2000) with some academic literature looking to positive economic impacts of infrastructure privatisations, popular in the United Kingdom and North America in the 1980s and 1990s (Marcelin and Mathur, 2015, Preston and Robins, 2013, Boardman and Vining, 2012, Preston, 1996). Many governments use this to support aims of improving public services through private-sector involvement to “assist the government in meeting its priorities, building on the clear recognition that public funds are limited” (Tang et al., 2010).

One of the primary advantages claimed for private involvement in public infrastructure development is to augment public-sector expertise, often on projects for which the local governments are unfamiliar but on which the private-sector entities have worked in other jurisdictions. This can save the public-sector resources and allow the local governments to concentrate on their primary duties (Cumming, 2007), which has been shown to produce a leaner civil service structure while improving the quality of the public infrastructure and associated services and reduce the risk of cost overruns and project delays (Edkins and Smyth, 2006, Ho, 2006, Li and Akintoye, 2008). Additionally, by identifying and assigning risks to the parties most able to mitigate them the overall risk profile can potentially be reduced (Shen et al., 2006). Criticism of the privatisation of infrastructure development is generally rooted in higher borrowing costs and private-sector partners acting in their own best interest, a matter of particular concern as much infrastructure serves as a natural monopoly (Gómez-Ibáñez, 2009). Corresponding concerns are associated with potentially reduced service quality including downgraded employment conditions for staff and service scope reduction for affordability reasons (Edwards et al., 2004).

1.3.1.1 The Growth of Public-Private Partnerships (P3s)

Private companies' roles have broadened to all aspects of public infrastructure development including financing and ownership as well as management, design, construction, maintenance and/or operations (Akintoye et al., 2016). The increasing prominence of private-sector parties in infrastructure delivery structures has been politically and industry led as an extension of neoliberal policies since the 1980s, particularly in OECD countries (Hood, 1995). The 1990s saw this 'new public management' theory and ideology gain ground with the use of Private Finance Initiatives in the United Kingdom, supported by both Conservative and Labour governments (Tang et al., 2010). These practices evolved further through the expansion of P3s in the late 1990s (Winch, 2000, Grimsey and Lewis, 2002a). Due to the variety of project forms and situations around the world, P3s have been defined in a number of ways (Hodge et al., 2010), including contracting out of public services to private firms, such as garbage collection (Sindane, 2000) and even full privatisation of formerly state-owned industries (Ng, 2000).

In addition to the definition used by the Canadian Council of Public Private Partnerships , as provided in Section 1.1, Tang et al. (2010) define them as "arrangements where the public and private-sectors both bring their complementary skills to a project, with varying levels of involvement and responsibility, for the purpose of providing public services or projects". They continue by separating P3s into the following categories:

1. *Cooperation*: using both the public and private-sectors to provide the skills and finance for infrastructure development and operations;
2. *Franchises*: the private-sector pays a fee during the concession period awarded by the government for the revenue (or a share of the revenue) that the service generates;
3. *Partnership investments*: ensuring public-sector sharing of the return generated by investments made by private-sector parties;
4. *Partnerships*: introduction of private-sector ownership into state-owned businesses through legislation, regulation, partnership agreements or retention of a special government share;
5. *Joint ventures*: the public- and private-sectors pool their assets, finance and expertise under joint management;
6. *Build–Operate–Transfer (BOT)*: the private-sector constructs the project, operates it for a concession period and then transfers to the public-sector client without consideration; and

7. *Private Finance Initiatives (PFI)*: the public-sector purchasing services from a private entity that finances, designs, builds and/or maintains the necessary infrastructure and covers the costs through charges, typically to the government or users of the asset.

Alternatively, the OECD defines P3s, more specifically, as a legal, public owner transferring economic ownership to another, private-sector party for the latter to accept the risks and rewards of using the asset (OECD, 2013). This arrangement is often through a BOT or a PFI, and even this most restrictive definition includes a breadth of different P3 models from which careful selection should be made based on the specifics of the situation. Despite the numerous definitions available, all P3s involve complex contractual arrangements and their success depends on well-developed political, legal, and economic environments (Kumaraswamy and Zhang, 2001).

Limited theoretical underpinning was identified specifically relating to the use of P3s in infrastructure development. A "Positive Theory" of P3s (Vining and Boardman, 2008) recognises them as a possible means of balancing the divergent objectives of the partners. These include private-sector goals of maximised risk-adjusted profit over the contract period and public-sector goals of minimised short-term and on-the-books expenditures and political costs for the current government. Normative theory suggests organisational partnerships with such conflicting goals results in high costs associated with contract negotiation, opportunistic behaviour, inability to achieve goals and partnership dissolution. P3s will only deliver projects at lower cost if the private-sector partner has appropriate incentives to align their profit maximisation with minimisation of project costs. Multiple factors associated with infrastructure projects risk this alignment including increased project size, complexity, uncertainty and asset specificity as well as low competitiveness. Transaction cost theory state that these factors raise contracting costs (Broadbent et al., 2003) particularly if the government initiating the P3 has poor contract development and management skills (Boardman and Hewitt, 2004). Still, Vining and Boardman note that if the factors above are well managed and potential gains are sufficiently large, due to factors such as higher private-sector efficiency and better ability to bear risks, the use of P3s can produce preferential outcomes.

Many P3s offer long-term, relational contracts that bundle multiple tasks within a single contract, proposing efficiency gains from the consolidation of contracts and risk transfer. Some research has occurred surrounding factors around the level of bundling, including the choice between integrating operational tasks alone, construction tasks alone or vertically integrating both operational and construction tasks. Findings show financial variables, market size and economic sector as being important drivers of contract choice and bundling decisions (Albalate et al., 2016). This concept of Vertical Integration, how much of an organisation's supply chain is owned by that organisation, is an interesting and relevant aspect of organisational theory that relates to P3s. Increased Vertical Integration is a management approach to avoid the "hold-up problem" (Williamson, 1979) but is also linked to decreased competition within the supply chain (Harrigan, 1986). Walston et al. (1996) examined the alleged benefits and actual outcomes of Vertical Integration in the health sector, comparing them to those observed in other sectors of the economy, but found difficulty transferring lessons learnt from business to health care at the time.

1.3.1.2 Health P3s in Ontario, Canada

With 209 projects reaching Financial Close from 2008 to 2018, including a transaction value of over $74 billion, Canada has one of the highest-volume P3 markets in the world; one dominated by social infrastructure (63%) and health (39%) deals. Dedicated P3 agencies exist within the federal and most provincial governments. Infrastructure Ontario (IO) is leading Ontario to be the country's most prolific province in developing P3s, contributing a total of 104 projects that closed over the same period. This is over double the number of transactions completed in British Columbia, the province with next most number of deals over the same period. Of these 73 were social infrastructure, well ahead of transport infrastructure, the next most popular sector at 26 deals. Fifty (50) health facilities were closed over the same period, the largest social infrastructure sub-sector, ahead of accommodations at 11 deals (Inframation Deals, 2019).

Historically, health care services and the facilities in which they are offered were provided both publicly and privately but since government-funded universal health insurance programs were established in Canada in 1957 public financing and provision became the norm (Canadian Museum of History, 2010). In Canada, about 11% of GDP is dedicated to health expenditure and much of this goes towards the construction and operation of health facilities (Canadian Institute for Health Information, 2016b). In Ontario, as with most provinces, the health sector is the largest expense item in the provincial budget. According to the Financial Accountability Office of Ontario (2019), $61.3 billion will be spent on the health sector in 2018-19, 41% of total provincial spending. Of this, the largest program area is hospital operations, accounting for $22.2 billion or 36%, and the smallest program is capital expenditures, accounting for $1.9 billion or 3% of total health expenditure.

1.3.2 Performance Evaluation

There are many ways to define and measure success with infrastructure development due to the number of stakeholders involved, often having potentially conflicting interests, and the variety of associated outcomes. This is particularly true with P3s (Hodge and Greve, 2018) however good research has been conducted to identify critical success factors with importance placed on private consortium strength, appropriateness of risk allocation and financial market availability (Li et al., 2005). Some studies have shown P3s to produce clearer and more transparent government policies and outcomes (Ball and Maginn, 2005, Li et al., 2005), through more sophisticated contracts (Ho, 2006, Tranfield et al., 2005), improved risk management (Grimsey and Lewis, 2002a) and better financial analysis (Akintoye et al., 2003). Additional studies have shown improved partnership between the public-sector and the private-sector as a result (Erridge and Greer, 2002, Ysa, 2007).

Critical evidence of the private-sector's role in infrastructure delivery often relates to profit seeking behaviours, impacts on socio-economic inequality and other concerns consistent with those of financialisation. The opportunistic nature of private-sector partners may be made worse by public-sector owners' aversion to shut down projects or impose penalties, often acting as lender and operator of last resort (Crozet, 2014). The increasingly high cost of public procurement processes (Akintoye et al., 2003) and scarce financing available to contractors in some developing countries (Norwood and Mansfield, 1999) favours larger players and has led to industry consolidation. This consolidation helps reduce interface risk between the delivery teams (Delmon, 2009) but also affects the balance of power between the public and private-sector actors (Schaufelberger and Wipadapisut, 2003). An example of this consolidation is reflected in the field of accounting. The Big Four accounting firms involvement in all phases of P3 development, from creating and reviewing policies and procedures and appraisal of projects, has been connected to the privatisation of the policies (Shaoul et al., 2010). Further conflicts of interest exist, particularly as the same parties often hold equity stakes with the private-sector proponents and/or key subcontractors (Shaoul et al., 2007b).

Stafford and Stapleton (2017) and Roehrich et al. (2014) concluded that insufficient evaluations existed of whether P3s achieve their objectives and that existing determinants of success are on the basis of technical achievement but that broader social and financial objectives have not been properly assessed. Comparison of operational efficiency between the models is a technical output metric which has minimal empirical analysis generally due to lack of available data. Data opacity is a particular problem throughout the infrastructure development industry, including P3s, and leads to the lack of empirical evidence (World Bank, 2013, Shaoul et al., 2010, Chen et al., 2015, Hodge et al., 2010). Due to the lack of empirical data, analyses are largely qualitative and based on individual accounts, with comparisons to counterfactual public provision scenarios being of questionable quality (Edwards et al., 2004).

This section continues by identifying research surrounding particular aspects of performance, generally framed from the perspective of good to the broader society as opposed to that of the private or public-sector partners in particular. An initial area of performance evaluation addressed by this study is financial, as supported by other researchers (Broadbent et al., 2004), including introductions to the concepts of Value for Money (VfM), Life Cycle Cost analyses and Risk Management. The following aspects are technical performance specific to the application. Specific focus is placed on aspects of operational performance evaluation and energy use as they are emphasised in the studies within the thesis. The concept of innovation is also introduced as it is often touted as a benefit of P3s and could impact either financial or technical aspects as well as community or environmental impacts. A balance of all these aspects can be used to measure success.

1.3.2.1 A Financial Lens

Researchers suggest that P3s have two main drivers, both of which are financial: firstly, a macroeconomic desire to control public debt (Quiggin, 2005), then by a belief that efficiency would be increased through greater competition introduced through private-sector bidding (Chung, 2009a) and bundling of contracts (Albalate et al., 2016). The macroeconomic agenda was a primary driver for some first generation P3s, and remains an important motivator for some public agencies, but P3 commitments typically only replace visible public debt with long-term contractual commitments to purchase services from private providers (Chung, 2009a). By pushing public debt off balance sheet, however, it can enable greater access to private financing and bypass public debt limits.

Government financing for infrastructure is a scarce resource. Though long-term bank debt is available in some markets, rating agencies require demonstrated track records from Project Company members and significant guarantees from state authorities (InfraDeals, 2016). Tightening banking regulation globally (Abadie and MacGray, 2013) has led to institutional investors, seeking stable returns from relatively low risk long term assets, being seen as necessary to fill the gap (Maguire, 2014). Canadian and Australian pension funds in particular have acted as pioneers in infrastructure investing since the early 1990s, with funds from other countries emerging since the 2008 global financial crisis (Inderst and Della Croce, 2013). Canadian pension funds have lead the way in making direct investments in infrastructure, as opposed to making commitments to infrastructure funds, and Canada's life insurance companies are joining them. Both pension plans and insurance companies often provide both debt and equity to match their liabilities (InfraDeals, 2016).

As a large number of P3s mature, the development of an active P3 Secondary Market attracts more investors due to the opportunity provided to sell their equity stakes once projects become operational thereby allowing developers to recycle their investments to finance a larger number of projects rather than tie them up for the full concession period (Rooseboom, 2013). Secondary sales are more common among institutional investors, developers and sponsors who often look to divest in a much shorter time frame (InfraDeals, 2016). Due to the dependency of P3 projects on cash flows to reimburse debt, private lenders may be incentivised to provide greater scrutiny of the financial practicality of specific proposed infrastructure investments, thereby reducing the probability of poor investment decisions by governments (Chan et al., 2009), though this claim has been challenged (Demirag et al., 2010).

Success of public-private cooperation on infrastructure development depends on strong rules, processes, institutions and practices by all parties involved and political support for often-required special legislation (Algarni et al., 2007). Jurisdictions may have these elements in place to create and oversee P3 actors but there remains intense competition for notoriously erratic private-sector capital. Both public- and private-sector actors target infrastructure fund managers to attract their investment. Important country factors driving investment decisions include market size, financial health, government stability and the business environment which results in many countries having difficulty accessing private financing. Therefore, although private investment has led to higher overall capitalisation to fund infrastructure development, the investment is often not drawn to those areas most in need (White, 2013). As such, private investment often flows to countries with greater available public wealth, where scarcity of government funds may be self-imposed and private infrastructure investment more a matter of choice than necessity. Although private investment in infrastructure may displace governmental expenditure the public does not typically get the service for free, with costs offset through user fees and other revenue tools directed to the public (Kumaraswamy and Zhang, 2001); costs may, in fact, increase due to higher private-sector borrowing fees and greater overhead.

Offering improved public services at lower cost is often the primary justification for delivering major infrastructure projects through P3s. Provided a proposed public infrastructure project has been justified economically, for example through cost-benefit analyses, a VfM analysis is a common method used by public procurement agencies to compare potential procurement approaches. Typically comparing a P3 model versus a hypothetical public-sector comparator, both scenarios represent total procurement costs, in Net Present Value, for the asset to provide an equivalent public service, accounting for adjustments such as risk transfers and tax. This is a highly subjective and therefore controversial *ex ante* process (Auditor General of Ontario, 2014) rife with difficulties establishing both indicators for financial performance and planning impacts. Yescombe (2011) found such financial performance indicators to include comparable cost figures, suitable discount rates, the project's financial structure and resultant tax adjustment of the private-sector entity, while Siemiatycki and Farooqi (2012) found such planning impacts to include community consultation, reduced future public flexibility and overstated transfer of planning-related risks from government to the private-sector partners. VfM models vary considerably by jurisdiction and their effectiveness is highly contentious due to evidence of prejudiced outcomes justifying political decisions (Shaoul et al., 2012) and limited analysis of empirical life cycle data upon project completion (Bidne et al., 2012). Based on these criticisms jurisdictions continue to review and update their VfM models (Infrastructure Ontario, 2015).

The majority of research on infrastructure delivery, including the performance of its associated structures, is restricted to examining the large initial development costs (Flyvbjerg et al., 2008, Flyvbjerg et al., 2003, Flyvbjerg et al., 2004). These have been a more attractive study option for early researchers as well as industry, the media and general public, which may be due to limited availability of empirical data from the operational phase (Chen et al., 2015) but also because upfront costs are higher per unit of time, making them appear more significant. Minimal *ex post* analysis has been conducted on the long term implications of ownership structures on the life cycle effectiveness and cost of the infrastructure (Stafford and Stapleton, 2017, Hodge and Greve, 2018, Roehrich et al., 2014).

Life cycle cost analyses encompass the initial development costs as well as those for operations, maintenance, upgrading and decommissioning (Rahman and Vanier, 2004). A life cycle approach is imperative when considering the overall sustainability of a project especially when initial capital costs of a hospital are equal to only two to three years of the facility's operational running costs (Rechel et al., 2009). As such, projects with an operation or maintenance aspect are worth significantly more on average (InfraDeals, 2016) with both aspects having a complex field of research in its own right. Some evidence has shown P3s to reduce life cycle costs (Li and Akintoye, 2008) but these findings are contentious due to the aforementioned lack of empirical P3 data for those projects in mature operations phases, let alone for those which have reached the end of contract terms or ultimately been decommissioned.

Risk management, particularly to the public finances, is a key motivator for private-sector involvement in infrastructure development and an important component of VfM analyses

(MMM Group Limited, 2015). Allocation of risk to the party most able to mitigate it is a goal of most P3 programmes in order to reduce the overall risk profile of the project (Ng and Loosemore, 2007, Bing et al., 2005). Risk evaluation is a complex and constantly evolving process requiring analyses from differing perspectives of public- and private-sector partners and successful contracts require risks to be identified, classified, allocated and presented with potential impacts and mitigation measures (Marques and Berg, 2010). Internal, external, project-specific and general risk factor groups (Yeo and Tiong, 2000) can be categorised in many ways including political, financial, promotional, procurement, development, construction completion, and operating (Grimsey and Lewis, 2002b). Specific risks include site acquisition; underground conditions; contamination; design and construction; changing policy, economic and market conditions; experience and stability of partners; industrial and legal action and force majeure (Shen et al., 2006). Risk perception and mitigation strategies depend on perspectives based on project phase (e.g. pre-procurement, construction, operations) and role (e.g. public client, contractor, financial institutions) (Li et al., 2005).

Successful public procurement requires robust institutions to pass necessary laws and regulations; ensure basic health and safety standards are met; provide specific expertise and oversight; and identify and manage risks (European Bank for Reconstruction and Development, 2013). Contract and relationship development are critical components of major infrastructure procurements and require well developed legal systems (Erridge and Greer, 2002, Sillars and Kangari, 2004). The level of governmental guarantee or support (Zhang, 2005) and concession period (Ng et al., 2007) are important factors in risk management for protecting the public interest while attracting private consortia to bid through potential profit generation. A consistent approach (Abdul-Aziz, 2001) and, due to an increasingly globalised market, culturally-sensitive and well defined contracts with effective management of political, exchange-rate and revenue risks is valued for maintenance of relations (Wang et al., 2000).

Capital cost escalation has high prevalence among infrastructure projects (Flyvbjerg et al., 2003). Though it has an inconclusive relationship compared to ownership or delivery structure (Flyvbjerg et al., 2004, Raisbeck et al., 2010), reforms related to increased competition have been found to reduce the magnitudes of cost overruns in road projects (Odeck, 2014). When problems such as cost overruns and legal disputes occur, even where the risk is assigned to the private-sector entity, such as with P3s, in many cases the public-sector covered the cost of failure (Kumaraswamy and Zhang, 2001) due to governments’ reluctance to cancel or delay, often high profile, projects (Flyvbjerg and Stewart, 2012).

1.3.2.2 A Technical Standpoint during Operations

Many technical metrics of performance exist, are often specific to the application and the user experience and discounted against the financial criteria in project evaluation (Shaoul et al., 2011b). This section focusses primarily on technical evaluations of the operational phase as it is the focus of the thesis. Morse (2011) found P3s including long-term contractual arrangements keep developers connected to the operations of the project. This can encourage private-sector parties to balance upfront capital and operational cost reductions via resource usage throughout the duration of the contract, which can lead to a variety of related technical outcomes. In practice, this mechanism is challenged by different companies within consortia providing design, construction and maintenance services and various parties selling their stake when complete.

Technical research applicable to many projects is generally that which is targeted to infrastructure engineers and maintenance managers, particularly that related to the field of life cycle costing and risk-based models to study the failure rate of construction alternatives (Salem et al., 2003), maintenance and management planning (Stenström et al., 2015) to balance structure performance and life cycle cost (Frangopol and Liu, 2007), a combination thereof (Daniels, 2008) and competitiveness (Adler and Liebert, 2014, Merkert and Mangia, 2014). Some research has shown P3 approaches to provide maintenance services and life cycling more effectively than more conventional term contracts (Ng and Wong, 2006, Devapriya, 2006). Maintenance covers the periodic servicing of fixed assets in order to be used over their expected service lives and is distinguished from major renovations, reconstructions or upgrades which substantially modify the form of the asset and/or its performance, capacity or expected service life (European Communities et al., 2009).

Working in the realm of health care in an era of evidence-based medicine (Sackett et al., 1996), means broaching a very highly researched field. Much of the research is clinically focussed with little consideration of the facility itself but this is beginning to change with increased attention in health care being placed on the design of facilities - including its architecture, technology and equipment - and the effects they have on outcomes such as patient safety (Reiling et al., 2008). There are researchers looking at these matters with respect to mental health facilities from their site planning (Dear, 1978) to furnishings and impacts on patient factors such as anxiety (Nanda et al., 2011) and use of medication (Hughes et al., 2000) to levels of staff job satisfaction (Mrayyan, 2005).

There is some dedicated research to the use of P3s in health care, particularly in the UK's National Health Service where the use of P3s is well established, having been in existence since

1992, with largely accounting-based findings (Broadbent et al., 2004). This includes attention to the associated initial capital investment, finding increased cost as well as bureaucracy associated with private involvement (Shaoul et al., 2011a), as well as their operations, finding concerns around transparency and accountability (Edwards et al., 2004). Alonso et al. (2016) found evidence of a relationship between the use of P3s and reduced clinical staffing levels in Spanish hospitals. Within the Canadian health sector, the Canadian Institute for Health Information collects and analyses a variety of performance-based data to inform policy and strengthen the management and performance of health systems across the country (Canadian Institute for Health Information, 2016a). Generally, research is showing that evidence-based health care design has increased knowledge around the field substantially in recent years and improved the hospitals' performance by making them safer, with better patient healing and serving as more attractive workplaces for staff (Ulrich et al., 2008).

In addition, infrastructure development is increasingly seen in a values framework with respect to how it contributes to society throughout its full life cycle and, as such, it can serve as a unique model for public-private capital and skills collaboration, thereby providing the potential to spur sustainable development across infrastructure, industry and society in general (Colverson and Perera, 2012). Public agencies can promote such innovations by defining social and environmental outputs within Project Agreements or Community Benefit Agreements (Musil, 2014).

1.3.2.3 Operational Energy Use and Environmental Performance

Much of the focus on sustainability is economic but some research exists on the social and environmental aspects as well (Hansmann et al., 2012). In particular, buildings globally account for around one third of the world's final energy use, with substantial economic and environmental implications. Specifically, this energy use corresponds to 18% of global direct and indirect greenhouse gas emissions globally. This surpasses emissions of the whole transport sector (14%) while being under that of industry (29%) and agriculture, forestry and other land use (25%) (Lucon et al., 2014). Assessing and improving the operational performance of existing buildings has hence become increasingly important and governments worldwide have responded with policy measures to improve buildings' energy efficiency (Bordass et al., 2001).

A growing body of evidence, however, identifies a discrepancy between expectations around the performance of buildings and their actual operational energy use, as well as the associated environmental performance (CIBSE, 2013). This "performance gap" (de Wilde, 2014) is particularly striking due to the dramatic rise in popularity of design-based rating systems for building efficiency, such as Leadership in Energy and Environmental Design (LEED), yet there is little correlation between this performance and certification level of the building or the number of energy credits achieved at design (Newsham et al., 2009). In the Canadian health sector over the past four decades newer hospitals have consistently used more energy than their predecessors (Natural Resources Canada, 2018) despite many public procurements including increasingly stringent LEED requirements in their contractual output specifications (CaGBC, 2019, Infrastructure Ontario, 2019b). Barriers to energy performance are often found to be neither technical nor economic, rather due to institutional regimes such as life cycle implementation (Fedoruk et al., 2015).

P3s with long-term contracts keep Project Companies connected to the operations of the projects. For many such projects life cycle (Ng and Loosemore, 2007) and energy (Himmel and Siemiatycki, 2017) performance risks are transferred to private-sector consortia. When this occurs, the requirement for private-sector partners to share responsibility for long term energy costs and consumption encourages energy efficient decision making throughout the project life cycle – throughout the design and construction phases as well as the operational term. In turn, these decisions drive innovation and contribute to minimise overall project costs(Altus Group, 2015). Minimal empirical research has taken place with respect to the contractual link between P3s and the operational performance of facilities, particularly with respect to energy use and associated environmental indicators. Addressing this gap is a focus of the research included in this thesis.

1.3.3 Summary

The review of literature within this study shows a diversity of infrastructure delivery structures being used globally to support infrastructure development in response to a reported deficit. This support is increasingly in the form of private-sector provision of financing, expertise and risk allocation – including the use of long term contracts bundling multiple services across the assets' life cycle – in return for potential revenues through various forms of P3s, and especially in the health field. Minimal *ex post* analysis has been conducted on the long term implications of these delivery structures on the life cycle effectiveness and cost of the infrastructure.

Studies of upfront capital costs have been more attractive to early researchers as well as industry, the media and general public; this is somewhat due to limited availability of empirical data from the operational phase but also upfront costs being higher per unit of time, making them appear more significant. Attention is increasingly encompassing the operations phase of infrastructure due to the importance it has on its long term sustainability and operational efficiency has been recently identified by researchers as an important question that has rarely been analysed empirically due to data availability. Operational energy use is a particular area of importance due to the significance it has on facilities' budgets (Adams et al., 2010) and the environment. Opportunities to analyse P3s including an operational phase are becoming available as governments become more transparent and more P3s become operational, particularly in mature infrastructure markets such as Europe and North America. As part-time academic researchers embedded in industry, DBA candidates are ideal conduits to relay this data as it becomes available.

1.4 Research Design

While extensive research exists in the health sector, questions concerning the delivery of health care facilities require additional attention. Identifying the gaps in knowledge and formulating a research response requires flexibility in developing compatible methods that reveal new knowledge and theory, and pragmatism provides a philosophical basis for examining the results of empirical research to answer the ensuing research questions. The following section elaborates on the research design and the rationale used for collecting and analysing data to draw coherent conclusions.

As described in Section 1.4.1, pragmatism emphasises empiricism and usefulness. Firstly, this drove the selection of an Alternative Format thesis that allows the incorporation of three articles suitable to submit for publication in a peer-reviewed journal. This drives the synthetisation of my research into discrete studies presented in a format that is digestible to academics and practitioners, thereby greatly increasing its potential impact. The inclusion of multiple studies within an Alternative Format thesis opens the door further for this pragmatist researcher to choose from a variety of methods, worldviews, assumptions, forms of data collection and analysis so to best meet the needs and purposes of the research for each article.

The extensive literature review of global infrastructure delivery approaches outlined in Section 1.3 preceded the identification of research topics and approaches for the three articles. This is a multidisciplinary topic with literature covered including a broad selection of industry reports and academic articles selected through extensive review using a variety of methods from keyword searches to broad-based searches of highly ranked journals in the field (Association of Business Schools, 2009, 2010). Emphasis was placed on identifying formative articles on the topic as well as recent work from academia and industry; contributing fields include accounting, economics, finance, engineering, management, public policy, environmental science and urban and regional planning. Literature from most fields touch on themes such as risk management and financial performance while some fields emphasise specific themes, such as engineering articles' focus on technical performance of specific maintenance cycles and accounting articles evaluation of Value for Money models. The exercise demonstrated a diversity of infrastructure delivery structures being used globally, increasingly with private-sector participation through various forms of P3s, and especially in the health field. Dedicated literature searches and inquiry results from each article provided clarity for the next stage of questions and research goals. As such, the research process for each article produced a flow of knowledge, experience and a platform to focus and draw conclusions that address the overarching research question of the thesis.

Researchers in the field use a variety of methodologies to study infrastructure delivery. The Case Study is a commonly used method (Shang and Zhang, 2013, Olesen, 2014) that enables researchers to focus on details of specific systems and associated decision-making processes in order to develop a concrete study of a discrete piece of infrastructure (Yin, 2009). These Case Studies can provide policy-makers with practical, context dependent examples of great value (Flyvbjerg, 2012). Some researchers apply a Mixed Methods approach (Creswell, 2014) in order to gain a more complete picture through the study of both quantitative analysis of financial, physical and temporal data as well as qualitative analysis of the state of infrastructure and contributing factors to the effectiveness of the infrastructure (e.g. operational conditions, technological advancements). The fusion of the Mixed Method and Case Study approaches has been used effectively (Dunning et al., 2008, Greenhalgh et al., 2010) including to study P3s bridges (Shaoul et al., 2011b) and hospitals throughout their life cycle (Rechel et al., 2009) from planning phase (Pollock et al., 1997) through to contract termination (Chung, 2009a, Chung, 2016).

A variety of tools are available to aid the collection and analysis of data. Many researchers use formalised survey models to collect and organise primary data to provide broader retrospective, cross-sectional and predominantly quantitative analyses on larger samples of data, though in prior research these generally focus on upfront capital costs rather than the operational phase or full life cycle (Flyvbjerg, 2007, Flyvbjerg et al., 2008, Flyvbjerg et al., 2003) as access to sufficient quantities of complete, reliable operations data is an issue (World Bank, 2013). Semi-structured interviews are a common approach to data collection for case studies due to their flexible nature allowing the interviewer to focus on areas of interest based on the research subjects' accounts (Edwards et al., 2004). This qualitative research uses semi-structured and open-ended questions for participants to share their views and seeks to understand the context or setting of the participants, shaped by their own experiences and background. The basic generation of meaning is always social, arising in and out of interaction with a human community, and an inquirer generates meaning from the data collected in the field (Crotty, 1998). The application of Mixed Methods research allows a pragmatist researcher to draw liberally from both quantitative and qualitative assumptions when they engage in their research in order to focus attention on the research problem and use diverse approaches to collect and analyse data to derive knowledge (Creswell, 2014).

This Research Design section continues with Section 1.4.1 introducing the author's epistemological influences, Section 1.4.2 providing an overview of the research phenomenon and the author's development of the his thesis and Section 1.4.3 summarises the methodologies incorporated in the work including each of the component studies.

1.4.1 Epistemological Influence

I struggled to identify a single epistemological worldview that reflects my personal and research style as the strengths and weaknesses of the unique approaches lend themselves to different problems. As learnt through my DBA coursework, this perspective (i.e. viewing epistemological approaches as problem-solving tools) is actually reflective of my pragmatic worldview. Pragmatism is not committed to any one philosophical system but approaches problems based on situations and consequences, rather than strict conditions, based on what works for the application and the variety of methods available (Rossman and Wilson, 1985). The remainder of this section outlines why aspects of various common epistemological worldviews - specifically postpositivism, constructivism and transformativism - appeal to me through my experiences and how the flexible, empirically-driven nature of pragmatism suits my research style and approach to this thesis.

The diversity in my professional and academic training has exposed me to a variety of perspectives and approaches to addressing various types of problems. My traditional engineering training addressed largely technical problems within the built world, applying the physical sciences and quantitative data-driven empirical analysis to test hypotheses and reach conclusions using the *scientific method*. This provides a strong postpositivist foundation to my research perspective. From this I hold a deterministic philosophy in which causes generally determine outcomes and so my research often aims to identify and assess this dynamic using a reductionist approach to break complex problems into discrete sets to test using data based on careful observation and measurement. I aspire to ontological realism and objectivity as a goal for competent inquiry to reflect a truth. As such, researchers must examine methods and conclusions for bias and maintain standards of validity, reliability and repeatability in their work.

I appreciate the structure inherent to the scientific method and postpositivist approach whereby researchers test hypotheses and research questions with evidence and rational considerations in order to develop relevant, true statements that describe causal relationships and shape knowledge of phenomena and verify/ refine theories and laws that govern the world. This is an ideal worth aspiring to, however, my extensive work with infinitely complex systems associated with environmental and social science highlights the associated limitations, as described by authors such as Phillips and Burbules (2000) who challenge the notion of the absolute truth of knowledge and challenge such claims when studying such complex systems. Evidence established in research is always fallible as researchers collect information on instruments, from participants and/or by observations recorded and interpreted by the researcher. Researchers must recognise that their own backgrounds shape their interpretation and often make sense of the meanings others have about the world. Individuals develop subjective meanings of their experiences that are varied and so researchers working with strong social influences should understand the importance of these as participants construct the meaning of a situation, typically developed through discussions or interactions with other people and through historical and cultural norms that operate in individuals' lives. This constructivist approach is often appropriate for qualitative and inductive research as it involves listening carefully to what other people say or do as they engage with their world and make sense of it based on their historical and social perspectives and aids identifying patterns of meaning (Creswell, 2014).

The work of scientific philosophers such as Max Weber (1947) and Isaac Levi (1960) supports a value-free ideal for the sciences and determines that the 'social sciences' should aim for the value-free impartiality and neutrality of the 'natural sciences'. Ernest Nagel (2011) refutes this view in *The Value-Oriented Bias of Social Inquiry* arguing that the social and natural sciences face similar issues and that values are applied in all sciences. I wish to extend Nagel's argument further by pointing out that the reason social and natural sciences face the same issues is that social sciences are natural sciences. This false distinction is based on an outdated concept of human exceptionalism from nature. The conventional, and still commonly held, concept that social sciences study only how 'human societies' (Oxford Dictionaries, 2014) "behave and influence the world around us" (Economic and Social Research Council, 2014) and are separate from natural sciences, which study the "physical world, e.g., physics, chemistry, geology, and biology" (Oxford Dictionaries, 2014) is flawed. As described by Robert Redfield in *Anthropology, A Natural Science?* (Redfield, 1926), all sciences conduct "systematic investigation of observed phenomena" whether social, physical or otherwise. A multidisciplinary approach to scientific research is increasingly common and has resulted in a collective realisation that the biology and behaviour of humans are not as exceptional in nature as once thought and that humans play an integral role in it.

All sciences must address bias, with "values" being one contributor that is inextricable from scientific research. They exist in the collective form as societal ethics, which guide individuals' behaviour, or those of the scientific community, to avoid negative impacts to research subjects or interviewees. The value-free ideal is false because scientists are depended upon to apply their expertise, a form of values gained through education and experience, in order to conduct research. Scientists should not apply values in a way that ensures a predetermined outcome but should use their expertise to identify bias and mitigate its effect on research findings. In order to address issues of bias, researchers must take a highly contextualised approach to values in research dependent on the field, the research subjects and the phase of research. Scientists should identify their values and other forms of bias introduced throughout their research, from topic selection to publication, and take a pragmatic and transparent approach to identify them and address any concerns. Scientific research is its own economy where research hours, facilities, funding and publication space are scarce resources that are assigned to studies deemed most worthy by individual researchers and the broader scientific community. The impact of values biases research output strongly to commercially promising research which is seen as a good investment due to potential positive impacts to a large portion of the population, or a powerful interest group, and so generates sufficient financial support from private and public sources. The scientific community, in general, believes that this application of values, and the resultant bias, is reasonably acceptable and does not hinder "the successful pursuit of objectively controlled inquiry" (Nagel, 2011). This application of values in research, particularly to topic selection, informs a Transformative Worldview that underscores the limitation of blind research and includes an action agenda. Pragmatists understand that research always occurs in social, historical, political and other contexts and allow a postmodern lens that is reflective of social justice and political aims.

Pragmatists challenge the traditional belief that inquiry should begin with a clean slate and a neutral starting point for it is based on evidence gained through prior inquiry (McDermid, 2018). It is difficult to generalise pragmatism as many, including its founding members - most prominent of which are Charles Sanders Peirce, William James, Chauncey Wright and Oliver Holmes, Jr. - were often in disagreement (Burke, 2007). Key common principles include: individuals should prioritise practical results over tradition and customs; philosophy should help solve human problems; an idea is best measured by its usefulness; experimentation enables positions to be tested; empiricism is essential in education and the formulation of ideas; truth and values are not fixed or absolute; human growth occurs from moulding and adjusting with their environment; change can be managed to satisfy human need; and democracy allows for individual and societal development (Hammond, 2018). A century later, after pragmatism lay dormant for decades, interest was rekindled in pragmatism's ideas and contributions. Contemporary American thinkers, led by Hilary Whitehall Putnam and Richard Rorty, launched their own version of the epistemology called Neopragmatism (Whitehead, 2016), while French economists incorporated pragmatism into their research perspectives of socio-cognitive resources used to advance society. These included environmental and health related applications (Diaz-Bone, 2016).

Through its 150-year history, critics have argued that pragmatism is a poor copy of British empiricism that defines truth by utility, changes with time and context and that people's perceptions of useful are not uniform, while others reject the concept of truth altogether (Riley, 1911). Despite its critics, pragmatism aims to apply scientific method to theoretical thought thereby providing a helpful framework for solving social problems and offers an accommodating map for individuals' reasoning of their experience. It emphasises matters of human existence and allows us to rely on the results that we find in experience and to break out of the paralysing intellectual traps of scepticism and epistemologies not grounded in reality. Pragmatism is not a single philosophy but a flexible method for approaching philosophy, providing individual researchers a freedom of choice to choose the useful constituents of all worldviews outlined above – the structure of postpostitivism, the sensitivity of constructivism and the motivation of transformativism. In this way, researchers are free to choose the methods, techniques, and procedures of research that best meet their needs and purposes.

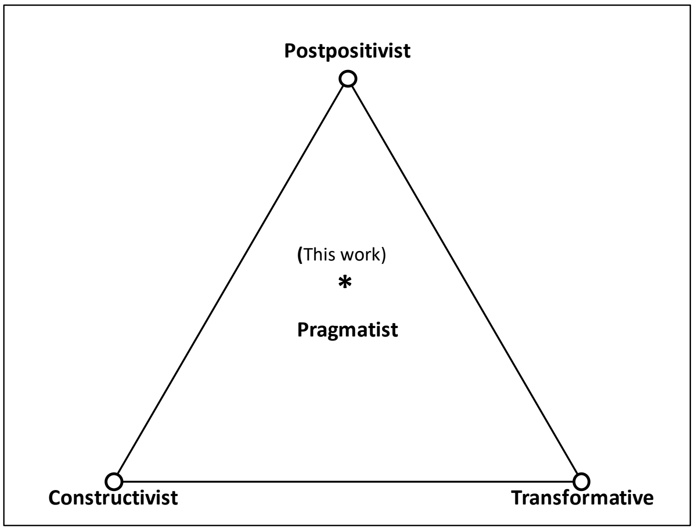

Figure 1: Planar model of pragmatist 'worldview' approach to this research

Pragmatism provides an appropriate epistemological approach to pursue the research questions and inquiry necessitated by this thesis. A strong use of quantitative data analysis and hypothesis testing is established through a postpositivist lens, however a constructivist understanding of the limitations of this approach to explain complex social institutions, relationships and experiences motivates the immersive Case Study approach, including the use of interviews, to gain greater insights into stakeholder perspectives. A transformative foundation motivated the initiation and continuation of the research. An affinity for Earth and its inhabitants and concern over the damage humans inflict on it motivated my study of Biological and Environmental Engineering. Personal and professional experience caused a realisation that environmental destruction is a social construction disproportionately affecting the most vulnerable that necessary technologies exist to resolve and that most underlying causes (e.g. unfettered growth, rampant consumerism, financialisation, excessive inequality, sprawl, lack of connection to place and community, violent conflict) are detractors rather than contributors to personal and societal wellbeing and utility. This led to graduate study of social sciences via urban development, economics and business - including this doctoral research - to better understand how to influence positive societal behaviour through public policy, specifically related to more sustainable infrastructure delivery. The topic has a strong social component as many marginalised populations are impacted more greatly by a public infrastructure deficit and environmental destruction, including associated displacement. As demonstrated in Figure 1, this pragmatic work is quite moderate between the various worldviews though somewhat emphasising the postpositivist approach. Fundamentally, pragmatism supported my selection of the Alternative Format for this thesis and the development of the three research articles contained within, through its reliance on utility and practical consequences. Extensive literature searches and a variety of research methods enabled each phase of research to build upon the findings of the former, producing new information, new questions and incremental resolution of the full picture.

1.4.2 Research Phenomenon and Thesis Development

Evidence identified through the extensive literature review process for this work isolated the following research phenomenon: *an increasingly diverse range of hospital facility infrastructure delivery structures are being used globally, and particularly in the Canadian province of Ontario, with little empirical understanding of their long-term relationship with operational performance*. This addresses specific gaps noted in the literature with respect to empirical studies of infrastructure delivery, particularly of P3 facilities in the operational phase, and opportunities identified to study mature P3 hospital facilities in Ontario, Canada. The term *'infrastructure delivery'* encompasses phases throughout the life cycle of the asset, from planning and design through construction and operations, including upgrading, to decommissioning. The term '*delivery'* is commonly used in the field and avoids matters of ownership that can come up in the study of P3s but is not central to this research. Facilities studied include a variety of conventionally-procured and P3 assets for which, in Ontario, it is regularly reinforced that the ownership is maintained by the public-sector (Infrastructure Ontario, 2018). The term *'operational performance'* encompasses a variety of empirical metrics including resource use (i.e. energy and labour), facility user satisfaction and Greenhouse Gas emissions, all themes in the articles included.

The resultant research objective is to conduct novel empirical analysis of operational performance among a set of mature hospital facilities in Ontario, which are delivered under a diversity of models including conventional and a variety of P3 structures. This empirical approach, using data collected in the field to conduct the research, is unique among the academic and industrial literature currently available and is intended to generate findings useful to aid relevant policy-makers to maximise the effectiveness of future public infrastructure investments. The following primary research question derives from this objective: *Is there a relationship between variations in delivery structure of hospital facilities in Ontario, Canada and the associated operational performance of the infrastructure, as measured by multiple specific facility resource use metrics relating to energy and labour?* Operational performance is measured in multiple ways among the articles including resource use (i.e. energy and labour), Greenhouse Gas emissions associated with energy use and facility user satisfaction. Each component article addresses aspects of the broader research question with one of its own, as follows:

- Article 1: *Is there a relationship between variations in delivery structure and 2016 energy intensity among operational hospitals in Ontario, Canada?*
- Article 2: *For the facilities included in this study, considering the context of their P3 contract, how do the facilities' operational energy use and associated environmental performance compare to one another and similar facilities?*
- Article 3: *Is there a relationship between variations in hospital delivery structure and effective resource use during operations, within a specific health care corporation in Ontario, Canada?*

These questions are carefully worded to build upon one another, thereby providing a more thorough answer to the primary research question though the complete multiphase study.

Article 1 analyses operational energy use at all hospitals in Ontario with the objective of generating quantitative comparative data for a one year period and comparing performance across various conventional and P3 delivery structures. Article 2 builds on the results of Article 1 by examining the phenomenon of energy use, and associated environmental performance, over the available operating term at two P3 hospitals with operating phases included in Article 1 and identified as notably high and low performing cases in the prior study. Article 3 builds on the prior two studies through examination of operational performance metrics beyond energy use at the high performing P3 hospital included in Articles 1 and 2 and a conventionally delivered hospital within the same health care corporation.

Based on the literature review and aforementioned professional experience of the author, the initial hypothesis related to the primary research question is that: *Ontario hospital facilities delivered as P3s with an operating phase have better operational performance over the period of study than other delivery structures*. An application of Vining and Boardman's (2008) "Positive Theory" of P3s, the hypothesis is that P3 structures that bundle the design, construction and operating phases provide the opportunity to transfer operational risks associated with all phases to the private-sector consortia, thereby incentivising associated risk-mitigating decision-making through the various phases of the contract through profit-maximising mechanisms. Each component article applies various methods outlined in Section 1.4.3 and contributes to evaluating this hypothesis through the analysis of a variety of specific operational performance metrics among the articles, namely: resource use (i.e. energy and labour), Greenhouse Gas emissions associated with energy use and facility user satisfaction. The articles also advance the process of inquiry having revealed surprises that yielded adjustments in data collection and research approach. Unique conceptual frameworks, objectives and research approaches directed each of the three articles but all were logically related with the second and third studies building on the findings and foundation of the first and second studies respectively and on the broader thesis objective.

1.4.3 Methodology

Study methods stem from the questions and objectives of the research project and the multiple research questions in this study promotes a Mixed Methods approach to develop a more complete understanding of the associated complex phenomenon. Various agents are involved in the delivery of public infrastructure, including hospital facilities, and studying their relationship with operational performance requires various types of data from these stakeholders. As discussed in Section 1.4, pragmatism allows an individual researcher the flexibility to use of a combination of quantitative and qualitative research methods as appropriate for the given research questions.

In order to addresses the primary research question, a Mixed Methods approach allows this researcher to draw from both quantitative analyses of physical and temporal data as well as qualitative analyses of the state of infrastructure and experiences with various processes throughout the life cycles of the facilities studied. As demonstrated in Figure 2, this Mixed Methods work emphasises more strongly the quantitative data inputs. Using a structure based on Creswell's (2014) Multiphase Mixed Methods Model, the procedure used in this study consists of the three sequential articles, as shown in Figure 3. The first two articles are quantitatively driven while Article 3 applies a Mixed Methods approach based on Davis et al.'s Interpretation Model (2011), notably supplementing analyses of quantitative data with qualitative interviews to help interpret and enhance the findings. This Mixed Methods approach is particularly important considering the relatively small sample sizes available.

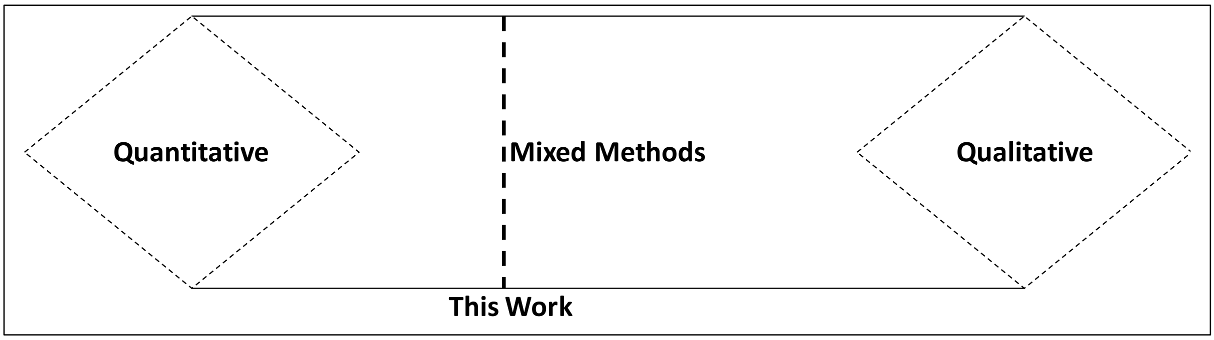

Figure 2: Thesis research methodology is toward the quantitative end of a Mixed Methods continuum

This Mixed Methods approach was selected to explore the social phenomenon described in this thesis with the goal of explaining how and why the methods are developed, as well as how to replicate the methods now or in the future. The combination of methods from the three articles include the quantitative components of Article 1's broad retrospective cross-sectional analysis of 2016 operational energy use across all hospitals in Ontario and Article 2 and 3's longitudinal explanatory analyses of a variety of operational performance metrics comparing high and low performing hospitals identified in the initial study. This quantitative analysis is complemented by qualitative components of semi-structured interviews of key public and private-sector stakeholders at the facilities studied in Article 3.

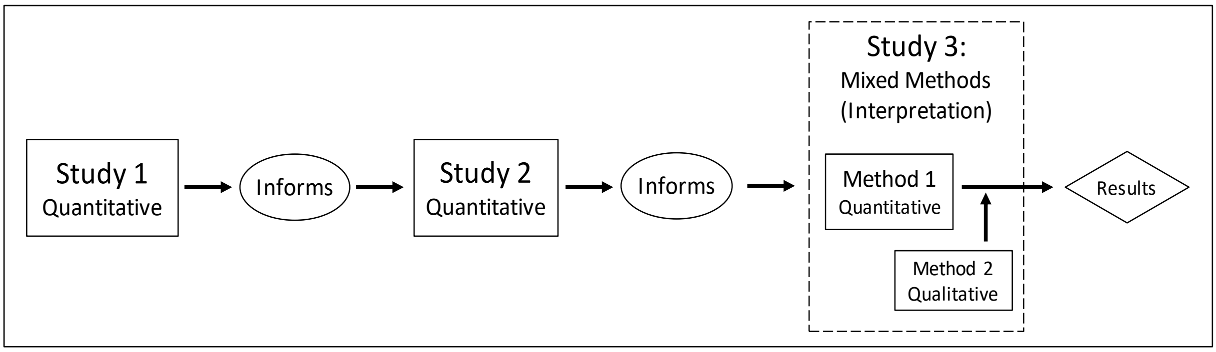

Figure 3: Thesis research methodology is based on a variation of Creswell's *Multiphase Mixed Methods Model* and Davis et al's *Interpretation Model for Mixed Methods*

Article 1's broad retrospective cross-sectional comparison of Broader Public-sector 2016 energy use data provided by the Ontario Ministry of Energy, Northern Development and Mines (2018a) permitted study of all hospitals in the province, including numerous P3 facilities entering operations in recent years. After extensive review and cleaning of the raw data, in order to test the article's research question, Infrastructure Ontario (2019b) project data was used to code the remaining dataset to identify the hospitals under four classifications of delivery structure. Through review of the Project Agreements of P3 facilities having an operational phase, found in the same Infrastructure Ontario (2019b) database used above, the facilities were also coded for three categories of their contractual approach to managing energy performance. In order to effectively determine if a relationship exists between delivery category and energy performance, Article 1 applies an established process (Natural Resources Canada, 2012) to compare energy intensity, indexing Total Energy Use of each delivery category by the sum of the total indoor space of all buildings in the same category, along with tabular and graphical methods. Working with population rather than sample data, and due to the relatively small numbers of facilities in some categories, other statistical tools were inappropriate for the study.

Articles 2 and 3 both use retrospective, comparative and longitudinal *case studies* (Creswell, 2014, Hammersley, 2004) to examine more deeply the relationship between variations in delivery structure and operational performance at specific high and low performing facilities studied in Article 1. In order to provide consistent ties throughout the broader study, one DBFM P3 facility and the energy use subset of operational performance are included in all three component studies. These, therefore, act as sorts of controls while other variables between the studies change. The Case Study is a commonly used method (Shang and Zhang, 2013, Olesen, 2014) that enables researchers to focus on details of specific systems and the decision-making processes associated with them in order to develop a concrete study of discrete facilities (Yin, 2009). This approach can provide a practical, context dependent example with great value for policy-makers (Flyvbjerg, 2012). Using wide-ranging professional contacts, access to operational data collected from electronic and paper archives and experience with the applicable contracts enabled reasonably complete and highly novel case studies to emerge. Access to data sources not in the public domain, due to the author's management role on associate projects, helps to address the aforementioned critique of a lack of transparency in the field. To satisfy stakeholder requests for anonymity of projects, all identifying information has been removed within the thesis. This includes associated reference documents marked as "Withheld".

Article 2 investigated energy use at two P3 hospitals that reached Substantial Completion in 2013 under similar contracts, though with subtle, yet important, differences in the management of energy performance. Using annual data for the four available Energy Years in their operational term and the author's in-depth knowledge of the facilities, a longitudinal analysis was conducted to identify any apparent trends between energy use and the facilities' delivery structures, including their specific contractual approach to energy management. The study analysed the multiple sources of energy used on site through an Energy Use Index (EUI) based on Source Energy, which provides the most equitable way to combine primary and secondary energy types into a common unit by ensuring that no building receives either a credit or a penalty based on its energy source or utility. In order to track the environmental performance of the facilities associated with their energy usage, another metric studied was greenhouse gas (GHG) emissions. The energy use of the sites, and the associated GHG emissions, were then compared using multiple independent nationally recognised measures and procedures.

Using a similar retrospective, comparative and longitudinal Case Study method to the prior article, Article 3 broadens its empirical analysis of relationships between variations in facility delivery structure and operational outcomes beyond that of energy use and its associated environmental performance to include data regarding facility maintenance staffing levels supported by facility user surveys and Elite Interviews (SAGE, 2006) with key stakeholders. Labour and energy use are two of the major components of hospital FM budgets (Adams et al., 2010). This more extensive examination compares the two major hospital facilities within a single health care corporation in a major municipality in Ontario, one conventionally procured and maintained by hospital staff and one facility delivered as a P3 with an operating phase (DBFM) and includes description of the facilities' backgrounds, contractual study and the author's in-depth knowledge of the facilities and their management structures. The P3 facility (Facility B) is included in the studies of Article 1 and Article 2 (Facility 2), which provides continuity throughout the thesis.

The explanatory semi-structured interviews (Mason, 2004) included in Article 3 serve to add a diversity of insights and support the heavily quantitative analyses conducted as part of the study and for the previous articles within the thesis. Interviewees participating in the research were selected through 'Purposive Sampling' (Creswell, 2014) as the subject group most appropriate for answering the research questions under investigation. Semi-structured interview questions included in Appendix I served as a guide during the interviews. Being exploratory interviews conducted before of the scope of the study was finalised, the prepared questions were very broad covering procurement, design, construction and operations phases, contract management, accounting and performance issues. There were too many questions to pursue in any depth within the time available with the interviewees. Additionally, not all questions were appropriate for, or answered by, each interviewee due to their specific experiences or involvement at the facilities. As such, throughout the interviews the author used interviewees' responses to signal areas requiring further questioning. The process was invaluable for identifying interesting areas and those with data availability in order to pursue further investigation. While Appendix J provides a breadth of highlighted responses from the interviewees yet, while all helped in the development of the study, only a selection were deemed valuable contributions to the final article text.

The formal interviews are supplemented by many informal interactions with other key stakeholders at the multiple operational sites and within the organisations with which the author has worked over the five year duration of the DBA. These interviews and other interactions generated empirical qualitative data on the quality and upgrading of the infrastructure, challenges faced and important procedural, technological or policy changes over time. Conducting this research in a hospital environment necessitated a more extensive ethics review process to ensure proper treatment of interviewees, protection of patients and management of data. Both the University of Manchester as well as the local municipal integrated research ethics board conducted this ethics review. The latter required over half a year to authorise the work, which severely impacted the planned scope of the formal interviews to a total of two individuals. Those included, however, were the key stakeholders selected through purposive sampling and were complemented by extensive professional involvement with all stakeholders, attendance at all key meetings and preparation or review of all key reporting over multiple years. The associated Research Protocol, Participant Information Sheet and Consent Form, Interview Questions, Interview Summary and Study Completion Form are included in

Appendix G, H, I, J and K, respectively. Further details of the research methods used for each of the three articles are included within each article and a summary of the contributions of the articles is located in Section 5 (Thesis discussion).

1.5 Summary and Thesis Roadmap

This Alternative Format thesis employs a multiphase Mixed Methods in addressing its overarching question about the operational performance of hospital facilities under various delivery structures. Its methods include a quantitative analysis of various operational performance metrics at hospitals across the provinces of Ontario plus qualitative interviews of key stakeholders. Principles of pragmatism drove the three paper format and methodological choices in order to encourage a diversity of scientific and experiential methods to address issues of human interest and their practical consequences. It is through exploration of different aspects of the research question that this collection of studies contributes new knowledge and theory.

The following is a summary of the articles included within this thesis:

Article 1 is guided by the research question, *Is there a relationship between variations in delivery structure and 2016 energy intensity among operational hospitals in Ontario, Canada?* This article applies a cross sectional analysis of 2016 energy use data across the full population of operational hospitals in Ontario, Canada. These facilities use a variety of delivery structures including those conventionally procured and maintained by hospital staff or FM contractors and multiple P3 forms, with and without operating terms. Through its inclusion of all hospitals in the province this study provides a valuable introduction to delivery of hospital facilities in the region and associated trends.

Article 2 pursues the research question, *For the facilities included in this study, considering the context of their P3 contract, how do the facilities' operational energy use and associated environmental performance compare to one another and similar facilities?* Using a comparative, longitudinal Case Study over four operational years, the article studies two chronic care hospitals in Ontario and therefore included in Article 1. Both facilities are early P3 hospitals delivered under the Design-Build-Finance-Maintain (DBFM) structure but with different contractual language to manage operational energy use. One facility applies a Regression Analysis model based on operational energy use to set annual energy targets, and payments, while the other sets energy targets using a bid Energy Model. This second article builds on the findings of the previous article as these approaches were identified in Article 1 as being low and high performing models. The Case Study within Article 2 investigates the mechanisms further through comparison of the facilities' operational energy use intensity, and associated environmental performance, using empirical data supplemented by contractual study and analysis.

Article 3 addresses the research question, *Is there a relationship between variations in hospital delivery structure and effective resource use during operations, within a specific health care corporation in Ontario, Canada?* This is accomplished through a four-year cross-sectional Case Study investigating operations of two hospital facilities within the same health care corporation including a conventionally-procured, publically owned and maintained facility and a P3 facility (DBFM). With both facilities located in Ontario, they were included in the analysis for Article 1 while the P3 facility was also one of those studied in Article 2. The study builds on Article 2's emphasis of energy metrics to include labour in order to conduct a more fulsome quantitative comparison of the facilities, supported by interviews of key stakeholders and facility user surveys.

The three articles combine into the broader thesis study as part of a Multiphase Mixed Methods Model (Creswell, 2014), with the first two articles being quantitatively driven while Article 3 applies a Mixed Methods approach based on Davis et al's Interpretation Model (2011), notably supplementing quantitative analyses with qualitative interviews to help interpret and enhance the statistical findings. This analysis of quantitative and qualitative data gathered through the various phases of this research contributes to the field through the identification of trends that exist in the data while soliciting data from a variety of sources to consider unanticipated sources of bias.

Recognising the limitations of studying one regional context, the analysis considers broader implications for future research. With P3 hospitals that reached Substantial Completion as early as 2006, the study includes many of the most mature P3 hospitals in Canada, an established P3 market globally (Siemiatycki, 2015). It is therefore well-positioned to identify practical influences, successes and challenges associated with infrastructure operations under different delivery models making the study particularly important for policy makers in the field. Following this introductory section the Articles 1, 2 and 3 can be found, respectively, in Sections 2, 3 and 4 and this is followed by the Thesis Discussion in Section 5.

A note to readers of the full thesis: The Alternative Format thesis's inclusion of three standalone articles requires the repetition of fundamental literature and other background information provided in this introductory section into each article. An unfortunate trade-off is that this leads to significant redundancy to the reader of the thesis in full.

2 Article 1: Addressing the Energy Performance Gap: A comparison of delivery structure and operational energy use at hospital facilities in Ontario, Canada

2.1 Abstract

Globally, governments deliver over a trillion dollars' worth of social infrastructure annually, including hospitals, using increasingly diverse approaches (Woetzel et al., 2016). Across Canada, particularly the province of Ontario, policy shifts favour using Public-Private Partnerships (P3s). Yet little empirical understanding exists of the implications these delivery structures have on operational outcomes like energy use, a major contributor to Facility Management budgets and climate change.

This study investigates the relationship between variations in facility delivery structure and operational energy use through a cross-sectional analysis of 2016 energy use data for all 286 hospitals in Ontario. Findings show facilities delivered through P3 contracts including an operating term had lower energy intensity (2.22 GJ/m^2) than those delivered conventionally (2.43 GJ/m^2) or via P3 contracts without an operating term (2.77 GJ/m^2).

Investigating P3 facilities with an operating term further found a strong relationship between energy intensity and contractual approach to energy management. Those using a bid energy model for annual targets, and payments, had the lowest energy intensity (1.48 GJ/m^2), capitalising on a risk transfer mechanism unique to delivery structures bundling design, construction and operating phases. Acknowledging the study's limitations (e.g. relatively few P3 facilities available in a single region), findings support further study into using delivery structure to address a recognised energy "performance gap" in public buildings.

2.2 Keywords

Infrastructure delivery; hospitals; facility operations; energy; performance gap; Public-Private Partnerships.

2.3 Introduction

Governments around the world spend over a trillion dollars of public money a year on social infrastructure, such as hospitals (Woetzel et al., 2016). Despite a growing use of green building certification regimes, such as Leadership in Energy and Environmental Design (LEED), there is often a significant 'performance gap' between predicted energy use of buildings and actual measured energy use once buildings are operational (de Wilde, 2014). Additionally, there is little correlation between this performance and certification level of the building, or the number of energy credits achieved by the building at design (Newsham et al., 2009). Barriers to energy performance are often found to be neither technical nor economic, rather institutional regimes such as how life-cycle stages were specified, contracted and implemented (Fedoruk et al., 2015).

Roehrich et al. (2014) identified an increasing diversity of delivery structures used for health care facility projects, yet little empirical evidence of their long-term implications on effectiveness and cost in the academic and industrial literature. Across Canada, and the province of Ontario in particular, this is marked by a notable policy shift favouring the use of Public-Private Partnerships (P3s). These P3s are positioned as a means to encourage innovation across the life cycle of major infrastructure projects (Regan et al., 2011), including for energy use (Himmel and Siemiatycki, 2017). Performance risks are often transferred to private-sector consortia in P3s that include operational terms, driving innovation in those areas throughout design, construction and operating phases of the facility (Altus Group, 2015). Theoretically, this approach to risk transfer should help address the observed energy performance gap, yet few empirical *ex post* operational studies exist to investigate whether these purported innovations are realised (Siemiatycki, 2015).

While much literature on improving building energy efficiency emphasises technical interventions, the purpose of this article is to investigate the influence of delivery structure on this aspect of operational performance. Specifically, the author studies relationships between variations in facility delivery structure and operational energy use, a major component of Facility Management (FM) budgets (Adams et al., 2010) and contributor to climate change (Lucon et al., 2014). This work addresses the problem through analysis of 2016 energy use data for all hospitals in Ontario, Canada. The facilities use a variety of delivery structures including those conventionally procured and maintained by hospital staff or FM contractors and multiple P3 forms, with and without operating terms.

Recognising the limitations of studying one regional context, and the relatively small number of operational P3 facilities available for study, the analysis considers broader implications for future research. With P3 hospitals that reached Substantial Completion as early as 2006, the study includes many of the most mature P3 hospitals in Canada, an established P3 market globally (Siemiatycki, 2015). It is therefore well-positioned to identify practical influences, successes and challenges associated with infrastructure operations and energy use under different delivery models making the study particularly important for policy makers in the field. To this end, Section 2.4 provides an overview of the literature supporting this research; Section 2.5 outlines the associated research methods used; Section 2.6 introduces the study findings; Section 2.7 provides further analysis and discussion; Section 2.8 concludes and Section 2.8.1 outlines further research opportunities.

2.4 Literature

Infrastructure enables social and economic activities through the physical structures and systems that provide the necessary spaces and services to communities. An increasingly private-sector-led range of infrastructure delivery structures since the 1990s has been both politically and industry led, with its origins linked to the United Kingdom's Conservative government 'new public management' theory and ideology (Khadaroo, 2014). Many governments now aim to improve public services by focusing on private-sector involvement to "assist the government in meeting its priorities, building on the clear recognition that public funds are limited" (Tang et al., 2010). Shaoul et al. (2007a), and later Roehrich et al. (2014) for health care facility projects specifically, found insufficient evaluations exist of whether private participation achieves its objectives and that social and financial objectives, in particular, were not properly assessed. Private companies' roles have broadened to all aspects of public infrastructure development including design, construction, maintenance, operation, management, financing and ownership (Akintoye et al., 2003) and these practices evolved further through the emergence of P3s in the late 1990s (Winch, 2000, Grimsey and Lewis, 2002a).

In a definition adopted by the Canadian Council of Public Private Partnerships (CCPPP), a P3 is any "cooperative venture between the public and private-sectors, built on the expertise of each partner, which best meets clearly defined public needs through the appropriate allocation of resources, risks and rewards" (Henk, 1998, CCPPP, 2015). This includes a breadth of different P3 models, all of which involve complex contractual arrangements with success dependent on well-developed political, legal, and economic environments (Kumaraswamy and Zhang, 2001). Vining and Boardman's (2008) "Positive Theory" of P3s recognises their ability to balance the divergent objectives of the partners; specifically, private-sector goals of profit maximization over the contract period and public-sector goals to minimise current on-the-books expenditures and political costs. While Vining and Boardman do not specifically include service quality as a public-sector goal it may be addressed indirectly through minimised political costs.

Many advantages of private involvement in public infrastructure development are claimed in the literature. Examples of these include reference by Cumming (2007) to private-sector augmentation of public-sector expertise and others speak to private-sector involvement creating a leaner civil service, improved public infrastructure quality and associated services, reduced risk of cost overruns and project delays (Edkins and Smyth, 2006, Ho, 2006, Li and Akintoye, 2008). A common theme of effective public- and private-sector involvement is to reduce overall project risk profile through assignment of specific risks to the parties best able to mitigate them (Shen et al., 2006). Criticism of the privatisation of infrastructure development is typically rooted in private-sector partners acting in their own best interest (Gómez-Ibáñez, 2009). The increasing scope and cost of public procurement processes (Akintoye et al., 2003) can inflate contract costs, favour larger players and promote industry consolidation, which further affects the balance of power between public and private-sector actors (Schaufelberger and Wipadapisut, 2003).

Innovation is often touted as a benefit of P3s that could affect a host of financial and technical aspects, with organisational environment (Gil and Miozzo, 2007) and public infrastructure procurement processes and contract forms (Uyarra and Flanagan, 2009) being shown to promote innovation and adoption of technology. Much of the focus on sustainability in academic and industry literature is economic, but some research exists on the social and environmental aspects as well (Hansmann et al., 2012). Public agencies promote social and environmental innovations by defining associated outputs within Project Agreements and Community Benefit Agreements (Musil, 2014).

Globally, buildings account for around one third of the world's final energy use, with substantial economic and environmental implications, and governments worldwide have responded with policy measures to improve buildings' energy efficiency (Lucon et al., 2014). A growing body of evidence, however, identifies a discrepancy between expectations around the performance of buildings and their actual operational energy use (CIBSE, 2013). This "performance gap" (de Wilde, 2014) is particularly striking due to the dramatic rise in popularity of design-based rating systems for building efficiency, such as LEED, yet there is little correlation between this performance and certification level of the building or the number of energy credits achieved at design (Newsham et al., 2009). According to research by Natural Resources Canada (2018) hospitals are Canada's most energy intensive building type, with newer hospitals having consistently used more energy than their predecessors over the past four decades. This despite many public procurements including increasingly stringent LEED requirements in their contractual output specifications (CaGBC, 2019, Infrastructure Ontario, 2019b). Barriers to energy performance are often found to be neither technical nor economic, rather due to institutional regimes such as life-cycle implementation (Fedoruk et al., 2015). P3s with long-term contracts keep developers connected to the operations of the project with life cycle (Ng and Loosemore, 2007) and energy (Himmel and Siemiatycki, 2017) performance risks often transferred to private-sector consortia, driving innovation in those areas (Altus Group, 2015).

With 209 projects reaching Financial Close from 2008 to 2018, Canada has one of the highest-volume P3 markets in the world, one dominated by social infrastructure (63%) and health (39%) deals. Ontario contributed a total of 104 projects that closed over the same period, of which 73 were social infrastructure and 50 healthcare (Inframation Deals, 2019). Dedicated P3 agencies exist federally and within most provincial governments. Infrastructure Ontario, founded in 2005, has led Ontario to be the country's most prolific Canadian province in developing P3s. According to Infrastructure Ontario (2019a), the province's P3 approach enables more efficient and cost effective project delivery than traditional procurement, including greater protection from cost overruns, through the transfer of project risks to the party with the "expertise, experience and ability" to best handle the risk.

Historically, health care services, and the facilities in which they are offered, have been provided both publicly and privately. Since government-funded universal health insurance programs were first established in Germany (1883), United Kingdom (1911) and Canada (1957) public financing and provision became the norm in many OECD countries (Canadian Museum of History, 2010). In Canada, about 11% of GDP is dedicated to health care expenditure and much of this goes towards the construction and operation of health care facilities (Canadian Institute for Health Information, 2016b).

Infrastructure development is increasingly seen in a values framework with respect to how it contributes to society throughout its full life cycle and, as such, it can serve as a unique model for public-private capital and skills collaboration, thereby providing the potential to spur sustainable development across infrastructure, industry and society in general (Colverson and Perera, 2012). Little empirical research has taken place with respect to delivery approach, including the use of P3s, and the operational performance of facilities, particularly with respect to energy use. This paper intends to help fill that gap.

2.5 Methods

Research in the field is largely theoretical and most of the limited empirical contributions have focussed on initial development costs due to limited availability of data from the operational phase (Chen et al., 2015). As such, minimal *ex post* analysis has been conducted on the long term implications of ownership structures on the life cycle effectiveness and cost of the infrastructure (Shaoul et al., 2007a, Roehrich et al., 2014). This despite operations, maintenance and upgrading phases generally surpassing upfront development costs over the life of the infrastructure (Dahl et al., 2005), thus having huge significance on the overall sustainability of the project (Rahman and Vanier, 2004). Operational energy use, in particular, is a major component of hospital FM budgets (Adams et al., 2010).

The operational phase is the focus of this study, with the leading research question: *Is there a relationship between variations in delivery structure and 2016 energy intensity among operational hospitals in Ontario, Canada?* The question is addressed using a broad retrospective cross-sectional comparison of Broader Public-sector 2016 energy use data provided by the Ontario Ministry of Energy, Northern Development and Mines (2018a). Similar data is available for years 2011 to 2016 but, with the number of P3 facilities entering operations in recent years, earlier datasets were found to be unsatisfactory for analysis. This is particularly true as many facilities have two year monitoring periods to set energy targets (Infrastructure Ontario, 2019b) while for others a *de facto* post-occupancy commissioning period is required to settle into their energy use, as demonstrated in Articles 2 and 3–.

All hospital facilities included in the study are assets under the oversight of Infrastructure Ontario, for which energy efficiency and sustainability is a stated goal (Infrastructure Ontario, 2020). According to the Ministry's records (Energy Northern Development and Mines, 2018b), all hospitals in the province reported their 2016 energy consumption for this dataset, therefore records for the full study population are analysed in this research. Upon application of filters by 'Sector' (i.e. 'Public Hospitals' and 'Facilities used for hospital purposes') the entries were reviewed for validity. In total, the author removed the eight entries listed in Appendix B from the data studied as they were determined to be incorrectly labelled as 'Facilities used for hospital purposes' and should be classified as 'Administrative offices and related facilities' or 'Other'.

In order to test the above research question, using Infrastructure Ontario (2019b) project data the author coded the remaining dataset for "Delivery Structure", identifying the hospitals with the following classifications:

1) Conventional delivery: Publically owned and operated, typically constructed using a Design-Bid-Build model.
2) Mix of conventional and P3 (no operating phase) delivery: Since the mid-2000, major additions or reconstructions of existing hospitals facility in Ontario were delivered as P3s without an operating phase. When the two components of a facility are not broken out in the dataset, the resultant energy use analysed is for a facility delivered using a mix of structures. These facilities are classified separately for analysis.
3) P3 delivery without an operational phase (e.g. Build-Finance, Design-Build-Finance)
4) P3 delivery with an operational phase (e.g. Build-Finance-Maintain, Design-Build-Finance-Maintain)

Hypothesis 1 of this study relates to the comparison of these four Delivery Structure classifications: *Of Ontario hospital facilities operating in 2016, those delivered as P3s with an operating phase (Group 4) will have the lowest energy intensity over the period of study.* An application of Vining and Boardman's (2008) "Positive Theory" of P3s, the hypothesis is that P3 structures bundling the design, construction and operating phases (Group 4) provide the opportunity to transfer operational energy use risk to the private-sector consortia, thereby incentivising energy-efficient decision-making through the various phases of the contract through profit-maximising mechanisms.

Through review of the Project Agreements of P3 facilities having an operational phase, found in the same Infrastructure Ontario (2019b) database used above, the author coded for the contractual "Energy Management Approach" using the following sub-classifications:

a) NA/Incentive: No applicable wording in the contract or a generalised incentive for good energy performance.
b) Regression Analysis Model: Use of a prescribed linear regression model to set annual energy targets based on past energy operational use and environmental determinants. Targets used to calculate annual payments to or from the Project Company based on energy performance (Painshare/Gainshare payments).
c) Bid Energy Model: Energy model provided by all proponents at bid, with associated energy use over operating term incorporated in a competitive evaluation of life cycle project cost. Annual energy targets from model adjusted per environmental determinants and used to calculate annual Painshare/Gainshare payments based on energy performance.

The contractual Energy Management Approach sub-classifications outlined above are based on those used by Infrastructure Ontario to internally classify the Energy Matters approach within the associated Project Agreement schedules among their P3 projects (Withheld, 2018c).

Hypothesis 2 of this study relates to the comparison of these three Energy Management Approach sub-classifications: *Of Ontario hospital facilities operating in 2016, those delivered as P3s with an operating phase (Group 4) and incorporating the 'Bid Energy Model' approach to energy management (Group 4c) will have the lowest energy intensity over the period of study.* The justification for this hypothesis is that the Bid Energy Model approach (Group 4c) maximises the opportunity of the P3 structures that bundle the design, construction and operating phases (Group 4) to transfer operational energy use risk to the private-sector consortia; a further application of Vining and Boardman's (2008) "Positive Theory" of P3s. Including operational energy use within the competitively tendered life cycle cost of the project incentivises proponents toward energy-efficient decision-making through the initial design and bid phase. Using the associated Energy Model to set annual energy targets throughout the operating term, holds successful teams accountable to: i)specify and correctly install energy efficient materials and equipment through the final design and construction phase, and ii)maintain, fix and upgrade any system components proactively throughout the operating phase. This compares to the Regression Analysis Model (subclass b) whereby annual energy targets are established based on energy performance during the operational term, thereby significantly limiting the transfer of energy performance risk to the Project Company.

In order to effectively determine if a relationship exists between delivery category and energy performance, this study applies an established process (Natural Resources Canada, 2012) to compare energy intensity. Hospital facilities across the province use multiple sources of energy for their operations, most notably Natural Gas for heating, grid-sourced electricity for cooling and other functions and fuel oil for backup generators. A small number of facilities use other sources such as district heating and cooling systems.

The Total Energy Use of each delivery category, reported in GJs, is a sum of all energy sources used by all facilities in the category. Energy Intensity (GJ/m^2) is calculated by dividing the Total Energy Use by the sum of the total indoor space (m^2) of all buildings in the same category. The Total Energy Intensity figure equals the weighted average of energy intensities of all sites, that use floor space as the weight, and is a more accurate comparison than that of an unweighted average of energy intensities. The dataset used reported "Total Indoor Space" figures as a mix of imperial and metric units, thereby requiring the author to convert all figures into m^2. The dataset also reported Energy Intensity figures for each facility but not Total Energy Use. The author calculated Total Energy Use for each facility by multiplying its Total Energy Intensity by the corresponding total indoor space. Using Infrastructure Ontario (2019b) data, the author coded, facilities by Delivery Structure and Energy Management Approach. Total indoor space, Total Energy Use and Energy Intensity figures were analysed for the various facility categories using tabular and graphical methods. The use of other statistical tools was inappropriate in this study due largely to the fortune of working with population rather than sample data. In addition, the relatively small numbers of facilities in some categories would have prevented the application of many statistical tools if sample data had been used.

The trouble with empirical research is that there are multitudes of known and unknown variables that affect the study subject, apart from those on which the research focusses. In order to test the robustness of findings, the author investigated two such known variables further: hospital facility's primary clinical function (i.e. Ambulatory Care, Nursing or Residential Care, General Medical & Surgical) and whether the facility is located in northern Ontario or southern Ontario. The study included these factors as many researchers (Jarvis and Choy, 2018, Natural Resources Canada, 2018) have demonstrated substantial variation in energy use across facilities of different primary clinical function, with General Medical & Surgical (or acute care) hospitals the most energy intensive by a wide margin. Regarding geographic location, Natural Resources Canada (2012) findings showed minor increased energy use of hospitals in the climate zone including northern Ontario over that including southern Ontario. In order to investigate these relationships, the author coded the facilities within the dataset by primary clinical function (i.e. Ambulatory Care, Nursing or Residential Care, General Medical & Surgical) through interpretation of descriptors provided (e.g. 'Sub Sector', 'Organization', 'Operation') and whether the facility is located in southern Ontario ('Great Lakes/St. Lawrence' Climate zone) or northern Ontario ('Other' Climate zone) (Natural Resources Canada, 2012). Tables showing the proportional summaries, by Total Indoor Space (m^2), of Delivery Structure and Energy Management Approach by primary clinical function and whether facilities are located in northern or southern Ontario are found in Appendix C.

2.6 Study Findings

As outlined in Table 1, the final dataset contained values for Total Indoor Space and Energy Use values for all 286 Ontario hospital facilities in 2016. A summary of these findings, broken out by Delivery Structure and Energy Management Approach, is shown in Table 1. Additional descriptive statistics are included in Appendix D. Unsurprisingly, at 247, the majority of facilities were delivered conventionally (*Group 1*) while, for the first time in 2016, a total of 39 facilities had a P3 component to them (*Group 2, 3 or 4*).

As represented in Figure 4, comparing Energy Intensity of the hospital facilities under the various delivery structures, found P3 facilities without an operational component (*Group 3*) used more energy per unit of area (2.77 GJ/m^2) than those delivered conventionally (*Group 1,* 2.43 GJ/m^2) and P3 facilities with an operating component (*Group 4*) used somewhat less (2.22 GJ/m^2). This finding supports *Hypothesis 1* of the study. Group 2 facilities have an energy intensity midway between *Group 1 and Group 3*, a reasonable finding since they are facilities delivered through a hybrid of the two structures.

Table 1: Summary of Total Indoor Space, Energy Use and calculated Energy Intensity of Ontario Hospital facilities by Delivery Structure and Energy Management Approach. 2016 data.

Delivery Structure	**Energy Mgmt. Approach**	**Count**	**Total Indoor Space** (m^2)	**Total Energy Use** (GJ)	**Energy Intensity** (GJ/m^2)
1) Conventional	a) NA-Incentive	247	5,412,144	13,148,814	2.43
2) Mix, Conventional & P3, no ops	a) NA-Incentive	11	459,790	1,272,036	2.60
3) P3, no operating term	a) NA-Incentive	12	510,375	753,266	2.77
4) P3, with operating term	Sub total	16	1,041,186	2,306,857	2.22
	a) NA-Incentive	*3*	*226,025*	*676,977*	*3.00*
	b) Regression Analysis Model	*7*	*304,787*	*876,613*	*2.88*
	c) Bid Energy Model	*6*	*707,633*	*1,836,615*	*1.48*
Grand total		**286**	**7,620,756**	**18,564,322**	**2.44**

Incorporating the sub-classification of Energy Management Approach to those P3 facilities with an operating component, as represented in Figure 5, finds the variance from conventionally delivered facilities to increase significantly. Group 4 facilities without a contractual approach to energy management in their Project Agreements, or basic incentives for good performance, use more energy (*Group 4a*, 3.00 GJ/m^2) than any other classification. Interestingly, facilities using a Regression Analysis Model for setting annual energy targets also use more energy (*Group 4b*, 2.88 GJ/m^2) than all other classifications except *Group 4a*. Impressively, facilities using the Bid Energy Model to set annual energy targets (*Group 4c*), and associated Painshare/Gainshare payments, use substantially less energy (1.48 GJ/m^2) than all other categories, about half that of *Groups 4a* and *4b*. This finding supports *Hypothesis 2* of the study however, with only 16 *Group 4* facilities available for study, the confidence level is low.

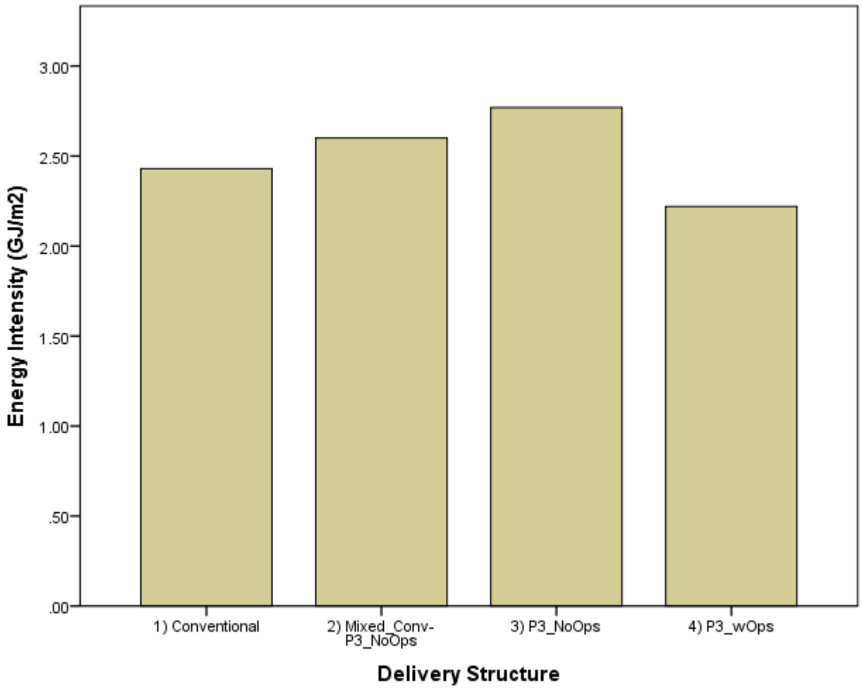

Figure 4: Chart showing Energy Intensity of Ontario hospitals, in GJ/m^2, by Delivery Structure. 2016 data.

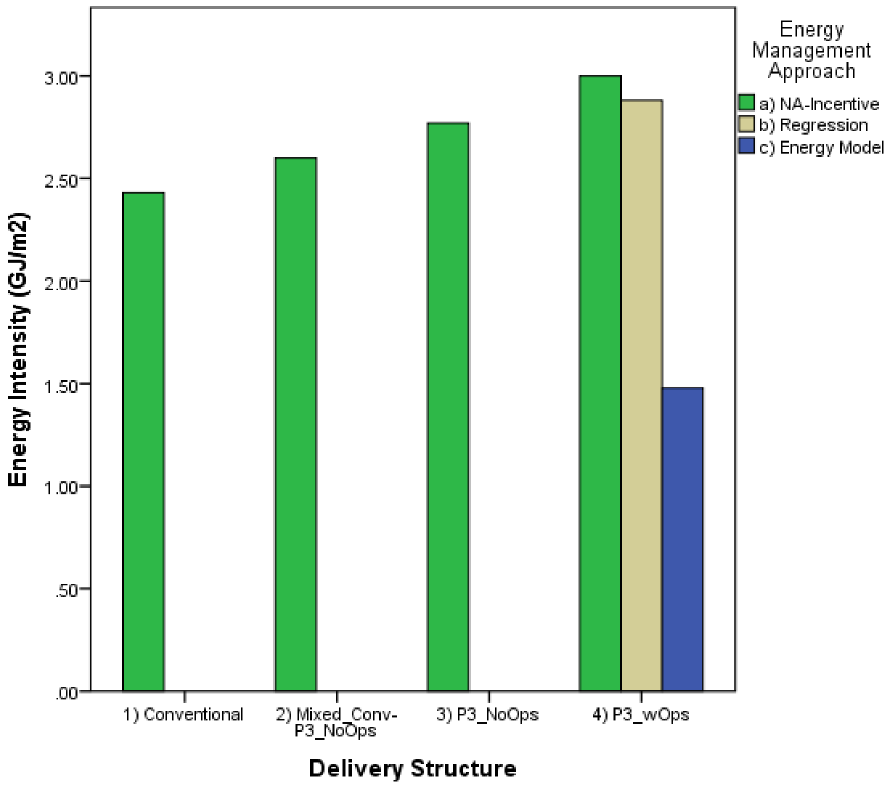

Figure 5: Chart showing Energy Intensity of Ontario hospitals, in GJ/m^2, by Delivery Structure and Energy Management Approach. 2016 data.

2.7 Analysis

A possible explanation for the increase in indexed energy use between the delivery structures, from *Group 1* to *Group 3*, is age. As summarised in Appendix E, a Survey of Commercial and Institutional Energy Use in 2014 conducted by Natural Resources Canada (2018) found a steady increase in energy use among hospital facilities constructed over the past four decades. The first P3 hospital facilities in Ontario, and this study, reached Substantial Completion in the mid-2000s. Before this time, all facilities were delivered conventionally and since this time construction of major hospital facilities have predominantly been delivered as P3s. The average age of *Group 4* facilities is less than *Group* 3 and both are substantially less than those delivered conventionally (*Group 1*). P3 facilities without an operating phase (*Group 2* and *3*) are operated similarly to Group 1 facilities, and those with an operating phase but no substantive contractual approach to energy management applied (*Group 4a*), have minimal contractual obligation to reduce energy use during the operating phase. For *Group 1*, *2*, *3* and *4a* facilities, age is inversely proportional to energy intensity; with no determinable difference in risk transfer for energy performance, it is therefore reasonable to expect their energy intensity to trend upward with the national figures. With additional parties involved in the operations of *Group 4a* facilities, more research is required to identify if other organisational mechanisms negatively affect their energy performance.

Group 4 is the delivery structure with the newest facilities however, at 2.22 GJ/m^2, they appear to counter the trend of inverse proportionality between facility age and energy intensity over recent decades. As shown in Figure 5, the excellent performance of *Group 4c* facilities (1.48 GJ/m^2) affects the broader category significantly as *Groups 4a* and *4b* have much higher values (2.88 GJ/m^2 and 3.00 GJ/m^2, respectively). *Hypothesis 2* predicted the high performance of *Group 4c* as the Energy Model approach maximises the opportunity of public-sector clients to transfer operational energy use risk to the private-sector consortia through P3 structures that bundle design, construction and operating phases. This approach includes competitively tendered bids that include operational energy costs complemented by corresponding annual energy targets over the operating term to hold the Project Company accountable through Painshare/Gainshare payments.

That the P3 facilities applying a Regression Analysis Model to set annual energy targets (*Group 4b*) have only slightly better performance than those without any substantive energy targeting process (*Group 4a*) is an unexpected finding, but not unreasonable. These contracts use a linear regression model based on operational performance to set future years' targets then, applied with environmental adjustments and actual energy performance, calculate

Painshare/Gainshare payments. The linear regression model used to set the formula for the targets is generally reset periodically (e.g. every 5 years) thereby mitigating associated risks to the Project Company but also reducing the opportunity for payback of investments by the Project Company into energy upgrades via increased Gainshare payments or decreased Painshare payments. In practice, the Regression Analysis Model of *Group 4b* facilities protects the hospital against major reductions in energy performance, through potential Painshare payments by the Project Company, and incentivises modest operational improvements, through potential Gainshare payments to the Project Company. The model does not incentivise investment by the Project Company into energy upgrades that require payback periods longer than the frequency of resets to the energy target formula, even if the facility is performing substantially below design expectations.

Notably, the robustness checks in Appendix C found *Group 4* facilities to have a proportion of General Medical & Surgical hospitals that were nearly double the average of the whole population. The proportional difference from the population was even greater for sub-classifications *Group 4b* and *Group 4c*. This could explain some of why the *Group 4b* facilities were so energy intensive but further accentuates the high performance of the *Group 4* facilities in general, and particularly so for the *Group 4c* facilities. The majority of facilities in all categories are located in southern Ontario. There were no *Group 4c* facilities located in northern Ontario, which could aid the low energy intensity of the category somewhat, but it is not expected to be overly significant due to the limited scale of proportional difference and that Natural Resources Canada (2012) findings showed the geographic effect to be small. Additionally, Energy Intensity was found to have little correlation to facilities' Median Total Indoor Space when categorised by Delivery Structure and Energy Management Approach. While high for a jurisdiction globally, the relatively low number of P3 facilities (n=39), and particularly *Group 4* facilities (n=16), available for study reduces the confidence in findings of such quantitative analysis.

2.8 Conclusions

The aim of this paper was to answer the following research question: *Is there a relationship between variations in delivery structure and 2016 energy intensity among operational hospitals in Ontario, Canada?* To do so, the author analysed 2016 energy use at all hospitals in the province. Including P3 hospitals that reached Substantial Completion as early as 2006, the study includes many of the most mature P3 hospitals in Canada, a well-established P3 market, so is well positioned to identify practical influences, successes and challenges associated with infrastructure operations and energy use, specifically, under the different delivery structures. The majority of facilities studied, at 247, include those delivered conventionally, procured and maintained by hospital staff or Facility Management contractors, plus 39 facilities with a P3 component to them, including those with and without an operating term. This analysis of delivery structure and operational outcomes is unique in the literature, particularly so using empirical data. Recognising the limitations of studying one regional context and relatively low number of P3 facilities available for quantitative analysis, this study considers broader implications for future research.

The author conducted a retrospective, cross-sectional comparison of the energy use data to compare energy intensity of the hospital facilities under the various delivery structures. The study found P3 facilities without an operational component used more energy per unit of area (2.77 GJ/m^2) than those delivered conventionally (2.43 GJ/m^2), while those P3 facilities with an operating component used somewhat less (2.22 GJ/m^2). Looking closer at those P3 facilities with an operating component found the approach their Project Agreements took to energy management had a very significant relationship with energy intensity. Facilities using a competitively tendered Energy Model to set annual energy targets, and associated Painshare/Gainshare payments, used substantially less energy (1.48 GJ/m^2) than all other categories. This was about half the energy intensity of P3 facilities with an operating phase but no substantive contractual approach to manage energy performance (3.00 GJ/m^2) and facilities using a Regression Analysis model for setting annual energy targets (2.88 GJ/m^2).

Analysis found facility age to be inversely proportional to energy intensity for those delivered conventionally, as P3s without an operating phase and as P3s with an operating phase but no substantive contractual approach to manage energy performance. With no determinable difference in risk transfer for energy performance, it is reasonable to expect the facilities' energy intensity to trend upward with national figures in recent decades. P3 facilities with an operating phase and applying a Regression Analysis Model to set annual energy targets, is the grouping with the second highest energy intensity. The contractual approach uses targets based on operational performance to calculate payments that protect the hospital client against major reductions in energy performance and incentivise modest operational improvements. Due to regular resets to the energy target formula, the approach disincentivises investment by the Project Company into energy upgrades that require payback periods longer than the reset frequency, even if the facility is performing substantially below design expectations. More so, the model does not use the opportunity made available by bundling design, construction and operating phases to drive energy efficiency at each phase through the transfer of operational energy performance risk to the Project Company.

P3 facilities with an operating phase that apply a competitively tendered energy model to set annual energy targets, which are then used to calculate Painshare/Gainshare payments, capitalises on the opportunity for hospital clients to transfer operational energy use risk to the Project Company. These highly accountable risk transfer mechanisms are uniquely available to delivery structures that bundle design, construction and operating phases as each time the owner ends a contract under other structures, they take on risk with new parties unwilling to guarantee prior parties' performance.

The study's findings show a significant relationship to exist between delivery structure and energy intensity among Ontario's hospital facilities, thereby supporting use of delivery structure as an innovative tool to address the recognised energy "performance gap" in buildings. Despite the positive energy performance demonstrated among facilities delivered through P3 contracts with operating terms, the divergent results by P3 facilities without an energy term are not fully explained by existing theory such as Vining and Boardman's (2008) "Positive Theory" of P3s. Instead, these findings, and the analysis of the P3 contracts' energy management approaches, suggest that practical outcomes are highly dependent on contractual structure and associated risk allocation among parties.

2.8.1 Future Research

Extensions to the research conducted for this paper include continued monitoring of the study population as new facilities enter operations to test and improve robustness of findings while investigating changes over facility life cycles. Additionally, it would be helpful to test the consistency of findings through investigation of energy use among other public facilities types, both social and civil, as well as through investigation of relationships between delivery structure and other operational performance outcomes such as labour utilisation and facility user satisfaction.

3 Article 2 - Operational Performance of P3s: A comparison of contractual approach to energy management at two Ontario hospitals

3.1 Abstract

In recent years an increasingly diverse range of infrastructure delivery structures are being used with little empirical understanding of their long-term implications on operational performance, including energy use. Across Canada, and the province of Ontario in particular, this is marked by a notable shift favouring the use of Public-Private Partnerships (P3s). With focus on operational energy use, this paper provides a comparative, longitudinal Case Study of two hospitals in Ontario, Canada. Both facilities are early P3 hospitals delivered by Infrastructure Ontario under the Design-Build-Finance-Maintain (DBFM) structure. Though both facilities reached substantial completion in 2013, their P3 contracts incorporate very different language to manage energy use during the operational phase. Facility 1 applies a Regression Analysis Model based on operational energy use to set annual energy targets and associated incentive payments. In contrast, Facility 2 sets annual energy targets using a bid Energy Model.

Comparison of facility operational energy use intensity and associated environmental performance, using empirical data supplemented by contractual study and analysis, found much better performance by Facility 2. These findings were compounded by greater reductions in energy use intensity by Facility 2 over the period of study, despite lower indexed incentive payments to the Project Company. Acknowledging limitations of the study, the article identifies practical influences and challenges associated with the facility's procurement and operations in order to support future planning and policy work.

3.2 Keywords

Infrastructure, Delivery, Facility Maintenance, Operations, Energy, Environment, LEED, Public-Private Partnerships.

3.3 Introduction

This article provides a Case Study of energy use and associated environmental performance at two nursing and residential care hospitals in Ontario, Canada delivered by Infrastructure Ontario under the Design-Build-Finance-Maintain (DBFM) structure of Public-Private Partnership (P3). Though both facilities reached substantial completion in 2013, their P3 contracts incorporate very different language to manage energy use during the operational phase. Facility 1 uses a linear regression model to set annual energy targets based on past energy operational use and environmental determinants. Instead, at the time of Facility 2's tender, all proponents submitted an energy model including energy use over the full operating term. Associated costs were incorporated into the life cycle project cost and incorporated into selection of the winning team. Throughout operations annual energy targets are retrieved from the model.

Through description of the facilities' backgrounds and associated contractual attributes, the paper provides an overview of their significance and specifications, outlining multiple established benchmarks for evaluation of energy use. The specific research question leading this study is: *For the facilities included in this study, considering the context of their P3 contract, how do the facilities' operational energy use and associated environmental performance compare to one another and similar facilities?* In order to address this question, the author conducts a longitudinal study of the facilities, employing annual data for the four available Energy Years since their 2013 Substantial Completion dates. Analysis of trends between energy use and the facilities' delivery structures, including their specific contractual approach to energy management, is supported by the author's in-depth knowledge of the facilities.

By addressing the above research question, this paper identifies practical factors associated with social infrastructure operations to inform further academic study and policy-makers in the health field and more broadly. These generalised findings are presented while recognising the limitations of a single case study including only two facilities over four years. Section 3.4 outlines the motivation for conducting the research and introduces the facilities, their specifications and history; Section 3.5 revisits the research question and outlines the associated research methodology including an in-depth examination of the data collected, particularly with respect to the contractual context of Infrastructure Ontario's P3 models; Section 3.6 outlines the study's findings while Section 3.7 provides further analysis and discussion, Section 3.8 concludes and Section 3.8.1 identifies future related research opportunities.

3.4 Literature

Infrastructure enables social and economic activities through the physical structures and systems that provide the necessary spaces and services to communities. The G20's Global Infrastructure Hub (2017) estimate a required global infrastructure investment of $94 trillion between 2016 and 2040, or $3.8 trillion per year and almost double the average $2.0 trillion annual global infrastructure investment between 2007 and 2015. To address this sizable need, in recent years an increasing diversity of infrastructure delivery structures are being used with little empirical evidence of their long-term implications on effectiveness and cost (Stafford and Stapleton, 2017, Hodge and Greve, 2018, Roehrich et al., 2014, Shaoul et al., 2007a).

Governments have a number of options to manage and fund public infrastructure investments and trends vary by application, throughout the development life cycle and over time (Jacobson and Tarr, 1995). The upfront allocation of funds through raising of taxes or cutting other expenses can lead to political hostility and broader economic costs. While governments can generally borrow more cheaply than private entities, public borrowing is restricted either due to rating agency concerns or self-imposed limits. Lastly, private financing can allow for accumulation of liabilities off the official balance sheet, to be paid back through the annual cash flows. Though accounting rules have tightened up around the use of the aforementioned off-balance-sheet techniques that could lead to the same restrictions for public borrowing (Fernandes et al., 2015, Finnerty, 2013).

Historically, health services and the facilities in which they are offered have been provided both publicly and privately. Since many Organisation for Economic Co-operation and Development (OECD) countries developed government-funded universal health insurance programs - beginning with Germany (1883) followed by the United Kingdom (1911) and Canada (1957) - public financing and provision became the norm (Canadian Museum of History, 2010). Scarcity of funds and expertise, as well as risk mitigation, has long led governments and the private-sector to cooperate on developing physical infrastructure (Albalate et al., 2014), including health care facilities. Political and commercial rhetoric often states that private-sector efficiency should maximise infrastructure value (Avishur, 2000). The increasingly private-sector led range of infrastructure ownership and management structures has been politically and industry led as an extension of neoliberal policies since the 1980s, particularly in OECD countries (Hood, 1995). This 'new public management' theory gained momentum in the 1990s with United Kingdom's Conservative and Labour governments in the form of Private Finance Initiatives. Governments around the world now emphasise private-sector involvement as a means of improving public services by "assist[ing] the government in meeting its priorities, building on the clear recognition that public funds are limited" (Tang et al., 2010). This global ideological shift is largely unsupported by any empirical understanding of its long-term implications on effectiveness and cost and criticisms include impacts on socio-economic inequality and other concerns consistent with those of financialisation (Khadaroo, 2014).

Stafford and Stapleton (2017), Shaoul et al. (2007a), and Roehrich et al. (2014) for health care facility projects specifically, found insufficient evaluations exist of whether private participation achieves its objectives and that social and financial objectives, in particular, have not been properly assessed. Further criticism of the privatisation of infrastructure development is typically rooted in private-sector partners acting in their own best interest (Gómez-Ibáñez, 2009). Arguments for public provision of infrastructure include the increasingly high cost of public procurement processes (Akintoye et al., 2003), which inflate contract costs and favour larger players. This leads to industry consolidation, which further affects the balance of power between public and private-sector actors (Schaufelberger and Wipadapisut, 2003). Private companies' roles have broadened to all aspects of public infrastructure development including financing and ownership as well as management, design, construction, maintenance and/or operation (Akintoye et al., 2003). These practices evolved further through the emergence of Public-Private Partnerships (P3s) in the late 1990s (Winch, 2000, Grimsey and Lewis, 2002a).

3.4.1 Public Private Partnerships (P3s)

Due to the variety of project forms and situations around the world, P3s have been defined in a number of ways (Hodge et al., 2010). In a definition adopted by the Canadian Council of Public Private Partnerships (CCPPP), a P3 is any "cooperative venture between the public and private-sectors, built on the expertise of each partner, which best meets clearly defined public needs through the appropriate allocation of resources, risks and rewards" (Henk, 1998, CCPPP, 2015). The OECD defines P3s, more specifically, as a legal, public owner transferring economic ownership to another, private-sector party for the latter to accept the risks and rewards of using the asset (OECD, 2013). Despite the numerous definitions available, all P3s involve complex contractual arrangements and their success depends on well-developed political, legal, and economic environments (Kumaraswamy and Zhang, 2001).

The "Positive Theory" of P3s (Vining and Boardman, 2008) recognises them as a way of balancing the divergent objectives of the partners; specifically, private-sector goals of profit maximization over the contract period and public-sector goals of minimize current on-the-books expenditures and political costs. One advantage touted for private involvement in public infrastructure development is to augment public-sector expertise, often on projects for which the local governments are unfamiliar but on which the private-sector entities have worked in other jurisdictions, which has been shown to save the public-sector resources and allow the local governments to concentrate on their primary duties (Cumming, 2007). That has been shown to produce a leaner civil service structure while improving the quality of the public infrastructure and associated services and reducing the risk of cost overruns and project delays (Edkins and Smyth, 2006, Ho, 2006, Li and Akintoye, 2008). Additionally, by identifying and assigning risks to the parties most able to mitigate them the overall risk profile can be reduced (Shen et al., 2006). Criticism of the privatisation of infrastructure development is typically rooted in private-sector partners acting in their own best interest (Gómez-Ibáñez, 2009). The increasing scope and cost of public procurement processes (Akintoye et al., 2003) can inflate contract costs, favour larger players and promote industry consolidation, which further affects the balance of power between public and private-sector actors (Schaufelberger and Wipadapisut, 2003).

In Canada, about 11% of the GDP is dedicated to health expenditure and much of this goes to the construction and operation phases of health care facilities (Canadian Institute for Health Information, 2016b). Additionally, Canada has one of the highest-volume P3 market in the world with a total of 209 projects reaching Financial Close from 2008 to 2018. Provincial agencies are responsible for the majority of projects in procurement with Infrastructure Ontario leading Ontario to be the country's most prolific province in developing P3s, contributing a total of 104 projects that closed over the same period. This is over double the number of transactions completed in British Columbia, the province with next most number of deals over the same period. Infrastructure Ontario uses P3 documents based from the United Kingdom's Private Finance Initiative structure and a $50 million threshold for projects, with other provincial agencies building on these. Government funding on projects is often quite large and delivered through an availability payment mechanism. Generally, prequalification rounds are used to reduce the risk of bid costs for participants by shortlisting three teams for projects. Canadian P3s are dominated by social infrastructure, accounting for 73 deals reaching Financial Close from 2008 to 2018. This is well ahead of transport infrastructure, the next most popular sector at 26 deals. Health was the largest sub-sector within social infrastructure at 50 of the closed deals, ahead of accommodations at 11 deals. (Inframation Deals, 2019)

3.4.2 Innovation and the Environment

Innovation is often touted as a benefit of P3s that could affect a host of financial and technical aspects and public infrastructure procurement processes and contract forms have been shown to promote innovation and adoption of technology (Uyarra and Flanagan, 2009) as can organisational environment (Gil and Miozzo, 2007). Much of the focus on sustainability is economic but some research exists on the social and environmental aspects as well (Hansmann et al., 2012). A large number of public procurements include third-party standards for buildings such Leadership in Energy and Environmental Design (LEED) and Building Research Establishment Environmental Assessment Methodology (BREEAM) in their contractual output specifications.

Globally, buildings account for around one third of the world's final energy use with substantial short-term economic costs and long-term environmental implications. Specifically, this energy use corresponds to 18% of global direct and indirect greenhouse gas emissions globally. This surpasses emissions of the whole transport sector (14%) while being under that of industry (29%) and agriculture, forestry and other land use (25%). The global significance of the building sector's energy use and related emissions has led to a number of policy measures being implemented worldwide aimed at improving facilities' energy efficiency (Lucon et al., 2014). Commonly, the tools used include performance standards and codes for new buildings and modifications to existing buildings, however a growing body of evidence has identified a discrepancy between the expectations around the performance of buildings and their actual energy use and resulting utility bills (CIBSE, 2013). This performance gap is particularly striking due to the dramatic rise in popularity of design-based rating systems for building efficiency such as those provided by LEED and BREEAM, among others. Assessing and improving the operational performance of existing buildings has hence become increasingly important (Bordass et al., 2001).

P3s' long-term contractual arrangements keep developers connected to the operations of the project, thereby encouraging them to balance upfront capital and operational cost reductions via resource usage throughout the duration of the contract; though this is challenged in practice by different companies within consortia providing design, construction and maintenance services and various parties selling their stake when complete (Morse, 2011). In addition, infrastructure development is increasingly seen in a values framework with respect to how it contributes to society throughout its full life cycle and, as such, it can serve as a unique model for public-private capital and skills collaboration, thereby providing the potential to spur sustainable development across infrastructure, industry and society in general (Colverson and Perera, 2012). Public agencies can promote such innovations by defining social and environmental outputs within Project Agreements or Community Benefit Agreements (Musil, 2014). Little empirical research has taken place with respect to the contractual link between P3s and the operational performance of facilities, particularly with respect to environmental indicators, and this paper intends to help fill that gap.

3.4.3 The Facilities

The two nursing and residential care hospitals analysed are located in the Greater Toronto and Hamilton Area of Ontario, Canada. Both are early facilities delivered by Infrastructure Ontario under 33 year DBFM structures of P3s that reached Substantial Completion in 2013 at a capital cost of about $600 million. Facility 1 incorporates a new 10-storey, 62,000 m^2, over 450 bed facility dedicated to the treatment of complex chronic diseases, including ambulatory care and educational space, as well as a 5-storey, 8,000 m^2 restored heritage space that houses administrative offices, education and support space. Facility 2 is a low-rise, 80,000 m^2, over

300 bed tertiary-care mental health hospital providing inpatient and outpatient care to those suffering with a severe mental illness or addiction, as well as medical outpatient clinics and diagnostic imaging services to the community, administrative, education and research space. (Withheld, 2015b)

Both facilities were originally procured in 2008/2009 as P3s (Withheld, 2008, Withheld, 2009b) using the controversial (Auditor General of Ontario, 2014) Value for Money calculations conducted for Infrastructure Ontario, which identified 10-14% cost savings over hypothetical traditional delivery model (Infrastructure Ontario, 2009, Infrastructure Ontario, 2011). The Project Company challenged the initial design concept and created a facility that was more compact, bringing key activities closer together and reducing operating costs (Withheld, 2015b) and the sites achieved LEED Silver and Gold certifications, respectively (Canadian Green Building Council, 2014). As early P3s and two of the first health care facilities in Ontario to be constructed on brownfield sites, the projects served as an example for procuring authorities across Canada as they began to look at P3s in general and specifically for major redevelopment/renovation projects (Withheld, 2015b).

Designed at similar times and build by the same constructor, the two facilities have similar plant configurations. The heating plants consist of both gas-fired hot water boilers and steam boilers. The near-condensing hot water boilers are used to provide hydronic heating to the air handling units, terminal reheat coils and the perimeter radiation system consisting of radiant ceiling panels. The steam boilers are used for the domestic hot water (DHW) systems and humidification. Cooling systems consist of a central constant speed chiller plant, cooling tower, circulation pumps, distribution piping system and cooling coils within air handling units to provide general cooling for the building and the 24/7 cooling applications systems that include computer rooms, communications closets, kitchen area refrigerators, freezers and diagnostic imaging equipment/rooms. Variable frequency drives are used on both the chillers and the circulating pumps to maximize the operating efficiency of the cooling plant to provide general space cooling. A dedicated outdoor air system with heat recovery ventilators and variable frequency drives provides ventilation to the building. Dedicated building automation systems incorporate direct digital control to provide energy management, equipment monitoring and control using an open protocol system to integrate all metering points and HVAC control and monitoring points (Withheld, 2015-2018).

Though both hospitals studied are P3 facilities delivered through Infrastructure Ontario's DBFM structure, where the client pays utility providers directly for building utilities, energy efficiency is encouraged using very different approaches within the Project Agreement between the hospital and the Project Company(Withheld, 2009a, Withheld, 2010b). Infrastructure Ontario uses a database of Project Agreements for P3 facilities including an operational phase, finds the following three contractual approaches to managing energy performance. The contractual classifications outlined below are based on those used by Infrastructure Ontario to internally classify the Energy Management Approach within the associated Project Agreement schedules among their P3 projects (Withheld, 2018c). These are as follows:

a) NA/Incentive: No applicable wording in the contract or a generalised incentive for good energy performance
b) Regression Analysis Model: Use of a prescribed linear regression model to set annual energy targets based on past energy operational use and environmental determinants. Targets used to calculate annual Painshare/Gainshare payments based on energy performance.
c) Bid Energy Model: Energy model provided by all proponents at bid, with associated energy use over operating term incorporated in a competitive evaluation of life cycle project cost. Annual energy targets from model adjusted per environmental determinants and used to calculate annual Painshare/Gainshare payments based on energy performance.

The contractual complexity and transfer of operational energy use risk to the private sector partner increases from Energy Management Approach a) to c). When accepted these can come with increased pricing of the associated risk into the value of the upfront bid.

Analysis of the Project Agreements for the hospitals studied with respect to their Energy Management Approach finds that Facility 1 follows Regression Analysis Model (Approach b) and Facility 2 follows the Bid Energy Model (Approach c). Both facilities attempt to incentivise energy efficiency through Painshare/Gainshare mechanisms that compare actual electrical and natural gas consumption to Annual Energy Targets. The primary difference is that for Facility 1 these targets are based on past operational consumption, after collecting data from a two year Initial Period at the beginning of the operational term and reset each five years using data collected over the period. Whereas Facility 2's Annual Energy Targets are provided by all proponents at the time of project tender, with associated energy costs over the operating term used in the calculation of the Net Present Value bid price for selection of the winning team. At both sites, these targets are adjusted annually to account for changes to programming within the building and weather conditions. Generally speaking, if actual electrical or gas use is greater than the target then the Project Company must reimburse the hospital for 100% of the discrepancy, whereas if energy usage is under the target then the Project Company and hospital share savings equally. A Utilities Management Subcommittee oversees energy and water use and meets quarterly with strict monitoring and reporting requirements, though, water efficiency is not incentivised during the operating term.

3.5 Methods

The research question leading this study is: *For the facilities included in this study, considering the context of their P3 contract, how do the facilities' operational energy use and associated environmental performance compare to one another and similar facilities?* The question is addressed using a retrospective, longitudinal Case Study (Creswell, 2014, Hammersley, 2004) of the site. The Case Study is a commonly used method (Shang and Zhang, 2013, Olesen, 2014) that enables researchers to focus on details of specific systems and the decision-making processes associated with them in order to develop a concrete study of a discrete facility (Yin, 2009). This approach can provide a practical, context dependent example with great value for policy-makers (Flyvbjerg, 2012).

The majority of research in the field is restricted to development of theory or examining the large initial development costs. These have been an attractive study option for early researchers as well as industry, the media and general public, partially due to limited availability of empirical data from the operational phase (Chen et al., 2015). Additionally, upfront costs are higher per unit of time, making them appear more significant. Minimal *ex post* analysis has been conducted on the long term implications of delivery structures on the life cycle effectiveness and cost of the infrastructure (Stafford and Stapleton, 2017). The operations, maintenance and upgrading phases generally surpass upfront development costs over the life of the infrastructure and thus have huge significance on the overall sustainability of the project (Rahman and Vanier, 2004). Operational energy use, in particular, is a major component of hospital FM budgets (Adams et al., 2010).

3.5.1 Facility Energy Use Intensity

There are multiple sources of energy used on site, most notably electricity and natural gas but also a small amount of diesel fuel for generators. Diesel fuel use is very minor compared to the electrical and natural gas consumption and is not tracked like electrical and natural gas consumption. For the purposes of this study, the facility's Total Energy Use is a sum of the electrical and natural gas use, all of which are reported in Gigajoules (GJ). Utility supplier bills report electricity use in kilowatt-hours (kWh) and natural gas in m^3. Electricity is converted at 0.0036 GJ/kWh and Natural Gas is converted at 0.0375 GJ/m^3. The Energy Matters section of the Project Agreement prescribes that utility bills shall serve as the source of actual energy consumption for the facilities however these figures were compared to on-site meters for both electrical and natural gas consumption. Only minor variations of about 2% were found between the figures, well within the typical 5% margin of error for site metres, so utility bills were maintained as the source for this study (Withheld, 2015-2018).

The Total Energy Use figure used above contains a mixture of natural gas, a raw fuel referred to as a primary energy source, and electricity, a converted product referred to as a secondary energy source. The calculation of Source Energy accounts for the total primary fuel needed to provide the facility with heat and electricity. In order to do this Source Energy incorporates losses that occur in the distribution, storage and dispensing of the primary energy sources (e.g. natural gas) and for conversion losses at the plant in addition to losses incurred during transmission and distribution of secondary energy sources (e.g. electricity) (Energy Star, 2013). The efficiency of energy production and distribution depends on the types of primary fuels that are consumed, the specific equipment that is used and efficiency differs by region. In order to provide comparisons of building energy efficiency relative to a national peer group national-level source-site ratios were used to convert from site energy use to source energy use. The Source-Site Ratio for Electricity purchased from the grid in Canada is 2.05 and for Natural Gas it is 1.02 (Energy Star, 2013).

Dividing energy use by an index value aids comparison of the facilities' energy use to those of different sizes. Typical index values can include number of units, beds or full time staff equivalents but the most commonly used, and that of this study, is gross floor area (m^2), thus allowing for more data to compare to. Most notably, this includes the broad national surveys of energy use by commercial and institutional buildings conducted by Natural Resources Canada (Energy Star, 2016a, Natural Resources Canada, 2018). An EUI based on Source Energy provides the most equitable way to combine primary and secondary energy types into a common unit by ensuring that no building receives either a credit or a penalty based on its energy source or utility. The National Median Source EUI is a recommended benchmark metric for buildings for comparing relative energy performance, rather than the mean, because it more accurately reflects the mid-point of energy use for most property types (Energy Star, 2016a). The Source EUI is collected from customised Energy Star reports with units of GJ/m^2 (Energy Star, 2019).

3.5.2 Energy Star Score

Energy Star is an external benchmarking system for commercial buildings developed by the Environmental Protection Agency (EPA) in the United States and in 2013 Natural Resources Canada joined with the EPA to expand the scoring system to Canadian buildings (Energy Star, 2014). There are currently 13 property types in Canada for which Energy Star scores are calculated (Energy Star, 2017). Both hospitals in this study are classified as a "Residential Care Facility" as this applies to facilities providing "permanent rehabilitative, restorative and/or ongoing skilled nursing care to patients or residents in need of assistance with activities of daily living" including those treating "mental health issues, substance abuse, and rehabilitation for injury, illness, and disabilities" (Energy Star, 2016b).

Using building details such as gross floor area, proportion air conditioned, number of beds, number of staff and location the online measurement and tracking tool Energy Star Portfolio Manager® calculates a predicted Source EUI using an equation based on a weighted ordinary least squares regression across a filtered data set of 142 observations (Energy Star, 2016b). These observations are for senior and residential care facilities in Canada based on data from the Survey of Commercial and Institutional Energy Use (SCIEU) commissioned by Natural Resources Canada and carried out by Statistics Canada based on energy consumption in 2009 (Natural Resources Canada, 2012). The Energy Star Score, expressed as a number on a 1 - 100 scale, is assigned based on an efficiency ratio between the actual Source EUI and the predicted Source EUI value on a percentile basis (Energy Star, 2014) and collected from customised Energy Star reports (Energy Star, 2019).

3.5.3 Greenhouse Gas Emission Intensity

In order to better track the environmental performance of the facilities associated with their energy usage, another metric studied is greenhouse gases (GHG) emissions. The energy used in commercial buildings accounts for roughly one quarter of worldwide emissions of GHGs of which Carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) are the most significant (Levine et al., 2007). The method for calculating GHG emissions combines direct and indirect emissions based on the Greenhouse Gas Protocol Corporate Accounting and Reporting Standard developed by the World Resources Institute (WRI) and World Business Council for Sustainable Development (World Resources Institute and World Business Council for Sustainable Development). GHG emissions are reported in kilograms of CO_2-equivalent and are also indexed by gross floor area to aid comparison between facilities of different sizes, resulting in a GHG Emission Intensity metric with units kgCO2e/m². Figures are retrieved from customised Energy Star reports (Energy Star, 2019).

Emissions are calculated by multiplying site energy values by provincially-based CO_2-equivalent emissions factors obtained from Canada's National Inventory Report (Statistics Canada, 2012) that incorporate the reference global warming potential of each gas (CO_2=1, CH_4=25, and N_2O= 298). To calculate direct GHG emissions, a default fuel analysis approach is used which assumes fuel-specific factors for heating value, carbon content, carbon to CO_2

ratio (12:44), and carbon oxidation factor (100%) for each fuel, and fuel-specific, commercial sector factors to estimate the relatively small CH_4, and N2O emissions associated with on-site fuel consumption. The Direct GHG Emissions Factor in CO_2-equivalent emissions for Natural Gas use in Ontario is 51.91 kg/MBtu. To calculate indirect emissions associated with the purchase of a utility-supplied electricity regional GHG factors are used to compute the GHG based on measured power plant data from utility owners and operators that accounts for differences in electric generation, transmission, and distribution methods. The Indirect GHG Emissions Factor in CO2-equivalent emissions for Electricity use in Ontario is 35.17 kg/MBtu (Energy Star, 2016c).

3.6 Study Findings

Figure 6 provides a summary of Source EUI and Energy Star Scores over the four complete energy years that the facilities have been in operation, from 1 April 2014 to 31 March 2018. The annual Source EUI of Facility 1 (average = 3.30 GJ/m²) is consistently greater than that of Facility 2 (average = 2.01 GJ/m²) and the National Median value (average = 2.09 GJ/m²). Both show improving trends in Source EUI ($m_{Facility\ 1}$ = -0.0003, $m_{Facility\ 2}$ = -0.0006), while the National Median value shows a very slight increase (m = 0.0002), though Facility 2 shows significantly greater improvements.

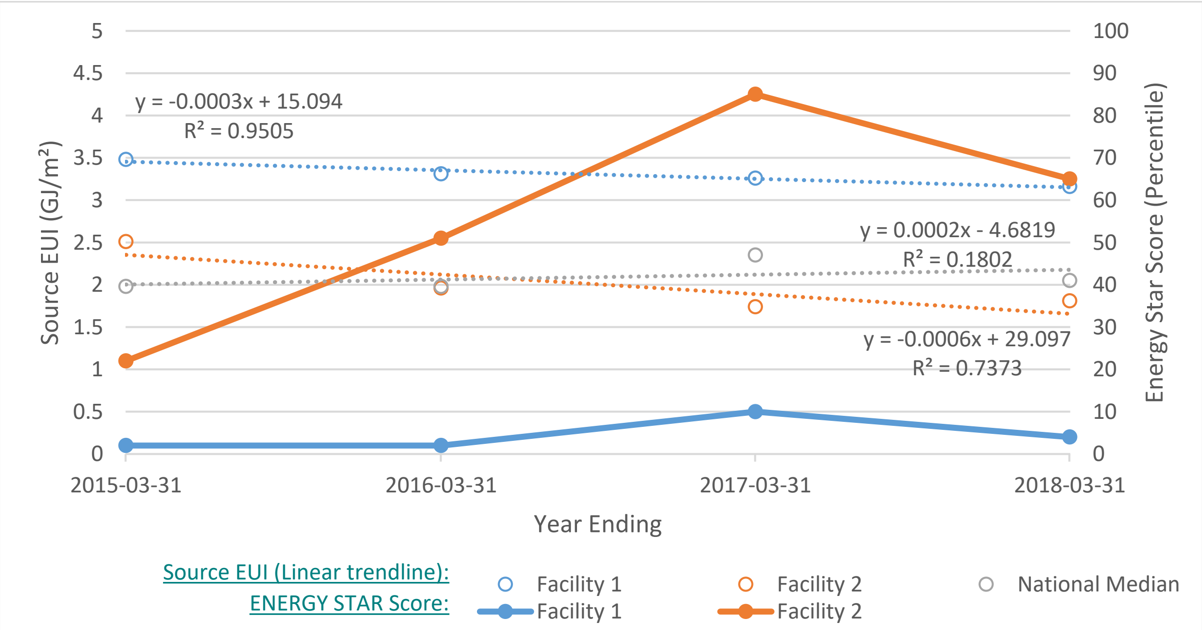

Figure 6: Facility Energy Intensity and Energy Star Scores, Facility 1 and Facility 2

The relative energy performance of the two facilities is reflected more clearly through the Energy Star Score, which for Facility 1 (average = 4.5) is consistently below than that of

Facility 2 (average = 55.8). As the Energy Star Score is a comparison of the facilities' energy performance verses similar facilities across the country, recorded as a percentile, the National Median value is always 50. As with Source EUI figures, both facilities show improving trends in their Energy Star Scores though this is much greater for Facility 2. Facility 1 had a low value of 2 in the first year and a high value of 10 in the third year while Facility 2 went from a low of 22 in the first year to a high of 85 in the third year. Facility 1 initially outperformed only 2% of similarly classified facilities across the country, and a maximum of 10% in the third year, while Facility 2 initially outperformed 22% of all similar facilities rising to 85% in the third year. Both facilities' relative performance dropped somewhat in the fourth year to 4 and 65 respectively, levels still better than the first two years.

Corresponding with the energy performance metrics above, Figure 7 summarises the facilities' GHG Emission Intensity over the four complete energy years that the facilities have been in operation. Annual GHG Emission Intensity of Facility 1 (average = 94.9 kgCO2e/m²) is consistently greater than that of Facility 2 (average = 49.1 kgCO2e/m²). GHG emissions at both sites have trended downward, in line with their energy use. These reductions have also been much greater at Facility 2 than Facility 1, 40% versus 15% less, respectively, between year 1 and year 4.

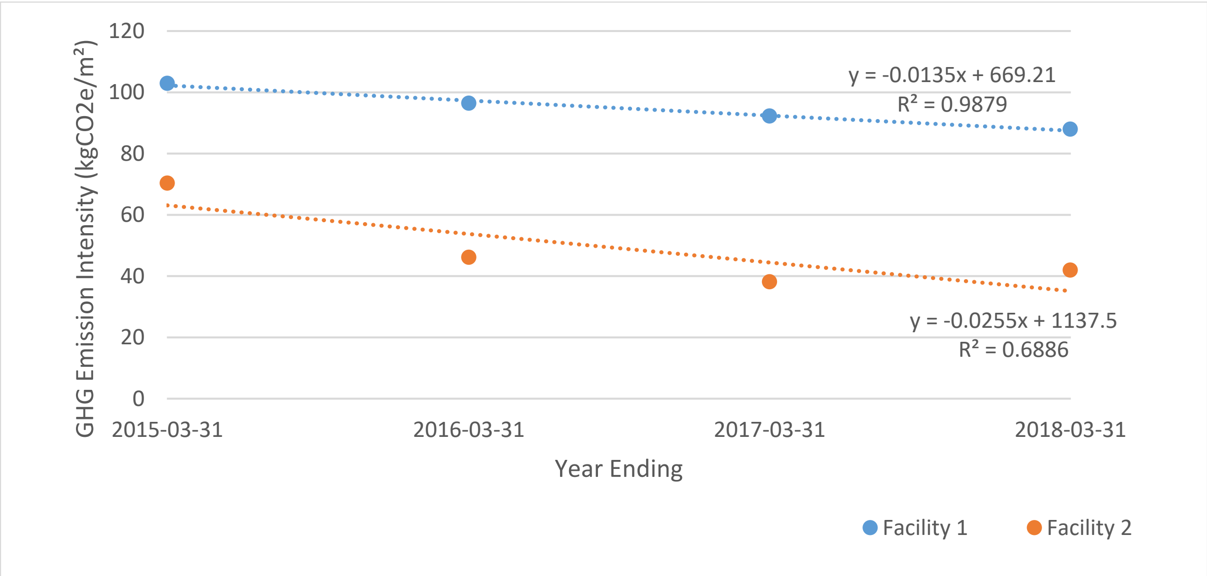

Figure 7: Facility Greenhouse Gas Emission Intensity, Facility 1 and Facility 2

3.7 Analysis

Many new facilities do not perform as designed, requiring investments of time and money to conduct extensive post-commissioning tweaking and modifications to the complex systems within modern buildings (CIBSE, 2013). This was true for both hospitals in this study at Substantial Completion and in the first years of operations. Despite being modern LEED Silver and Gold rated buildings, according to their Energy Star Scores, Facility 1 outperformed only 2% of similar facilities nationally in the first year of the study and Facility 2 outperformed only 22% of similar facilities. Although Facility 2 had better initial energy performance than Facility 1 across all metrics included in this study, it improved its performance much more over subsequent years. In the second year Facility 2's energy performance surpassed the National Median value and significantly surpassed it in the third and fourth years, all while Facility 1's performance peaked at the tenth percentile in the third year of the study.

A primary difference between the sites is the contractual approach their P3 Project Agreements take to energy management, specifically how they set the Annual Energy Targets used to incentivise energy efficiency through Painshare/Gainshare mechanisms. Facility 1's Project Agreement uses a Regression Analysis Model where Annual Energy Targets are based on operational consumption during a two year Initial Period at the beginning of the operational term and reset each five years thereafter. Facility 2 targets are provided by all proponents at the time of bid and associated energy costs over the operating term are used as part of the Net Present Value calculation in the selection of the winning team. Figure 8 demonstrates how this contractual approach is realised in practice by showing the Facility Energy Cost Intensity and Net Painshare/Gainshare Intensity for the two sites over the four operational years studied. Although Facility 1 had consistently higher indexed energy costs over the period (average = 53%), it also had typically more favourable indexed Painshare/Gainshare adjustments for the Project Company.

Facility 2's energy performance in the first year of the study was poor when compared to similar facilities nationally, as represented by its Energy Star Score, and also to its Annual Energy Target. This led to a Painshare payment of over $\$4/m^2$ from the Project Company to the hospital, or about three quarters of a monthly FM service payment. As such, a program was developed to reduce the facility's energy use going forward and a number of interventions took place over the second energy year to reduce consumption including:

- the repair of multiple heat wheels that were not functioning for much of the first winter leading to dramatic increases in Natural Gas use;
- amending occupancy schedules for domestic hot water to reduce Natural Gas use;
- tests and adjustments to condensing and steam boilers' sequencing to increase efficiencies and reduce Natural Gas use;

- adjustments to air handling unit sequencing and schedules to increase occupant comfort and decrease energy use;
- adjustments to lighting schedules and installation of LED lamps in key areas to reduce electrical requirements;
- optimisation of various Building Automation System controls; and
- implementation of energy saving awareness programmes.

These initiatives led to significant savings in the second year, including an almost 50% drop in Natural Gas use and over 10% reduction in electricity use. Correspondingly, there was a much smaller Painshare payment, though savings were somewhat offset by increased prices for Natural Gas and, to a greater degree, electricity. The gains made, along with the incentive of higher energy prices, meant many of the programmes continued in the third year leading to further reductions in energy use to below the Annual Energy Target for the first time that year. This reduction led to over $5/m^2 in energy cost savings to the hospital versus the modelled expenditure of which $1.50/m^2 was provided to the Project Company as its first Gainshare payment.

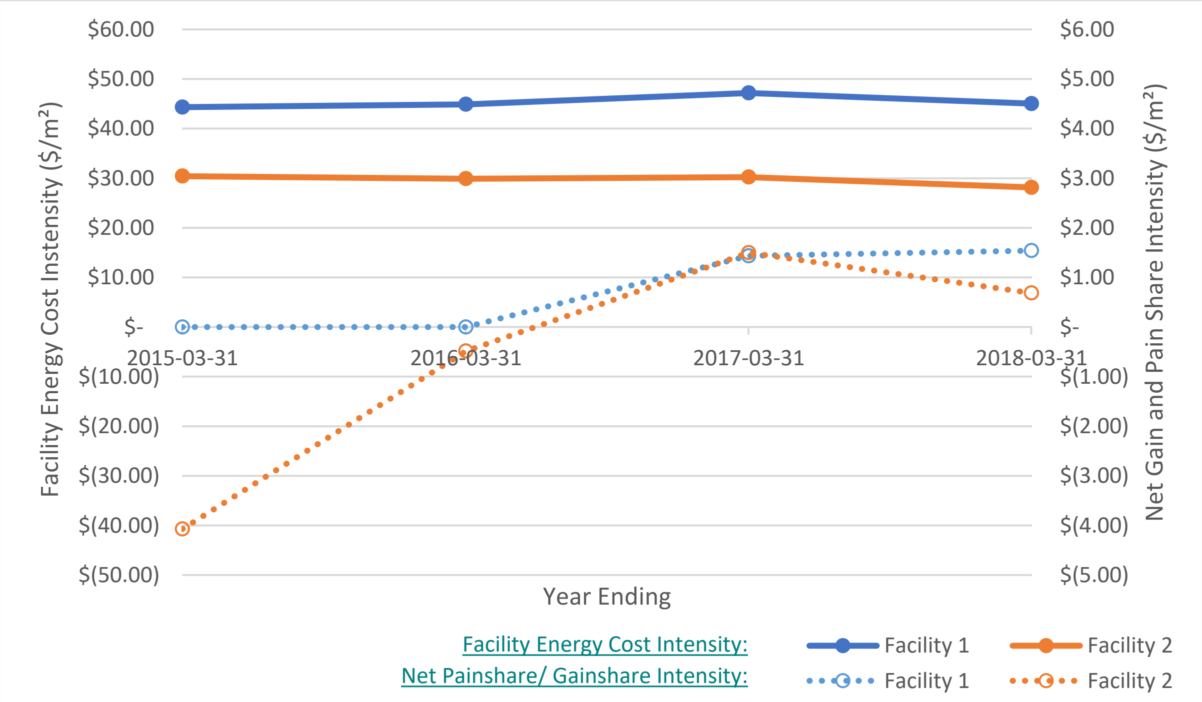

Figure 8: Facility Energy Cost Intensity and Net Painshare/Gainshare Intensity, Facility 1 and Facility 2

In contrast, the first year of this study was the final year of Facility 1's Initial Period. Therefore the Project Company was not subject to Painshare/Gainshare payments and so had minimal need to achieve high energy performance during the period. In fact, there was a disincentive to do so as it would set lower Annual Energy Targets for future years. Over the second, third and fourth years, as long as the Project Company reduced energy use slightly from the Annual Energy Target, it could generate a Gainshare payment. However, pushing energy performance too much would trigger more stringent Annual Energy Targets after the five year reset. Although energy saving interventions, such as those performed at Facility 2, have been proposed the contract disincentivises such investment by the Project Company. This is particularly true if such investments require payback periods longer than the reset frequency, even if the facility is performing below design expectations.

Given Facility 1's substantially higher Energy Intensity throughout the study period, as to Facility 2, the public-sector partner at Facility 1 paid its utility companies a significantly higher amount for energy throughout the year, per m^2 of the facility, and then paid the Project Company a higher Gainshare payment at the end of the year. Corresponding to the two facilities' energy performance, as measured by Source EUI and Energy Star Score, and associated costs are their environmental performance, as measured by GHG Emission Intensity. Strikingly, Facility 2 produced under half the GHG emissions per unit of area than Facility 1 in three of four years. These advances in GHG emissions could have been greater, however, if incentivised directly in the contract.

3.8 Conclusions

This article studies the relationship between facility energy use, including associated environmental performance, and the contractual approach to energy management among P3 hospitals in Ontario, Canada. The author uses a retrospective, longitudinal Case Study to investigate two nursing and residential care hospitals delivered by Infrastructure Ontario under the DBFM structure. The article provides an overview of their history and specifications with emphasis placed on energy use and associated environmental performance in the operations phase as well as associated language within the contract between the Project Company and hospital. The specific research question leading this study is: *For the facilities included in this study, considering the context of their P3 contract, how do the facilities' operational energy use and associated environmental performance compare to one another and similar facilities?*

While both hospitals completed construction in the same year and by the same general contractor, with high LEED certifications, this study's findings show dramatically better energy performance at Facility 2 than Facility 1 throughout the study period, as measured by Source EUI and Energy Star Score. Additionally, though both facilities showed improving trends over the period of study, they were much greater for Facility 2. Facility 1 initially outperformed only 2% of similarly classified facilities across the country, and a maximum of

10% in the third year, while Facility 2 initially outperformed 22% of all similar facilities to 85% in the third year. Both facilities' relative performance dropped slightly in the fourth year. The study found corresponding results for the facilities' associated energy costs and environmental performance, measured by GHG Emission Intensity, with Facility 2 producing under half the GHG emissions per unit of area than Facility 1 in three of four years.

A primary difference between the sites is the approach their P3 contracts take to energy management, specifically how they set the Annual Energy Targets used to incentivise energy efficiency through Painshare/Gainshare mechanisms. Facility 1's Project Agreement uses a Regression Analysis Model where Annual Energy Targets are based on operational consumption and reset each five years. Facility 2's Annual Energy Targets are provided by all proponents at the time of bid and associated energy costs over the operating term are used in the selection of the winning team. As a result, although Facility 1 had an average of 53% higher indexed energy costs over the study period, it also paid much higher net Gainshare payments to the Project Company. In comparison, while the first two years of Facility 1's operations were used to set future years' Annual Energy Targets, during these years major Painshare adjustments were leveraged to the Project Company at Facility 2 for not meeting the Annual Energy Targets established during the bid phase. The risk of future payments inspired major work to correct a multitude of lingering design, construction, commissioning and operational issues that are common within the complex systems of modern buildings. While similar improvements were proposed for Facility 1, they are not incentivised contractually and have not occurred.

Additionally, Facility 1's linear regression model used to set the formula for the Annual Energy Targets is reset every five years. This mitigates associated risks to the Project Company and reduces the opportunity for using future increased Gainshare payments, or decreased Painshare payments, to finance investments by the Project Company into energy upgrades. In practice, the Regression Analysis Model of Facility 1 protects the hospital against major reductions in energy performance – through potential Painshare payments by the Project Company - and incentivises modest operational improvements – through potential Gainshare payments to the Project Company. The approach does not, however, incentivise investment by the Project Company into energy upgrades that require payback periods longer than the frequency of resets to the energy target formula, even if the facility is performing substantially below design expectations.

Recognising the limitations of studying two facilities over four years, generalised lessons are identified for project planners and policy makers preparing to procure such facilities in the future. Most importantly, while much academic and industry literature dedicated to improving building energy efficiency (and/or associated environmental performance) emphasises technical interventions, the findings of this study demonstrate the importance of contractual interventions and their use as a tool to promote such desired outcomes. Specifically, Facility 1's contractual language does not take advantage of opportunities made available by bundling design, construction and operating phases to drive energy efficiency at each phase through the transfer of operational energy performance risk to the Project Company. Instead, the Bid Energy Model approach of Facility 2 maximises the opportunity of the hospital to transfer operational energy use risk to the Project Company through the bundled DBFM structures. This is achieved through inclusion of operational energy costs within competitively tendered bids. Additionally, corresponding Annual Energy Targets over the operating term to hold the Project Company accountable through Painshare/Gainshare payments. The approach informs decision making by the private-sector consortium throughout the design, construction and operational phases of the project to reduce life cycle costs associated with energy and helps drive the positive performance demonstrated in this study.

3.8.1 Future Research

As a single Case Study over only a few years of operations, generalisations are limited in the findings. Important future development of the research would be to continue following the facilities as they mature and to include other categories of P3 and conventionally-procured health care facilities to investigate the relationship between their contracts and resource use more generally. Investigating the effects of an intervention to adjust the contractual approach to Energy Management a Facility 1 would be an interesting Action Research study.

4 Article 3: Are Public Private Partnerships Sustainable? A study of facility resource use effectiveness at a Canadian health care corporation

4.1 Abstract

In recent years an increasingly diverse range of infrastructure delivery structures are being used with little empirical understanding of their long-term implications on operational performance, particularly regarding resource use. Across Canada, and the province of Ontario in particular, this is marked by a notable shift favouring Alternative Finance and Procurement approaches, including the use of Public-Private Partnerships (P3s). With focus on resource use during the operational phase, this paper provides a Case Study of a specific health care corporation in Ontario, Canada including an early P3 hospital delivered by Infrastructure Ontario under the Design-Build-Finance-Maintain (DBFM) structure, as well as a conventionally procured and operated facility. The article identifies the practical influences and challenges associated with the facilities' procurement and operations in order to consider broader implications for future research and to support planning and policy work.

The author uses empirical data to study facility energy use and Facility Management labour performance, supplemented by facility user surveys, interviews of key stakeholders and contractual study. Findings show consistently better performance at the P3 facility, though after a short bedding-in period for energy performance. Many best practices were transferred from the P3 facility to the conventionally procured facility to improve data tracking and reporting, but internal accountability remains a challenge and budgeting factors negatively impact the conventionally procured facility. The mix of strong financial penalties and incentives within the P3 contract between Project Company and the hospital, which all proponents' bids were subject to in the procurement phase, are identified as likely drivers for high performance of energy use and maintenance activities directly, and facility user satisfaction levels indirectly. Notably, the dramatic improvements in energy use at the P3 site is not matched by the facility's water use, for which, unlike energy, conservation is not incentivised in the contract.

4.2 Keywords

Infrastructure delivery, facility operations, resource use, Public-Private Partnerships

4.3 Introduction

Governments around the world spend over a trillion dollars of public money a year on social infrastructure, such as hospitals (Woetzel et al., 2016). Shaoul et al. (2007a) identified an increasing diversity of infrastructure delivery structures being used with little empirical evidence of their long-term implications on effectiveness and cost, which still holds true.

Across Canada, and the province of Ontario in particular, this is marked by a notable shift favouring the use of Public-Private Partnerships (P3s), often positioning them as means to encourage innovation across the life cycle of major infrastructure projects (Himmel and Siemiatycki, 2017). Yet, in particular, very few *ex post* accounts of operational facilities exist in the academic or industrial literature, particularly of P3 health care facilities (Roehrich et al., 2014).

The purpose of this paper is to empirically identify relationships between variations in facility delivery structure and operational outcomes. This is achieved through a Case Study of a health care corporation in Ontario, Canada with two large hospitals, one conventionally procured and maintained by hospital staff and one facility delivered as a P3. The author provides description of the facilities' background and compares performance between the sites using empirical data for specific Facility Management (FM) processes, supported by facility user surveys and interviews with key stakeholders. Analyses are underpinned by contractual study and the author's in-depth knowledge of the facilities and their management structures. Recognising the limitations of generalising findings from a single Case Study, analysis within considers broader implications for future research.

Having reached Substantial Completion in 2013, the study includes one of the more mature P3 hospitals in Canada. As such, it is well positioned to identify practical influences, successes and challenges associated with infrastructure operations and maintenance under the different delivery models. Though advocates increasingly identify P3s as a tool to encourage innovation, specifically toward cost reduction and enhanced quality (Regan et al., 2011), empirical evidence to support such claims is limited and so it is unclear whether these innovations are actually being realised (Siemiatycki, 2015). This makes the study particularly important for policy makers and practitioners in the field.

4.4 How to Measure Facility Resource Use Effectiveness

Research in the field is largely theoretical and most of the limited empirical contributions have focussed on initial development costs due to limited availability of data from the operational phase (Chen et al., 2015). As such, minimal *ex post* analysis has been conducted on the long term implications of delivery structures on the life cycle effectiveness and cost of the infrastructure (Shaoul et al., 2007a). This is despite the operations, maintenance and upgrading phases generally surpassing upfront development costs over the life of the infrastructure, thus having huge significance on the overall sustainability of the project (Rahman and Vanier, 2004). The operational phase is the focus of this study, with the leading research question: *Is there a relationship between variations in hospital delivery structure and effective resource* *use during operations, within a specific health care corporation in Ontario, Canada?* The question is addressed using a Mixed Methods approach involving a retrospective Case Study (Creswell, 2014, Hammersley, 2004) of the site with both quantitative and qualitative analyses. The Case Study is a commonly used method (Shang and Zhang, 2013, Olesen, 2014) that enables researchers to focus on details of specific systems and the decision-making processes associated with them in order to develop a concrete study of discrete facilities (Yin, 2009). This approach can provide a practical, context dependent example with great value for policy-makers (Flyvbjerg, 2012) and has been used well with hospitals, including P3s (Chung, 2009b).

Available quantitative data on facility maintenance staffing levels, energy use and user satisfaction was obtained and used to compare operations between the facilities. Analysis of this information is supported by relevant quotations from exploratory semi-structured Elite Interviews (SAGE, 2006) of two key personnel managing the facilities within the health care corporation (details in Appendix F). The interviewees included FM Committee members of the P3 facility in senior roles within the hospital and the Project Company. The individuals were purposely selected due to their unique and longstanding involvement with the P3 project throughout the procurement, design-build and operational phases. Representing both the public and private-sector partners, in order to attempt to balance their respective biases, the interviewees were asked questions specific to the facilities included in the Case Study as well as general questions on the use of P3s for health care, with emphasis on operational outcomes. The hospital's representative manages all of the health care corporation's facilities so was able to provide valuable insights into the various approaches used.

4.5 The Subject

The health care corporation studied is a regional, tertiary academic health science and research centre operating multiple campuses within a major urban centre in Ontario, Canada. Founded in the mid-19th century, the organisation serves hundreds of thousands of patients annually with over 4,000 staff, 700 physicians and 600 volunteers and average expenditures of over $500 million. Its two main hospitals, located under one kilometre from one another, are included in this study. Facility A is a downtown acute care hospital with over 600 beds, surgical centre, emergency department and birthing programs as well as numerous research institutes (Withheld, 2017). The site was initially occupied at the turn of the 20th century and the current facility was developed in multiple phases since that time. The majority of its current 118,000 m^2 (Indoor Floor Space, IFS) structure completed in 1990 (Savage, 1990) and the latest renovation and major expansion completed in about 2010 (Interviewee 2, 2017).

Facility B is a low-rise, 80,000 m^2 (IFS), over 300 bed, tertiary-care mental health hospital. The facility provides inpatient and outpatient care to those suffering with severe mental illness or addiction, as well as medical outpatient clinics and diagnostic imaging services to the community, administrative, education and research space (Withheld, 2017). The facility reached Substantial Completion in 2013, replacing a former regional psychiatric hospital about half the size and made up of a collection of 60 to 150-year-old buildings that housed inpatient and outpatient services. The new facility has 49% more beds and 62% more outpatient services than its predecessor with a vision to be recovery-oriented, destigmatising and uplifting through the use of design elements to integrate mental health and community services plus improve the quality of care, user satisfaction and safety (Ahern et al., 2015).

The hospital's redevelopment team initially began procuring the new facility under a traditional delivery model. Delivery as a P3, using the Design-Build-Finance-Maintain (DBFM) structure, was a funding requirement imposed late in the process by Ontario's Ministry of Health and Long Term Care (MoH or Ministry). *"We had already done all of the work and were ready to award a contract and the Ministry said 'put on the breaks, this is going to be a DBFM' and we had no choice in the matter; if we wanted Ministry funding that is… Honestly, I think the reason why we're doing this model is because the Ministry didn't have the funding"* (Interviewee 2, 2017). Despite Interviewee 2's reluctance, the change in delivery model to a P3 with an operating phase allowed application of the contractual mechanisms designed to promote maintenance, life cycle and energy performance throughout operations. The effectiveness of these mechanisms are investigated in this study. Facility B's 2009 procurement (Withheld, 2008) was based on the contentious (Auditor General of Ontario, 2014) VfM calculations conducted for Infrastructure Ontario identifying a 14% cost savings over a hypothetical traditional delivery model (Infrastructure Ontario, 2011).

Though the construction phase met the targeted Substantial Completion date and Construction Variations only added about 0.5% to the capital price at bid (Withheld, 2015a), as with any project the construction was not without its challenges. With respect to the proposed benefit of bundling in DBFM contracts, Interviewee 2 (2017) stated, *"The selling feature of this kind of procurement model was meant to be the synergies between the operations component and the mechanical and electrical designers making things the way they should was supposed to be part of the process. I don't know if that actually happened because, although [the Service Provider] sat at the table in all of the design meetings they literally didn't speak once… All of that expected expertise being brought during the design phase didn't happen. I think [this led to] some of the issues that we have [in operations]."* The issues Interviewee 2 refers to include problems typical in the early-stage operations of such complex modern buildings. Examples of issues experienced at Facility B include poor functioning of security components such as the real-time locating system as well as the required interventions to rectify energy performance discussed within Section 4.6.1.

Additionally, about six months before Substantial Completion a major subcontractor on the job went into receivership, leading to a scramble by all parties in the final months of construction and through commissioning. In retrospect, Interviewee 1 (2017) confirmed, *"The building was not ready. OK. It was not ready [at Substantial Completion]"*. Despite the problems, Interviewee 1 (2017) points out that, *"the DBFM [model] is what saved [the hospital], quite frankly, because had this been a Design-Build, with that receivership it would have been just horrific for the hospital to try and go back to [the builder]. Just think of how many resources the hospital would have had to marshal to understand the technical nature of the problems and to be able to take the design-builder to task. Now they just look at it and say 'it's broken, we've got penalties, you fix it'."*

Ultimately, as an early Canadian P3 and one of the first health care facilities in Ontario to be constructed on a brownfield site the project served as an example for procuring authorities across Canada as they began to look at P3s in general and specifically for major redevelopment and renovation projects. The Project Company challenged the initial design concept and created one that was more compact, intending to bring key activities closer together and reduce construction and operating costs (Withheld, 2015b). The site achieved LEED Gold certification in 2014 (Canadian Green Building Council, 2014), exceeding the Request for Proposal (RFP) obligation of LEED Silver (Withheld, 2008).

4.6 Key Metrics

In order to address the research question the study focussed on two primary resources used in the management of the subject facilities, resources that are required for the facilities to provide the services necessary to clinical staff and patients. Those resources are energy, in the form of electricity and natural gas, and unionised labour within the FM team. These resources are also two of the most significant expenditures in the FM budget and therefore good proxies for comparable core facility operating expenditure, which was unavailable as the health care corporation studied does not produce either public or internal annual reports to track these figures (Interviewee 2, 2017). Additionally, in order to investigate the effectiveness of the FM resource use, the study includes satisfaction survey data of building users collected in previous years by the FM teams for analysis and comparison.

4.6.1 Energy Use

Energy use is one of the most significant expenditures on FM budgets (Adams et al., 2010). There are multiple sources of energy used at the facilities. Most notably these include Natural Gas, a raw fuel referred to as a primary energy source, and electricity, a converted product referred to as a secondary energy source. These energy forms are summed to provide the total energy use. Consumption statistics are collected from utility supplier bills that report Natural Gas use in m^3 and electricity use in kilowatt-hours (kWh). Total energy use is reported in Gigajoules (GJ) with Natural Gas converted at 0.0375 GJ/m^3 and electricity converted at 0.0036 GJ/kWh. A small amount of diesel fuel is used at the sites for generators but is very minor compared to the electrical and Natural Gas consumption, not tracked as closely and therefore excluded from the study. Also excluded is electricity produced by photovoltaic panels installed on the roof of Facility B in 2016 as they are owned by a third party leasing roof space from the hospital and feeding produced electricity directly into the grid for general use.

Building energy efficiency also depends on source selection due to production and distribution impacts, which vary by location. Source-site ratios are applied to the Natural Gas and electricity use to convert to Source Energy Use to account for the total primary fuel needed to provide the facility with heat and electricity by incorporating losses from the distribution, storage and dispensing of the primary energy sources (e.g. Natural Gas) and conversion, transmission and distribution losses for secondary energy sources (e.g. electricity). The Source-Site Ratio for Natural Gas in Canada is 1.02 and for electricity purchased from the grid is 2.05 (Energy Star, 2013). In order to aid comparison between sites, the Source Energy Use is divided by the IFS to produce a Source Energy Use Index (EUI), which provides the most equitable way to combine primary and secondary energy types into a common unit by ensuring that no building receives either a credit or a penalty based on its energy source or utility (Energy Star, 2016a). The Source EUI is reported in GJ/m^2.

Energy Star is an external benchmarking system for commercial buildings developed by the Environmental Protection Agency (EPA) in the United States. In 2013 Natural Resources Canada joined with the EPA to apply the scoring system to Canadian buildings as well (Energy Star, 2014). There are currently 13 property types in Canada for which Energy Star scores are calculated (Energy Star, 2017). Facility A is classified as a “Hospital (General Medical & Surgical)” while Facility B is classified as a “Residential Care Facility” as this applies to facilities primarily providing “permanent rehabilitative, restorative and/or ongoing skilled nursing care to patients or residents in need of assistance with activities of daily living” including “mental health and substance abuse facilities”. Using building details such as gross floor area, proportion air conditioned, number of beds, number of staff and location the online measurement and tracking tool Energy Star Portfolio Manager® calculates a predicted Source EUI using an equation based on a weighted ordinary least squares regression across a filtered data set of 142 observations (Energy Star, 2016b). These observations are for facilities in Canada with the same classification, based on data from the Survey of Commercial and Institutional Energy Use (SCIEU) commissioned by Natural Resources Canada and carried out by Statistics Canada based on energy consumption in 2009 (Natural Resources Canada, 2012). The Energy Star score, expressed as a number on a 1 - 100 scale, is assigned based on an efficiency ratio between the actual Source EUI and the predicted Source EUI value on a percentile basis (Energy Star, 2014).

Figure 9 provides a summary of energy use intensity, as measured by Source EUI, at Facility A and Facility B between 2014 and 2017, the four years for which Facility B has been in operation. Energy use intensity was generally flat ($m_{trendline,1,EUI} = 0.018$) over the four years at Facility A, with an average value of 3.70 GJ/m2. Energy use intensity had a strong downward trend ($m_{trendline,2,EUI} = -0.232$) over Facility B's first four years of operations. Corresponding to the findings for facility energy use intensity, Figure 10 shows Energy Star scores for Facility A and Facility B over the same period. Energy Star Scores at Facility A had a slight downward trend ($m_{trendline,1,ES} = -3.1$) over the four years, from outperforming 57% of similar buildings surveyed in 2014 to 44% in 2017. Facility B's Energy Star scores had a strong upward trend ($m_{trendline,2,EUI} = 16.3$) from outperforming only 22% of similar buildings surveyed in its initial year whereas in 2017 it outperformed 65%, with peak performance in 2016 when it was in the 85th percentile compared to similar buildings surveyed.

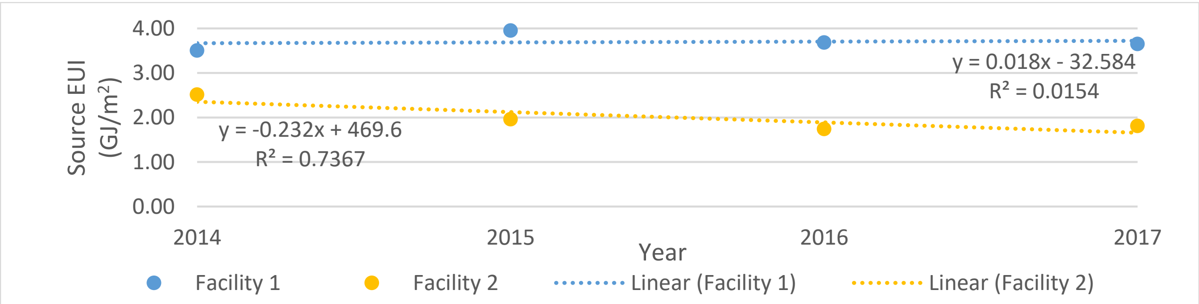

Figure 9. Facility annual energy use intensity at Facility A and Facility B, 2014-2017.

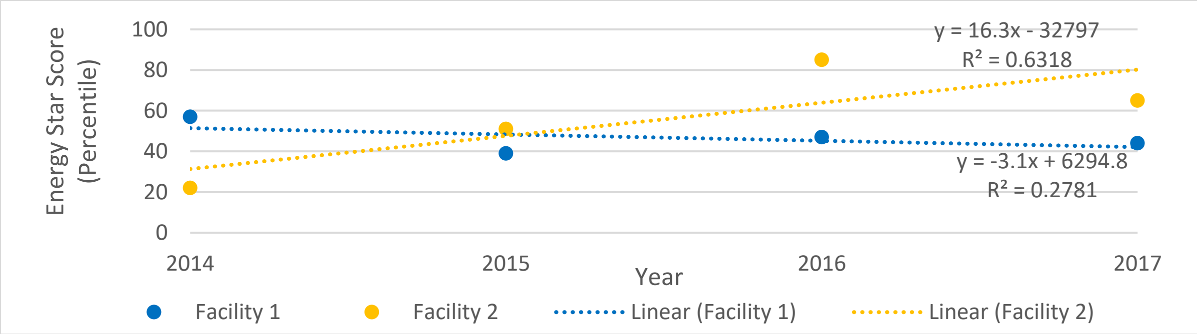

Figure 10. Facility Energy Star Score at Facility A and Facility B, 2014-2017.

These findings show relatively flat, if not slightly worsening, energy performance at Facility A that, with an average Energy Star score of 47, is generally below the performance at comparable sites. This compares to dramatically improved performance at Facility B over the same period; though the facility had very poor performance compared to similar buildings in its first operational year, it quickly improved to be near the top of its class. Why might this be? The health care corporation pays providers directly for building energy and utilities at both facilities and so should be motivated to achieve energy efficiency by reduced energy costs at both sites. At Facility B, the Project Company is not responsible for purchasing energy directly but energy is managed by the Project Company and efficiency is strongly encouraged through the contract between the hospital and the Project Company, specifically within the "Energy Matters" Schedule (Withheld, 2010b). The strongest tool to incentivise energy efficiency is the Painshare/ Gainshare structure that compares actual electrical and natural gas consumption to an Annual Energy Target (AET) provided by all proponents at the time of bid and used in the selection of the winning team. The AET includes Discrete Energy Targets (DET) for both Electricity and Natural Gas consumption, which are adjusted annually over the contract term based on weather data, programme changes and building modifications (Withheld, 2010b). If actual electrical or gas usage is greater than 105% of the Adjusted DET (ADET) then the Project Company must reimburse the hospital for 100% of the discrepancy, whereas if energy usage is 80%-95% of the ADET then the Project Company and the hospital share savings equally. Any savings greater than 20% of the ADET go 100% to the Project Company (Withheld, 2010b). These figures are provided within the Energy Analysis Reports provided annually (Withheld, 2015-2018).

As the findings show, there were problems with Facility B's energy use at Substantial Completion. As a LEED Gold facility it was expected to outperform most buildings but, as the Energy Star score (22) shows, it did not perform well in the first year. In fact, many new facilities do not perform as designed, including LEED facilities. Therefore, they require large investments of time and money to conduct extensive post-commissioning adjustments to the complex systems within modern buildings, though the work is often not done (CIBSE, 2013). Instead, Facility B's contract strongly financially-incentivises energy performance and the exceedance of the energy target in 2014 resulted in a Painshare payment to the hospital of over $300,000; a significant portion of the operational portion of the Monthly Service Payment. As such, a program was developed to reduce the facility's energy use going forward and a number of interventions took place over the second energy year to reduce consumption. These interventions included: heat wheel repairs, amending occupancy schedules, adjustments to condensing and steam boilers' and air handling unit sequencing and schedules, installation of LED lamps in key areas, optimisation of Building Automation System controls and implementation of energy saving awareness programmes. As Interviewee 1 (2017) stated, latent construction defects *"are par for the course. These occur past the warranty period, something that was working - was tested, tried and proven - and then broke some time later. We ran into some issues on the [heat] wheels, they all started falling apart … but [the Project Company consortia members] worked their way through the process. It's the ongoing P3 relationships between [the consortia members] that allowed that process to work successfully. I believe you would be less successful in a Design-Build type of environment because the design builder wouldn't have any liability so [the hospital] would have to end up taking the equipment manufacturer to task."*

The energy initiatives led to significant savings in 2015 and a much smaller Painshare fee. The gains made, along with the incentive of higher energy prices, meant many of the programmes continued in 2016 leading to further reductions in energy use to below the adjusted AET for the first time that year. This reduction led to over $400,000 in savings in energy costs versus the modelled expenditure, of which over $100,000 was provided to the Project Company as its first Gainshare payment. Although benchmarks other than the AET are not used much at the site, the inclusion of AET with the Aggregate Energy Model in the competitive tender process did result in an Adjusted AET that, once met, allowed the facility to achieve substantial increases in its Energy Star score. The Source EUI performance, and associated Greenhouse Gas emissions, could have improved, however, if incentivised directly. For example, these figures would be markedly better if the photovoltaic array installed on the building roof was used by the facility directly to reduce grid energy use, as proposed unsuccessfully as an innovation in the Project Company's original bid, but this would remove a separate revenue stream for the hospital.

While not an emphasis of this study, the Project Company's scope covers the management of all utilities at Facility B including water and diesel fuel use. Conservation of neither resource is incentivised in the contract, as done with electricity and Natural Gas use (Withheld, 2010b). As noted above, the total cost of diesel use is insignificant as compared to other forms of energy use and not tracked in the same manner. The unit and total cost of water at the facility are about one tenth those of electricity and half those of Natural Gas, so it also does not demand the same attention by the stakeholders. While corresponding information was not available for Facility A, it is interesting to compare trends in water use to those of energy use at Facility B over the period of study. Reviewing a metric referred to as the Water Use Index (WUI) from 2014 to 2017 shows the following respective values: 0.670 m^3 (water)/m^2 (IFS)/year, 0.635 m^3 (water)/m^2 (IFS)/year, 0.744 m^3 (water)/m^2 (IFS)/year, and 0.706 m^3 (water)/m^2 (IFS)/year. As compared to established industry benchmarks (BOMA, 2017) performance at the site is mediocre. Performance is expected to be quite good because, in order to gain the facility's LEED Gold certification, the design and construction process involved various measures to reduce water use including installation of low flow fixtures and appliances, drought-tolerant plantings and a rainwater collection system. Instead, in comparison to the significant improvements in energy use, annual water use was highly variable over the period, with a possible upward trend ($m_{trendline,2,WUI} = 0.0218$). Unlike for electricity and Natural Gas use, with no contractual Key Performance Indicators or incentives included in the P3 contract to motivate the Project Company to help the hospital conserve water throughout the operations phase, minimal attention is dedicated to this matter.

4.6.2 FM Labour

FM labour is a key resource to run any health care facility and another very significant expenditure in any FM budget (Adams et al., 2010). Much has been said about private-sector involvement maximising efficiency (Avishur, 2000) of P3s (Fitzgerald, 2004) and Alonso et al. (2016) found evidence of a relationship between the use of P3s and reduced clinical staffing levels in hospitals. Clinical staffing is retained by the hospital in both facilities, as is typical in Canada, but this study looks at unionised FM staffing levels to identify if a similar relationship may exist. Total unionised FM staffing levels are compared between the facilities due to their similar unionised environment and to avoid discrepancies in management structure between the P3 and conventional facilities.

In order to aid comparison between facilities of different size and other characteristics (e.g. age, hospital type) the total staffing levels are separately indexed by the size of the facilities, as measured by IFS, and the number of annual Work Order (WO) events inputted into the facilities' Computerised Maintenance Management Systems (CMMS). Acknowledging that neither is perfect, the study applies two differing approaches to indexing staffing levels in an attempt to improve robustness of findings and offset potential bias imposed through discrepancies in the facilities' age, type and built form or by one or other indexing metric. The use of building size (IFS) to index staffing levels is an established benchmarking practice in industry, including for FM services at health care facilities (Adams et al., 2010). A concern with comparing these two facilities in this manner is that a stated goal when designing and constructing Facility B was to create a new purpose built, space conscious facility in order drive down construction and operational costs. Therefore, a space based index could favour Facility A due to its older, sprawling form with many wings and additions.

Due to the issue outlined above, another FM-staffing level index was sought by the author to support the robustness of associated findings. Bed count, another established index for hospitals, was not used due to the differing type of the hospitals - namely acute verses chronic care. With Facility A adding a CMMS in 2017 in order to manage WOs like Facility B, the opportunity arose to compare the facilities' FM staffing levels using total annual WOs as an indexing metric. As such only 2018 data was used for this comparison. The profile of WOs tends to be similar across facilities on an annualised basis, dominated by minor concerns related to temperature, plumbing, electrical and other systems such as cameras or door controls, which are resolved relatively quickly. The WO profiles can change somewhat over time with a higher prevalence of time consuming issues early in operations - such as at Facility B - while FM staff gain familiarity with the facility, work through quirks and stabilise system performance. Instead, older facilities with high levels of deferred maintenance, such as Facility A, may have systemic problems causing time consuming rectification of some WOs.

Table 2 below includes a summary of unionised labour employed for FM services at the two facilities as well as indexed figures by average number of annual WO events completed and total IFS. All data is using figures from 2018 collected directly from interviews and supplementary reports provided. The number of WO events completed per unionised FM employee at Facility B is 12% greater than at Facility A and total IFS per unionised FM employee is 24% greater at Facility B. Both metrics indicate greater efficiency of labour use at Facility B. Interestingly, a requirement in the P3 procurement of Facility B (Withheld, 2008) was that the winning consortium transfer the maintenance personnel over from the hospital that it replaced, subject to the employees' approval, while retaining them in the same union as other hospital employees; thereby maintaining work conditions such as schedules, salary and other benefit levels. Of the 16 maintenance personnel at the old facility, seven stayed with the hospital, of whom four were on long term disability. The nine employees transferred to the winning consortiums' FM Service Provider were augmented by three new hires (Interviewee 1, 2017). Therefore, 12 active unionised FM staff were maintained for a facility almost twice as large.

Table 2. Unionised FM labour levels for Facility A (traditional) and B (P3), 2018 (Interviewee 2, 2017, Withheld, 2018a).

Metric	Facility A	Facility B
Total number of unionised FM employees:	22	12
WO events completed:	10,800	6,600
WO events completed per unionised FM employee:	490	550
IFS (m^2) per unionised FM employee	5,362	6,627

Notably, having a CMMS is a contractual requirement for Facility B (Withheld, 2010a), central to the extensive reporting and accountability structures at the facility, and Facility A installed a CMMS as a best practice transfer from Facility B (Interviewee 2, 2017). The addition made data available for this comparison. The above findings were supported by Interviewee 2 (2017): *"Demand Maintenance response times [at Facility B] are excellent, they're really good! … The strength [of the DBFM model] was bringing in the CMMS that was tried, tested and true and having the maintenance staff start out right away with it. The ability to keep track of all the work orders is really good and to be able to time when they were called in, when they need to be responded to and when they need to be rectified, putting that whole rigor around it - I love that. For the most part that's been [Facility B's] greatest success… Anecdotally, the [Facility] Manager at [Facility A] said there's no way that our guys could meet the response and rectification times [achieved at Facility B]."* Interviewee 1 (2017) supported this saying that *"Demand Maintenance works well because, they open a ticket, it's logged, subject to performance penalties"*. This penalty regime is a core component of the contract (Withheld, 2010a).

Interviewee 1 also raised the matter of ad hoc work and how it interacts with maintenance activities: *"If [the staff] want to add an extra electrical outlet, well it's going to cost money so it's got to … be approved. They used to just get away with stuff because they had in-house electricians. The perfect example was in one of my conversations with [Interviewee 2] where she said "why should I pay you $800 to put in an electrical outlet if I've got an electrician down in [Facility A] sitting around doing nothing to do it for free". My question was "Why do you have an electrician in [Facility A] sitting around doing nothing? Because that's costing me money as a taxpayer."* In response to this matter, Interviewee 2 (2017) stated: *"Ad hoc* *work to me is another thing that I feel like when we ask for it, the Service Provider is doing us a favour when they do it. I have no question when I'm at [Facility A], I say to the guys "I need this done" and 'BOOM!' it's done. Whereas [at Facility B], the response is "if we do that, then your Demand Maintenance may be affected". There's more of a negotiation and I don't like that…that's a big difference in these procurement models. At [Facility A] they work for me, here they don't work for me. Do they get their Demand Maintenance responses done quicker because I don't interrupt them like at [Facility A]?"* The data suggests that, with more WOs completed per unionised FM employee, this is the case. A Project Manager with the hospital advised that at prior hospitals in which he worked FM employees were only allowed to conduct maintenance work and not any new installations in order to avoid such distractions (Withheld, 2018b).

4.6.3 Facility User Satisfaction

Comparisons of FM effectiveness by quantity of resources used, or expenditure, is challenged due to the prevalence of deferred maintenance, and other underinvestment in the facility; Roberts and Samuelson (2015) estimated Canadian hospitals to have $15-20 billion of such accumulated deferred maintenance costs. According to Interviewee 2 (2017), this is particularly true in conventionally delivered facilities such as Facility A, where *"millions and millions and millions of dollars"* of deferred maintenance has accrued over time and Ministry funding must be used to supplement life cycle activities that *"address the most risky parts of the hospital, but that still leaves us more at risk than we have [at Facility B]."* They *"do an assessment of all the deferred maintenance [at Facility A] but we don't need to [at Facility B] because it's a DBFM… [DBFM] is a much better model - much, much better - because your actual life cycle is built into the project. I know that my roof is going to be ok, I don't have to try to wrestle the money through [MoH] funding or through our capital funds through our hospital, which always go to patient care equipment before it goes to fixing the roof. So, there is no doubt it is far superior in this model."*

In order to help investigate and compare the effectiveness of FM service delivery at the two facilities, the author used existing satisfaction surveys conducted by FM teams at the respective facilities between 2015 and 2017. The completion of these annual surveys identifying building users' impressions of the facility, and associated FM activities, are a contractual requirement at Facility B (Withheld, 2010a). Upon receiving the first report, the health care corporation conducted a comparable survey at Facility A, though did not repeat it in later years. At Facility B, the results of these surveys are reviewed annually to demonstrate performance by the FM service provider. It is unclear how the results of the survey at Facility

A were used or why it was not continued beyond the one occurrence. Across the surveys, the vast majority of respondents were hospital staff; small numbers of contractors, patients, family members and others also providing their views on FM-related activities and outcomes.

Noting limitations of using surveys conducted by other parties – namely control over methodological approach to development and implementation – the author was unable to deploy similar surveys across the facilities studied due to resourcing and access issues. Instead, the available surveys occurred over multiple past years, which provided the opportunity to see trends in responses over time. From these surveys, the following three questions were compared in this study:

- What is your overall satisfaction with the facility and related services?
- What is your overall satisfaction with the Building Services Employees? and
- Requests for repairs are dealt with promptly and efficiently?

These three questions were selected from the broader questionnaires retrieved from the two sites for the following reasons: 1) the questions were included in all available surveys thereby providing data for comparison; 2) and the questions related most to the outcomes of FM activities, associated processes and their management making them most relevant to the focus of the research; and 3) they reflected outcomes with minimal impact from the type, age or configuration of the facility, which aided the ability to compare between the sites. All surveys were multiple choice with four answers to choose from; "Delighted", "Satisfied", "Dissatisfied" and "Very Dissatisfied".

Results are provided as a percentage of respondents that approved with the statement, meaning they selected "Delighted" or "Satisfied" as their answer. Table 3 shows the results of the selected survey questions for the various years performed. In all three cases, Facility B had a higher percentage of respondents that approved the statement in 2015 and had improved approval rates between 2015 and 2017. While 2016 shows a decline in user satisfaction in relation to how the FM team deals with repairs, it appears to be an exception and results increased substantially the following year. The positive, and generally improving, results through the operational phase at Facility B suggest that FM services are being performed effectively and that conditions are not degrading significantly.

As a key facility user, Interviewee 2 offered many important insights on her satisfaction of the two facilities' performance. Generally, Interviewee 2 (2017) summed up the relative operating environment at the two facilities in the following way, *"there is definitely more rigor to adhering to [Key Performance Indicators]s [at Facility B] than [Facility A] because we* *don't have to at [Facility A].“* Interviewee 1 (2017) supported this saying they *“get more and better information from the DBMF site”* and that *“sticking to [Key Performance Indicators] is better [at Facility B] because it's built into the contract”*. Despite her positive perspective of Facility B’s performance, Interviewee 2 provided the following reflection on Facility B’s delivery model, *“the question really is, if the government or if the Ministry of Health had the funds available and didn't have to go to an external developer to raise funds, would we still want to do a DBFM? Is it a truly better model for care? And “I don’t know”, is the answer.”*

Table 3. FM Survey results for Facility A and B, 2015-2017, user approval ratings (number of respondents).

	What is your overall satisfaction with the facility and related services?		What is your overall satisfaction with the Building Services Employees?		Requests for repairs are dealt with promptly and efficiently?	
Year	**Facility A**	**Facility B**	**Facility A**	**Facility B**	**Facility A**	**Facility B**
2015	78% (405)	79% (265)	86% (406)	92% (243)	68% (404)	85% (263)
2016		80% (174)		94% (170)		73% (157)
2017		95% (212)		97% (204)		93% (192)

Therefore, despite observations showing better operational maintenance, life cycle and energy performance at Facility B, as outlined in this study and acknowledged by Interviewee 2, she is unconvinced by the model. She clarified further that, *“at [Facility A] my budget keeps getting reduced because we have budget constraints, while at [Facility B] the budget keeps going up because of [Consumer Price Index] increases, so I almost have to try to take more out of other sites’ [budget] to accommodate for the lack of reduction in the building services side [at Facility B]…every hospital [has reductions]”*. This point reflects an unsustainable situation of high importance to hospital decision-makers.

4.7 Conclusions

This article introduces and analyses a health care corporation in Ontario, Canada with two large hospitals, one conventionally procured and maintained by hospital staff and one facility delivered as a P3 including an operating phase. A retrospective, longitudinal Case Study using empirical data for specific FM processes - supported by facility user satisfaction surveys, interviews with key stakeholders and analysis of the P3 contract between the Project Company and the hospital - provides an overview of their history, significance and specifications. Emphasis was placed on building energy and FM labour use in the operations phase. This study’s findings show the P3 facility to have more efficient use of energy and unionised FM labour during the period surveyed, along with facility users that are more satisfied with the FM services. Though many problems existed at the P3 facility upon Substantial Completion, this is common at new facilities and longitudinal analyses of the energy and facility satisfaction metrics show an improving trend as the facility moved further into its operational phase. For energy use in particular, Facility B made dramatic progress in energy efficiency from a position of relative underperformance to Facility A, relative to similarly classified facilities, to a position of significant outperformance. The positive, and generally improving, facility user satisfaction survey results through the operational phase at Facility B suggest that FM services were being performed effectively over the period of study and that conditions did not degrade significantly.

With respect to Energy Use, Facility B is one of the first projects in Infrastructure Ontario's portfolio to incentivise high energy performance using the contractual approach to Painshare/ Gainshare in place at the site. This structure compares actual electrical and Natural Gas consumption to discrete energy targets provided by proponents at the time of bid and used in the selection of the winning team. These penalty and incentive mechanisms are unavailable for traditionally-procured facilities as the public owner takes on risk between contracts with the parties in the operating term unwilling to take the same risk of the Design-Builders' performance. This study found that, based on poor energy performance in Facility B's first operational year, the Project Company was assessed a large Painshare payment. In response, the Project Company implemented an extensive remediation programme to address deficiencies, thereby leading to a large Gainshare payment only two years later. Looking at other forms of resource use at Facility B, this high performance observed for Energy Use does not appear to be matched by the facility's water use for which, unlike energy use, conservation is not incentivised in the contract.

For labour use specifically, the study identified lower efficiency measured by both annual WO events completed per unionised FM employee and IFS (m^2) per unionised FM employee. This evidence corresponds with findings by Alonso et al. (2016) of lower clinical staffing levels in Spanish P3 hospitals as compared to traditionally delivered comparators. A suggestion by Interviewee 2 is that the lower efficiency at Facility A relates to the hospital's struggle with holding their internal staff to account. The hospital installed a CMMS at Facility A to aid processing and trending of WOs, based on the positive experience at Facility B. However, while FM employees at both facilities are part of the same labour union, Interviewee 2 stated that they did not foresee the union representatives of the hospital's own FM employees at Facility A ever agreeing to hold their members to the same expectations for response and rectification times as at Facility B.

Through the interviews, multiple possible reasons came up for the higher performance among the selected metrics for core FM services at Facility B. Generally, Infrastructure Ontario contracts for P3 projects with an operating phase – like those of Facility B – emphasise the promotion of high maintenance performance through risk transfer to the Project Company using a penalty-based approach whereby deductions and failure points are imposed due to building areas or services being unavailable. The *ex post* analyses conducted for this study were in response to requests by Shaoul et al. (2007a), Siemiatycki (2015) and others to investigate the effectiveness of such policies empirically. The findings of this study support Infrastructure Ontario's approach, claims of P3s encouraging innovation toward cost reduction and enhanced quality (Regan et al., 2011) and earlier findings of better P3 performance more broadly by Ng and Wong (2006), Devapriya (2006) and others.

4.7.1 Practical Implications

The key findings from this case, which are likely to be replicated at other sites and therefore have broader implications for researchers, policy-makers and future project planners are as follows:

(1) **P3s bundling design, construction and operating phases are supported as a sustainable infrastructure delivery model.** The core FM processes included in this study suggest that FM resource use is more effective at Facility B - the P3 facility, which includes an operating phase. Such P3 contracts can promote positive operational performance of the public asset through transfer of a breadth of associated, manageable facility performance risks to the private sector partner. This opportunity for operational risk transfer is made available by bundling design, construction and operating phases. The competitive tendering of this operational risk transfer at the bid phase of Facility B's redevelopment through a P3 informed decision making by the private-sector consortium throughout the design, construction and operational phases of the project to reduce associated life cycle costs while meeting strict contractual output specifications. This mechanism was predicted by the literature (Regan et al., 2011) and evidenced by the interviewees' responses and in supporting documents, particularly for the aspects studied including FM labour, energy, materials etc. This dynamic helps to overcome traditional, and in some cases increasing, challenges for public facility operations with respect to labour utilisation and energy use. The potential results are demonstrated by Facility B's positive performance in this study.

(2) **There are benefits to having a diversity of facility delivery models within the same health care corporation.** Evidence was found of the hospital transferring (at least

partially) multiple best practices from Facility B to Facility A. Specifically, it was observed by the installation of a CMMS system and application of facility user satisfaction surveys at Facility A based on the experiences at Facility B. It is also likely that the hospital's experience conducting FM activities directly at Facility A makes them a more educated and discerning client overseeing the Project Company's activities at Facility B.

(3) **There are also detriments to having both traditionally delivered and P3 facilities within the same health care corporation.** Despite observations showing better operational maintenance, life cycle and energy performance at Facility B, as outlined in this study and acknowledged by Interviewee 2, she was unconvinced by the model. Due to funding constraints, largely decided at the provincial level, the hospital is pressed to reduce operational expenditures across its facilities on an annual basis. The contractual obligations of a DBFM protect against such cuts negatively impacting the long term performance of the hospital building, as demonstrated at Facility B. Unfortunately, for a hospital corporation with multiple hospital facilities delivered under a variety of structures this funding scenario can mean amplified cuts at the non-P3 facilities, as experienced at Facility A. A possible long term effect of this situation is even greater disparities in operational performance between the facilities over time, thereby providing greater support for the P3 model and its future use. The process could then continue in a self-reinforcing feedback loop if more DBFM facilities were brought into the hospital corporation's portfolio.

4.7.2 Future Research

As a single Case Study over only a few years of operations, generalisations are limited in the findings. While this study helps to answer calls for such *ex post* analyses of relationships between infrastructure delivery structure and life cycle effectiveness and cost (Shaoul et al., 2007a), an important future development of the research would be to continue following the facilities as they mature. This includes further investigation into other aspects of resource usage – such as expansion on references to water and diesel fuel use – as well as total operational expenditure of the facilities. This would aid specific investigation into organisational structure and decision making processes at the respective sites. Study of other categories of P3 and conventionally-procured facilities would allow further investigation into the relationship between their contracts and resource use in order to test the robustness of findings from this work.

5 Thesis Discussion

This Alternative Format thesis investigates relationships between variations in hospital facility delivery structure and operational performance. A multiphase Mixed Methods approach, conducted across three articles, incorporates quantitative and qualitative data from numerous sources. Guided by the overarching research question, *Is there a relationship between variations in delivery structure of hospital facilities in Ontario, Canada and the associated operational performance of the infrastructure, as measured by multiple specific facility resource use metrics relating to energy and labour?*, the subcomponents of the broader study all investigate public hospital facility infrastructure in the province of Ontario, Canada that are delivered under a variety of structures, including multiple P3 models.

Throughout his career working in public infrastructure development, the author observed marked differences in how projects proceeded under different delivery structures. He theorised that the potential impact of these delivery/ contractual approaches could surpass technological or other drivers to encourage improved project efficiency. The opportunity to link his position in industry to academia in order to access valuable data to study these impacts further was the author's primary motivation for conducting the research part-time as part of a DBA. The author's epistemological pragmatism also drove selection of the format and methods used in order to promote use of a diversity of scientific and experiential methods to explore different aspects of the research question and findings' practical consequences.

The studies all focus on the relationship between the variation in these infrastructure delivery approaches and their operational performance using numerous aspects such as energy use and associated environmental performance, facility management labour use and facility user satisfaction. These metrics were investigated for the importance they serve in Facility Management budgets and to other matters of societal importance such as climate change. The concept of 'delivery structure' was used in the research to avoid matters of ownership that can arise in the study of P3s but are not central to the research. Across Canada, it is regularly reinforced that the ownership of public infrastructure delivered as P3s, hospitals in particular, is maintained by the public-sector.

In retrospect, the greatest strengths of the work are reflective of the motivations the author had to conduct the research. Specifically, these relate to novel data collection from industry combined with analysis of an embedded practitioner to benefit of academics, policymakers and other practitioners. The investigations conducted of how delivery/contractual approaches may address noted performance gaps in operational public buildings are unique, more so when backed by a broad *ex post* analysis of all hospitals in Ontario combined with in depth comparative case studies and interviews of key stakeholders. In all the work contributes to filling research gaps identified through the author's literature review.

As with any research of this duration and complexity, a number of challenges were faced throughout. Having begun the DBA programme working for a railway, the author began with a focus on civil infrastructure and spent over two years on associated research and papers. An unexpected job change shifted the focus of the research but also provided better access to novel data more appropriate to the research intent and an opportunity to garner lessons from Ontario's first wave of mature social infrastructure/ hospital projects to its next wave of civil projects. Though data access improved, availability of facility data – particularly operational P3s – is still a weakness of the work. This limitation of available facilities for study is a situation noted throughout the field of study and the novelty of data included in the articles also serve as a strength of the work.

Another challenge faced was a very lengthy ethics approval process conducted by the hospital's ethics board in order to conduct the study associated with Article 3. Though having already completed the University of Manchester's ethics approval process, the hospital requested that the author complete their own process though inappropriate for the form of non-clinical research. The process took many months longer than expected and severely limited opportunity to conduct planned research scope and number of interviews during the available window. While the author managed to interview key stakeholders with the greatest insights on the associated facilities and delivery models used, the small number of interviews is another apparent weakness of the thesis. This was unfortunate as the author and his academic supervisors identified interviews as a worthy complement to the largely quantitative approach of the other articles. Still, those interviews completed add important perspectives to the work and were a valuable learning experience integral to the doctoral process. For the remainder of this Thesis Discussion, Section 5.1 provides an overview of the articles within the thesis; Section 5.2 highlights the key findings of the research; Section 5.3 outlines the practical implications of the work; and Section 5.4 provides opportunities for future research.

5.1 Overview of Articles

The multiphase Mixed Methods approach used in the study begins in Article 1 with a broad retrospective cross-sectional analysis of energy use across all operational hospitals in Ontario in 2016. The findings of the study are supported and expanded by longitudinal comparative case studies of specific hospitals delivered under a variety of structures in Articles 2 and 3. This use of qualitative data analysis to help interpret findings from prior quantitative data analysis allows a greater depth to findings supported by the perspectives of key stakeholders at indicative facilities delivered under a variety of structures. The collection and analysis of empirical data helps to answer the call for such evidence of the long-term impacts of an increasing diversity of delivery structures on health care facility effectiveness and cost by Roehrich et al. (2014), Siemiatycki (2015) and others. The author's access to data sources not in the public domain helped to address an established critique of there being a lack of transparency in the field.

5.1.1 Article 1 Summary

Article 1 was guided by the research question, *Is there a relationship between variations in delivery structure and 2016 energy intensity among operational hospitals in Ontario, Canada?* This article analysed 2016 energy use data for all operational hospitals in the province. These facilities use a variety of delivery structures including those conventionally procured and maintained by hospital staff or FM contractors and multiple P3 forms, with and without operating terms. Findings showed facilities delivered through P3 contracts including an operating term had lower energy intensity than those delivered conventionally or via P3 contracts without an operating term. These outcomes supported the author's hypotheses based on literature review, professional experience and an application of Vining and Boardman's (2008) "Positive Theory" of P3s due to structures bundling design, construction and operating phases enabling incentivisation of operational outcomes through profit-maximising mechanisms associated with operational risk transfer to private-sector partners. With P3 facilities having an operating term being the category with the newest facilities, this countered a trend of newer hospitals consistently using more energy than their predecessors (Natural Resources Canada, 2018), indicating that the need for more efficient use of energy is ever more important because of the increased desire to adopt technological solutions in health care. Preliminary investigations into different contractual approaches among P3 facilities including an operating term found widely divergent results related to their contracts' energy management approaches. Facilities with P3 contracts applying a competitively tendered Bid Energy Model to set annual energy targets, which are then used to calculate Painshare/Gainshare payments, had markedly better performance than all other categories. P3 facilities with an operating phase and that apply a Regression Analysis Model to set energy targets based on operational performance, and those without significant contractual language on the issue, had worse performance than the much older stock of hospitals facilities delivered conventionally.

5.1.2 Article 2 Summary

Article 2 used a comparative, longitudinal Case Study of two P3 facilities with an operating term to further investigate preliminary findings in Article 1 of a strong relationship between energy intensity and contractual approach to energy management. To do so, the article pursues the research question, *For the facilities included in this study, considering the context of their P3 contract, how do the facilities' operational energy use and associated environmental performance compare to one another and similar facilities?* Over four operational years, the article studied two chronic care hospitals in Ontario. Both facilities are early P3 hospitals delivered under the DBFM structure but with different contractual language to manage operational energy use. One facility applies a Regression Analysis Model based on operational energy use to set annual energy targets, and payments, while the other sets energy targets using a Bid Energy Model. These approaches were identified in Article 1 as being low and high performing models and the Case Study investigated the mechanisms further through comparison of the facilities' operational energy intensity, and associated environmental performance, using empirical data supplemented by contractual study and analysis.

Energy intensity within Article 2 is measured using the Source EUI metric, which takes into account losses for each primary and secondary energy source. These losses are due to factors specific to the site location such as generation, conversion, distribution and storage. Instead, Article 1 applies a simpler Site EUI metric due to the method used to calculate an aggregated energy intensity for entire groupings of facilities. The Site EUI indicates the amount of heat and electricity consumed by the facilities, without taking into account losses to supply energy to the sites. The analysis conducted for Article 1 identified Facility A as exemplary for a P3 facility with an operating term and a contract applying a Regression Analysis Model to manage operational energy use (Group 4.b). Facility 1's average Site EUI over four years of study (ending in March 2015 to 2018) was 2.94 GJ/m^2 which is slightly above the 2.88 GJ/m^2 for similar Group 4.b) facilities, as calculated in Article 1 using 2016 data. Alternatively, the Article 1 analysis identified Facility 2 as exemplary for a P3 facility with an operating term and a contract applying a Bid Energy Model to manage operational energy use (Group 4.c). Facility 2's average Site EUI over the study period was 1.44 GJ/m^2 which is slightly below the 1.48 GJ/m^2 of Group 4.c) facilities as a whole. Consistent with Article 1's findings for Group 4.b) facilities as a whole, Facility A's energy intensity (as measured by Site EUI, 2.94 GJ/m^2), is significantly above that of Ontario hospitals as a whole (2.44 GJ/m^2), all conventionally-delivered hospitals (2.43 GJ/m^2) and P3s with an operating phase (Group 4 = 2.22 GJ/m^2). Conversely, consistent with Group 4.c) facilities, Facility 2's energy intensity (1.44 GJ/m^2), is significantly below these figures.

Comparison of facility operational energy intensity, and associated environmental performance, found much better performance over the period by the facility applying the Bid

Energy Model. These findings were compounded by greater reductions in energy use intensity by the same facility, despite lower indexed incentive payments to the Project Company.

5.1.3 Article 3 Summary

Article 3 used a second four-year Case Study to broaden the investigation to include FM labour utilisation as well as energy use at a conventionally procured and operated hospital and an early DBFM P3 hospital within the same public health care corporation in Ontario. The study addressed the research question, *Is there a relationship between variations in hospital delivery structure and effective resource use during operations, within a specific health care corporation in Ontario, Canada?* The study used energy and labour metrics to compare the facilities quantitatively and supported this analysis with interviews of key stakeholders and facility user surveys.

The key findings from this case were as follows:

(1) **P3s bundling design, construction and operating phases were supported as a sustainable infrastructure delivery model.** The core FM processes included in the study, namely FM labour and energy use, suggest that FM resource use is more effective at the P3 facility that includes an operating phase.

(2) **There are benefits to having a diversity of facility delivery models within the same health care corporation.** Evidence was found of the hospital transferring best practices from the P3 facility to the conventionally delivered facility. It was also likely that the hospital's experience conducting FM activities directly at the conventionally delivered facility made them a more discerning public-sector partner at the P3 facility.

(3) **There are also detriments to having both traditionally delivered and P3 facilities within the same health care corporation.** Due to funding constraints hospitals are driven to reduce operational expenditures across their facilities on an annual basis. Contractual obligations at the P3 facility protect against such cuts negatively impacting the long term performance of the hospital building but result in amplified cuts at the hospital corporation's other facilities. Over time this could lead to increasing disparities in operational performance between the facilities thereby providing greater support for the P3 model and its future use.

Building on the findings of Article 1 and 2, similar competitively tendered contractual mechanisms within the P3 contract between the Project Company and hospital, based on strong financial penalties and incentives, were identified as likely drivers for the high performance of both facility energy use and FM labour utilisation directly, and facility user satisfaction levels indirectly. Based on limited analysis, the dramatic improvements in energy use at the P3 site over the operating period did not appear to be matched by the facility's water use. This is an interesting area for further study as, unlike energy, water conservation over the operating term is not incentivised in the contract. The exclusion of operational water conservation measures is typical of existing Infrastructure Ontario contracts, though the addition of such language is proposed for future contracts.

While the results largely support the positive performance of the P3 facility, budgetary concerns were raised that would negatively impact the non-P3 facility's performance. Additional concerns from the literature, that were not explicitly within the scope of this study, are that in some jurisdictions like Ontario P3s are seen as the only option and that the public sector loses the ability to monitor and control the projects and adequately shift risk to the private sector partners (Shaoul et al., 2010, Crozet, 2014). In short, while the study's findings demonstrate positive operational performance at the DBFM site, within the scope of the research, the situation is complex and involves trade-offs.

5.2 Key Findings

The overarching finding of this thesis is that delivery structure is a potentially useful tool to drive positive operational performance, and thereby address recognised performance gaps in public buildings (de Wilde, 2014), but that effectiveness is highly subject to contractual details with respect to risk transfer. Each component study shows a relationship to exist between delivery structure and specific operational performance metrics among Ontario's hospital facilities, including energy use, labour use and user satisfaction. The results of each study support the initial hypothesis that: *Ontario hospital facilities delivered as P3s with an operating phase have better operational performance over the period of study than other delivery structures.*

Ample literature has claimed P3s ability to enable risk transfer unavailable in traditional procurement approaches to encourage innovation (Regan et al., 2011) and improve performance (Ng and Wong, 2006, Devapriya, 2006). This enhanced performance is often attributed to opportunities made available to allocate risks to parties most able to mitigate them, thereby reducing the overall risk profile of the project (Ng and Loosemore, 2007, Bing et al., 2005). Others have shown that, in practice, risks do not always transfer successfully (Shaoul et al., 2010, Crozet, 2014). The divergent results among P3 facilities demonstrated in Article 1 and 2, are consistent with findings of earlier researchers but not well explained by existing theory such as Vining and Boardman's (2008) "Positive Theory" of P3s. These findings, and the analysis of the P3 contracts' energy management approaches, suggest that empirical outcomes are highly dependent on *how* project risks are assigned to the parties in practice and also the complexity of the relationships between them.

As demonstrated in all three articles for matters of energy use, P3 contracts with an operating phase and applying a bid Energy Model to set annual energy targets, and associate Painshare/Gainshare payments, capitalise on the opportunity for hospital clients to transfer operational energy use risk to the Project Company. Article 3 demonstrated the ability for competitively tendered P3 contracts with an operating phase to enable hospitals to transfer operational FM labour utilisation risk to the Project Company and hold them accountable through strong financial penalties and incentives in order to drive positive operational performance. The highly accountable risk transfer mechanisms identified in all studies are uniquely available to delivery structures that bundle design, construction and operating phases as each time the owner ends a contract under other structures they take on interface risk with new parties unwilling to guarantee prior parties' performance, as demonstrated in Figure 11 below.

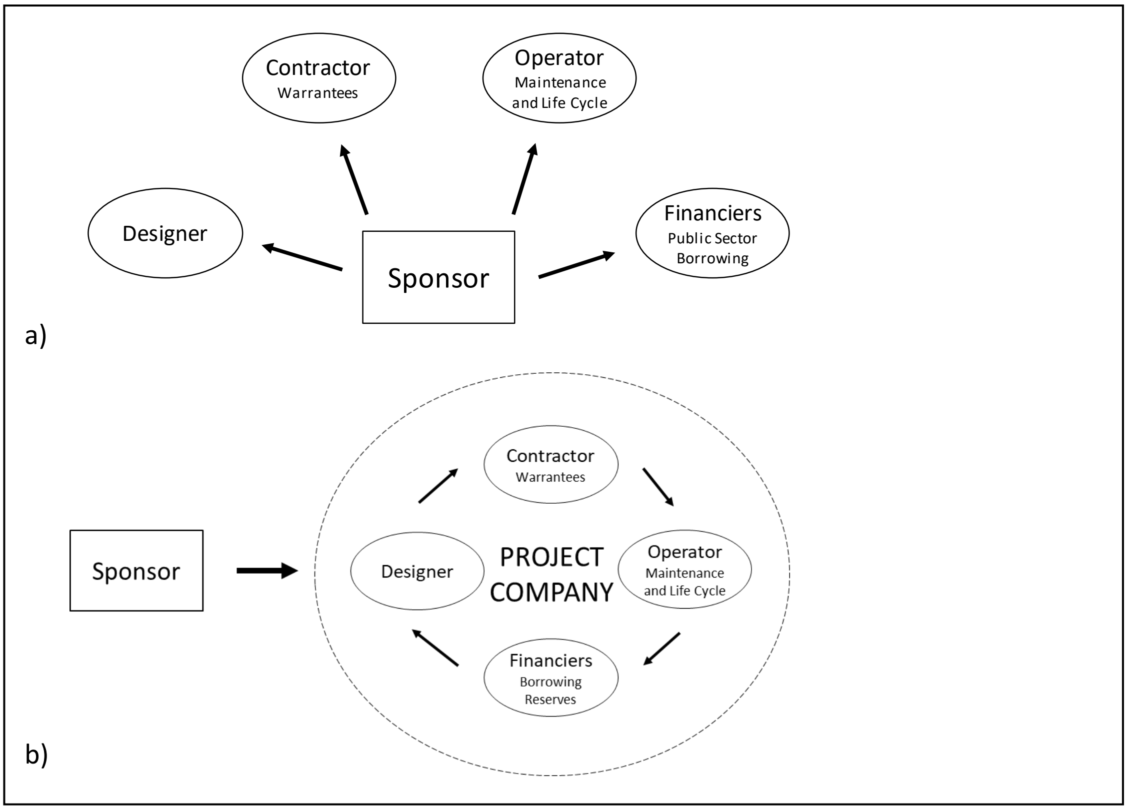

Figure 11. a) Traditional approach to delivery of infrastructure projects through multiple contracts between the project sponsor and separate entities for discrete functions vs b) P3 (DBFM) approach of a single contract between the sponsor and a Project Company for all applicable functions.

The contractual continuity associated with bundling of DBM components, and associated opportunities to transfer operational risk to the private-sector partner, is a key premise for P3s with an operating phase (OECD, 2013, Altus Group, 2015). Key functional elements include the construction, maintenance and life-cycling of the various facility components in order to meet strictly prescribed output specifications. The risk for associated staffing, training and other requirements – as investigated in Article 3 – are up to the Project Company, as long as these output specifications are met.

As identified by others (Altus Group, 2015), the transfer of operational performance risk to the private-sector partner can drive innovation through competitively driven mechanisms that incentivise efficient resource use over the contract term. The studies within this thesis help answer calls for operational evidence of these mechanisms in practice (Siemiatycki, 2015). The exclusion of services from this regime, however, removes the associated contractual conservation mechanisms. This is evidenced by facilities studied using the Regression Analysis Model, or without any significant approach to energy management in Article 1 and 2 and water management at the P3 facility studied in Article 3. It is highly possible that the exclusion of performance risk mechanisms negatively impacts resource conservation efforts, as suggested in this study, due to the complexity of the relationships in these partnerships. More research is required to study these effects, however.

The analysis of empirical quantitative and qualitative data gathered through the various phases of this research allowed the identification of trends in the data. Longitudinal analyses of multiple hospital facilities revealed valuable data that positioned the researcher to proceed to the next set of refined research questions and selection of appropriate methods. Recognising the limitations of studying one regional context, the analysis considers broader implications for future research. Having studied all hospitals in Ontario, including P3 hospitals that reached Substantial Completion as early as 2006, the study includes many of the most mature P3 hospitals in Canada, an established P3 market globally. The contribution of this thesis to academia, industry and policy makers in the field – in particular – is to identify practical influences, successes and challenges associated with infrastructure operations under different delivery models. The novelty of the research, along with the increased attention due to the growth in infrastructure funding, has attracted the attention of conference organisers and journal editors and thus the dedication of my time may be rewarded.

5.3 Practical Implications

The findings of this thesis suggest a relationship does exist between delivery structure and a variety of operational performance metrics among Ontario's hospital facilities. Energy Use was the greatest focus across the studies with findings showing facilities delivered through P3 contracts including an operating term having lower energy intensity than those delivered conventionally or via P3 contracts without an operating term. Additionally, facilities with P3 contracts applying a competitively tendered Bid Energy Model to set annual energy targets through operations, which are then used to calculate Painshare/Gainshare payments, had markedly better performance than all other categories. Further study of FM labour use found it was also more effective at a P3 facility with an operating phase than at a comparable conventionally-delivered facility.

In support of available theory (Vining and Boardman, 2008), the observations by the studies within this thesis found the P3 facilities that include an operating phase to generally outperform the comparator facilities. This supports the use of delivery structure as an innovative tool to address operational performance issues among much public infrastructure. In particular, this includes a recognised energy "performance gap" in buildings, which exists despite a growing use of green building certification regimes such as LEED (de Wilde, 2014). For energy use, a major component of FM budgets (Adams et al., 2010) and contributor to climate change (Lucon et al., 2014), there were however very divergent results among the P3 facilities studied, correlated to the contracts' approaches to energy management. This suggests a need to build on existing theory to improve the explanation of practical outcomes observed and inform decision making for future projects.

The bundling of design, build and operations/ maintenance components of infrastructure delivery at the bid phase of some P3s can serve to enable operational risk transfer to proponents in order to incentivise efficient resource use over the contract life. Successful examples of this were observed in this thesis with FM labour use at the P3 facility studied and those P3 contracts applying the Bid Energy Model to energy management. In both cases, conservation is driven through competition among proponents to win the project tender, often strongly linked to the lowest Net Present Value of costs over the duration of the contract. Traditionally delivered public facilities, and those delivered via P3s without an operating phase, separate contracts for design, construction and operations thereby removing opportunities to utilise the operational incentive mechanisms made available through bundling (Altus Group, 2015), as described above.

When items are not included in the scope of a P3 bid, or accountability is insignificant, the competition and risk transfer mechanisms are not enabled. Examples of this were observed in this thesis by P3 facilities having contracts without a substantive approach to energy management or those applying the Regression Analysis Model. Preliminary analysis also suggested water use at the P3 facility studied to be another example as its conservation is not typically addressed operationally by P3 contracts in the jurisdiction studied. Absent or unclear conservation risk transfer to the Project Company in the P3 contract, may lead to worse resource use performance than conventionally-delivered comparators due to the additional parties and complex relationships involved in the operations of P3s facilities. The implications of the above point suggest the public-sector should transfer the maximum amount of risks to the private partner. However, as projects get larger and more complex, a number of high profile players such as SNC-Lavalin Group Inc. and Fluor Corp. have chosen to move away from P3s. They note fixed-price contracts and too many risks being transferred to the private-sector parties as reason for their departure (Rubin and Powers, 2019). This provides an important counterpoint to the above, specifically the importance of identifying and assigning risks to the parties most able to mitigate them in order to reduce the overall risk profile of the project (Shen et al., 2006). Transferring too many risks to the Project Company leads to increased costs through pricing of risk into bids and/or through reduced competition.

In order to inform decision makers of the massive public funds spent annually on social infrastructure, while also gaining feedback for the ongoing research and analysis, the findings of this thesis have been shared to academia and industry through various avenues. The author presented component studies within this thesis at multiple conferences including the Second International Conference for Sustainable Design of the Built Environment: Research in Practice (SDBE) in September 2018 and University of Manchester DBA conferences over multiple years. Related information was also presented at a conference targeted to practitioners titled "Lessons Learned in Developing PPP/AFP hospitals" hosted by The Canadian Institute in October 2016. Articles have been submitted for publication including to the academic journal "Sustainable Cities and Society" and inclusion of a version of Article 1 in the proceedings for the SDBE conference attended in 2018. Comments from conference attendees and publication reviewers have been incorporated within the articles contained in the thesis. There are plans to submit articles 2 and 3 to the journals *Building Research and Information* and *Journal of Health, Organisation and Management*, respectively.

Additionally, findings from the thesis have informed practical outcomes in industry through the author's professional responsibilities. These include identification of best practices and challenges at operational P3 hospitals on which the author is Project Company Representative and sharing of findings across the affiliated public and private partner organisations. The information garnered has informed decision making at affected sites, particularly related to acceptance of proposed energy initiatives through better understanding of contractual mechanisms by the clients. Presentation of findings to project sponsors in less mature P3 jurisdictions outside Ontario, including multiple US states, has also informed procurement and contract development of new projects.

5.4 Future Research

With the purpose of informing future infrastructure planning and policy work, the articles constituting this thesis present various forms of evidence about delivery of health care facilities, a social infrastructure subset, and the relationship with operational performance through a variety of metrics. Designed to be replicable, the research methods lend themselves to follow-up studies based on updates of the data from secondary sources. An update of the cross-sectional comparative analysis of infrastructure developed in Article 1 would reveal the robustness of findings in subsequent years or other jurisdictions. Similarly, an update of the longitudinal data used for the comparative case studies in Articles 2 and 3 would extend the explanatory timeframe of the associated studies through the contract term for the P3 facilities, in particular. While a final Value for Money analysis at the end of the 30 year term is unlikely, interim assessments like those conducted in this thesis may actually be of more use because finding may be actionable to influence the ongoing performance of the facility.

As jurisdictions continue to innovate with delivery models - including those bundling design, build, operating and maintenance phases with varying levels of public and private financing (Dahl et al., 2005) - further study of the impact of this financing component on operational outcomes is warranted. Many jurisdictions include significant portions of public-sector financing to mitigate the higher costs of private-sector borrowing while keeping the Project Company involved through the contract term. Long term contracts with a design, construction and operating component but no private financing can retain a security from the Project Company in the form of performance bonding or a letter of credit of a substantial enough sum to incentivise the Project Company to maintain the system in good repair. Limited comparison or optimisation work has been done of these models to evaluate operational outcomes including Value for Money analyses.

Further investigation is also warranted of the cost benefit analyses for the approach to resource use components not included in the contracts of P3s with an operating phase, including risk transfer trade-offs and understanding the significance of negative incentive mechanisms associated with relational complexity of parties and whether they should be addressed. These aspects are lacking in existing theory such as Vining and Boardman's (2008) "Positive Theory" of P3s. This suggests a need to build on available theory to improve the explanation of that practical outcomes observed and inform decision making for future projects

Additionally, the author wishes to investigate the development of new contractual approaches such as operational interventions on structures found less successful, such as incorporating aspects of bid Energy Model contract approaches to energy management on projects with a Regression Analysis structure. As well, new delivery approaches are constantly developed and should be evaluated for their effectiveness. Recently, this has included projects resulting from Exclusive Negotiating Agreements or Project Development Agreements. These new approaches have the core project concept defined by a client but the developer, with or without construction or operating partners, is engaged early to plan and deliver the project in a way that can drive efficient, creative, technical and financial solutions. On the other hand, the approach loses some competitive mechanisms of a more standard P3 procurement.

The papers within this thesis compare operational performance across health care facilities in Ontario, a leading P3 jurisdiction globally. The first wave of P3 projects in the province were Social Infrastructure facilities, driven by the health sector, the first of which entered operations in the late 2000s to early 2010s. The second wave of projects, currently underway, are Civil Infrastructure facilities, driven by the public transportation sector, with eight of the province's eleven deals closing in the 12 months leading to November 2015 being civil projects (InfraDeals, 2016). The first of these entered operations in 2017. An intent of the research was to identify lessons learnt from the early operational Social Infrastructure projects to inform the operations of the early Civil Infrastructure projects and research should be conducted to see how lessons are being learnt on the new projects. This is particularly important for the transport sector, the highest value infrastructure sector in many markets accounting for more than half of the European Union's total investment between 2006 and 2009 (Fernandes et al., 2015).

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Appendix A: Literature review summary table of themes researched and associated gaps.

Theme/Method Researched	Summary of Findings	Literature Gaps
Infrastructure Provision	• Diversity of infrastructure ownership and management structures being used globally to fill reported infrastructure deficit. • Increased private-sector provision of financing, expertise and risk allocation in return for potential revenues through various forms of P3s. • Well established use of P3s in health field, Canadian & Ontario markets.	• Limited evaluations of operational P3s
Research Contexts	• Relevant, established research constructs in related fields such as Operations Research (e.g. Life Cycle Cost) and Organisational Theory (e.g. Vertical Integration) as well as various applications including social infrastructure, transportation and utilities.	• Process-based comparison between a P3 site and a conventionally-procured, vertically-integrated one
Performance	• Many ways to evaluate infrastructure performance. • Financial performance metrics are dominant, including Value for Money (VfM), Life Cycle Cost (LCC). Encompasses Risk Management. • Technical performance metrics are often driven financial interests (e.g. effectiveness of maintenance cycles or equipment/materials) but can include purely environmental or social indicators. • Often specific to application such as health outcomes for hospitals (e.g. patient/staff satisfaction, residence time, sleep effectiveness) • Innovation research is emphasised as an important driver for, and metric of, performance that can relate to financial or technical aspects.	• A financially-driven *ex post* performance evaluation of a P3 facility and its *ex anti* performance models, incorporating technical aspects such as energy use and health outcomes
Research Design	• A variety of methods (e.g. study structures, survey tools) used in related research • The Case Study is particularly valuable for focussing on a small sample of facilities (e.g. 1 to 5) • Examples: Formalised survey models (NPT) and analytical frameworks (Macário) used with semi-structured interviews and questionnaires.	• A mixed-methods Case Study of a P3 facility vs a conventionally-procured comparator using aggregated financial data (e.g. financial) and semi-structured

		interviews to analyse broad metrics as well as specific processes between the sites

Appendix B: Article 1 - Removed dataset entries

The author determined the eight entries listed in Table 4 as incorrectly labelled as "Facilities used for hospital purposes" and should be classified as "Administrative offices and related facilities" or "Other". They were therefore excluded from the data studied.

Table 4: Removed dataset entries

Organisation	**Facility**
Dryden Regional Health Centre	Ambulance Garage
Pembroke Regional Hospital Inc.	D'Youville Warehouse
Pembroke Regional Hospital Inc.	Pembroke Regional Hospital (Ambulance Building)
Renfrew Victoria Hospital	Dispatch Centre
Toronto Hospital for Sick Children	Atrium
Toronto Hospital for Sick Children	Peter Gilgan Centre for Research and Learning
Toronto Sunnybrook health Sciences Centre	SB - Bayview - R - (100% Hospital Research)
Toronto Sunnybrook health Sciences Centre	SB - Bayview - S - (100% Hospital Research)

Appendix C: Article 1 - Robustness checks

Table 5: Total Indoor Space (m^2) of facilities by primary clinical function (i.e. Ambulatory Care, Nursing or Residential Care, General Medical & Surgical), Delivery Structure and Energy Management Approach.

Delivery Structure	Energy Mgmt. Approach	Clinical Hospital Type: Ambulatory Care	%	Nursing or Residential Care	%	General Medical & Surgical	%	Total
1) Conventional	a) NA-Incentive	562,238	10.4%	3,983,406	73.6%	866,500	16.0%	5,412,144
2) Mix, Conventional & P3, no ops	a) NA-Incentive	1,337	0.2%	664,833	94.0%	41,463	5.9%	707,633
3) P3, no operating term	a) NA-Incentive	32,263	7.0%	410,148	89.2%	17,379	3.8%	459,790
4) P3, with operating term	a) NA-Incentive	-	0.0%	192,685	85.2%	33,340	14.8%	226,025
	b) Regression Analysis	15,979	5.2%	179,256	58.8%	109,552	35.9%	304,787
	c) Energy Model	30,364	5.9%	318,305	62.4%	161,706	31.7%	510,375
	Total	46,343	4.5%	690,246	66.3%	304,598	29.3%	1,041,187
Total	a) NA-Incentive	595,838	8.8%	5,251,072	77.2%	958,682	14.1%	6,805,592
	b) Regression Analysis	15,979	5.2%	179,256	58.8%	109,552	35.9%	304,787
	c) Energy Model	30,364	5.9%	318,305	62.4%	161,706	31.7%	510,375
	Total	642,181	8.4%	5,748,633	75.4%	1,229,940	16.1%	7,620,754

Table 6: Total Indoor Space (m^2) of facilities in northern Ontario (i.e. North=Y) or southern Ontario (i.e. North=N) by Delivery Structure and Energy Management Approach.

Delivery Structure	Energy Mgmt. Approach	North				Total
		Y	%	N	%	
1) Conventional	a) NA-Incentive	561,560	10.4%	4,850,584	89.6%	5,412,144
2) Mix, Conventional & P3, no ops	a) NA-Incentive	96,139	13.6%	611,494	86.4%	707,633
3) P3, no operating term	a) NA-Incentive	-	0.0%	459,790	100.0%	459,790
4) P3, with operating term	a) NA-Incentive	65,305	28.9%	160,720	71.1%	226,025
	b) Regression Analysis	54,150	17.8%	250,637	82.2%	304,787
	c) Energy Model	-	0.0%	510,375	100.0%	510,375
	Total	119,455	11.5%	921,732	88.5%	1,041,187
Total	a) NA-Incentive	723,004	10.6%	6,082,588	89.4%	6,805,592
	b) Regression Analysis	54,150	17.8%	250,637	82.2%	304,787
	c) Energy Model	-	0.0%	510,375	100.0%	510,375
	Total	777,154	10.2%	6,843,600	89.8%	7,620,754

Table 7: Median Total Indoor Space (m^2) and of facilities by Delivery Structure and Energy Management Approach.

Delivery Structure	Energy Mgmt. Approach	Count	Median Total Indoor Space (m^2, x1000)	Energy Intensity (GJ/m^2)
1) Conventional	a) NA-Incentive	247	9.0	2.43
2) Mix, Conventional & P3, no ops	a) NA-Incentive	11	27.2	2.60
3) P3, no operating term	a) NA-Incentive	12	70.1	2.77
4) P3, with operating term	Sub total	16	57.4	2.22
	a) NA-Incentive	3	33.8	*3.00*
	b) Regression Analysis Model	7	64.8	*2.88*
	c) Bid Energy Model	6	65.3	*1.48*
Grand total		**286**	**7,620.8**	**12.4**

Appendix D: Article 1 - Data summary

Table 8: Descriptive statistics for Total Indoor Space and Energy Use by Delivery Structure and Energy Management Approach.

Delivery Structure	Energy Mgmt. Approach	Count	Total Indoor Space (m^2, x1000)				Energy Use (GJ, x1000)			
			Sum	**Min**	**Max**	**Median**	**Sum**	**Min**	**Max**	**Median**
1) Conventional	a) NA-Incentive	247	5,412.1	0	202.1	9.0	13,148.8	0	828.3	20.8
2) Mix, Conventional & P3, no ops	a) NA-Incentive	11	459.8	0.7	83.6	27.2	1,272.0	1.8	235.3	80.6
3) P3, no operating term	a) NA-Incentive	12	510.4	21.5	169.7	70.1	753.3	10.5	288.5	82.0
4) P3, with operating term	a) NA-Incentive	3	304.8	13.8	91.3	33.8	876.6	6.6	218.9	140.9
	b) Regression Analysis	7	707.6	1.3	114.1	64.8	1,836.6	1.5	312.1	188.3
	c) Energy Model	6	226.0	33.3	127.4	65.3	677.0	46.8	345.7	284.5
	Sub total	16	1,041.5	1.3	127.4	57.4	2,306.9	1.5	345.7	118.7
Grand total		**286**	**7,620.8**	**0**	202.1	**12.4**	**18,564.3**	**0**	828.3	**27.3**

Appendix E: Article 1 - Canadian hospital building characteristics

Table 9: Canadian hospital building characteristics, energy use and energy intensity by year of construction, 2014 (Natural Resources Canada, 2018)

Year of Construction	Buildings #	Proportion	Energy intensity GJ/m^2
Total	798	100%	**2.45**
Before 1920	23	3%	1.99
1920 to 1959	162	20%	2.68
1960 to 1969	148	19%	2.41
1970 to 1979	124	16%	2.98
1980 to 1989	102	13%	2.08
1990 to 1999	58	7%	2.24
2000 to 2009	158	20%	2.36
2010 or later	23	3%	2.40

Appendix F: Article 3 - Interviews

Recorded using Sony IC Recorder ICD-PX370 with manual transcription of points of interest.

Interviewees included:

1. Former Project Company Representative & Former Facility Management Committee Member. October 28, 2017. Duration: 60 min. Location: Interviewee's home.
2. Former Hospital Representative & Current Facility Management Committee Member. Date: November 2, 2017. Duration: 70 min. Location: Conference room at P3 site

Appendix G: Article 3 - Research protocol

Research Protocol

Version 4, 31/08/2017

Title: Relationships between facility management structure and operations: A Case Study of (Withheld) hospital facilities

Primary Author: Alexander White, P. Eng. - Doctoral Candidate (University of Manchester, UK) | (Withheld)

Local Principal Investigator: (Withheld)

Introduction

Purpose: *To identify relationships between variations in facility management structure and operational outcomes.*

Research question: *Is there a relationship between variations in facility ownership and management structure and the effectiveness of operations, within (Withheld)'s network of hospital facilities?*

Rationale: *(Withheld) facilities operate under different management structures, specifically the current (Withheld), delivered as a public-private partnership (P3), its predecessor and the (Withheld), both conventionally procured and vertically integrated. This provides an opportunity to compare the operations of facilities under different management structures to analyse the relationships between these aspects.*

Benefit to scientific community and society: *This study will use actual data from two operational hospital facilities under the same health care organization but including one facility delivered as a P3 and one conventionally procured. Huge sums of public money are spent on social infrastructure, such as hospitals, yet very few such ex post accounts of operational facilities exist in the academic or industrial literature, particularly including P3 facilities. With one of the more mature P3 hospitals in Canada, this study is well positioned to identify practical influences, successes and challenges associated with infrastructure operations, maintenance and accounting under the different management models. The findings are intended to support future planning and policy work.*

Study design, population, sample size, inclusion and exclusion criteria

Design: *Case Study*

Population: *(Withheld)'s primary hospital facilities (Withheld)*

Sample size: *Three (3) primary facilities (Withheld)*

Selection criteria: The whole *population* of primary (Withheld) hospital facilities are included in the s*ample.*

Note that individuals participating in the research have been selected through 'Purposive Sampling' as the subject group most appropriate for answering the research questions under investigation.

Target End Points

Primary outcome: *General overview of facility performance at (Withheld)'s primary hospital facilities, including comparison across management structure, determined from aggregated quantitative analysis of available facility data supported by qualitative analysis of interview responses.*

Secondary outcomes: *General overview of performance of specific facility management processes (e.g. general maintenance, life cycling, project work, energy management) at hospital facilities, including comparison across management structure. Measured through quantitative analysis of available facility data and qualitative analysis of interview responses on facility processes. In particular, comparisons will be made of the number of steps and people involved in the processes at the different facilities.*

Methodology

A Mixed Methods approach will be used including:

- Semistructured interviews of key employees of (Withheld) and its suppliers who are involved with facility operations in order to collect and analyse qualitative data on specific aspects of facility management processes

- Collection and analysis of secondary quantitative data of facility operational outcomes (e.g. user experience/satisfaction, energy use, financial)

Principal Investigator (PI) Alexander White will conduct all interviews and consolidate secondary quantitative data from multiple sources. He is supervised by Professor Anne Stafford and Professor Pam Stapleton from the University of Manchester and Local Principal Investigator (LPI) (Withheld).

Qualitative Data Collection: Semistructured interviews

Participants

Number and how selected: *Up to 50 employees of the hospital and its suppliers, selected through 'Purposive Sampling' as the subject group most appropriate for answering the research questions under investigation.*

Participants will be included only if they have experiences and/or characteristics relevant to the research question(s) being investigated. Participants will be excluded only when they do not have experiences or characteristics relevant to the research question(s) being investigated.

Requirements: *Participants will be asked questions during an interview, relating to the management and operations of hospital facilities. This may include:*

- *Collection of non-sensitive personal data that could allow others to identify individuals, groups or organisations that participated in the research (e.g. from publishing, reporting or transferring data). This includes using direct quotations from respondents or naming individuals, groups or organisations that take part.*
- *Some participants could be considered to have a particularly dependent relationship with the researcher(s)*

Recruitment: *The PI will approach participants directly and will:*

- *not pursue non-responders beyond two reminders*
- *provide an information sheet to all persons invited to take part that explains in concise and clearly understandable terms:*
    - *who is conducting the research,*
    - *why it is being conducted (including the true purpose of the research),*
    - *why they have been asked to take part,*
    - *what is requires of them (including the amount of time they will be required to commit and what they will have to do),*
    - *what will happen to the data they provide,*
    - *whether and how their anonymity and confidentiality will be maintained,*
    - *that their participation is voluntary and they are free to withdraw at any time without detriment;*
- *give participants at least 24 hours to decide whether or not to take part in the research and ensure that participants sign/mark a consent form to indicate that they have received sufficient information about the research and are happy to take part;*
- *ensure that there is no coercion to participate in the study and will take special steps to ensure that participants are made explicitly aware of their rights to choose not to take part and to withdraw, without repercussion;*
- *maintain the anonymity and confidentiality of responders and non-responders; and*
- *not provide participants payment or other incentives for taking part in the research.*

See a copy of the Participant Information Sheet and Consent Form *attached.*

Location

The interviews will be conducted at the participant's place of work. A setting which poses no significant risk to the safety and well-being of participants or researchers.

Interview Questions

Find a sample of semistructured interview questions attached.

Quantitative Data Collection

In order to determine an aggregated evaluation of facility performance quantitative data will be collected in the following categories: financial, patient outcomes/experience and environmental. Working with hospital and other key staff as well as third party organisations the following data will be collected, as available:

1) Financial data
    - Health Spending Data by facility:
        - The Canadian Institute for Health Information (CIHI)
            - National Health Expenditure Database (NHEX)
            - Canadian MIS Database (CMDB), staffing, cost, workload and provision of health services;
            - Canadian Patient Cost Database (CPCD), estimated costs by patient group;
        - Ontario Ministry of Health and Long-Term Care (MoHLTC)
            - Cost of a Standard Hospital Stay
            - (Withheld) Annual reports (2000-2016) [Why not published online?]
            - Facility Operations/Maintenance costs by facility
            -
2) Patient outcomes/experience data
    - Ontario Ministry of Health and Long-Term Care (MoHLTC)/ Ontario Hospital Association (OHA)/ InterRAI
        - Length of stay/ Repeat Hospital Stays for Mental Illness
        - Potentially Inappropriate Use of Antipsychotics in Long-Term Care
        - Hospital Standardised Mortality Ratios (HSMR, Hospital Deaths)
        -
    - CIHI
        - Patient Harm Metrics: Medication incidents, Patient Trauma
    - OECD
        - Healthcare Quality Indicators: Mental Healthcare (Suicide rate)
    - (Withheld)
        - Patient experience reports/ User satisfaction survey results
3) Environmental data
    - Energy usage and/or cost
        - Target: Non-user loads
        - Likely unit: Gigajoules per square metre
        - Source: (Withheld) records (primary), Service Provider & IO records to supplement

Data Management

Analysis

Facility performance will be determined using a Mixed Methods approach through aggregated quantitative analysis of facility data though the specific statistical tool used will depend on data availability. With limited datasets, approaches used are likely to include graphical and numerical comparisons though other basic statistical tools may be used as feasible (e.g. Student t-test to compare means). These results will be supported through qualitative analysis of interview responses on facility processes.

Storage and Use

Data collected will be used for the sole purpose of the research. All data will be treated as confidential by the researchers and will be used in order to reach a clear understanding of the management structure and the facility operations.

- *All personal data will be kept securely. It will be stored on secure University of Manchester network storage and not on PC hard drives or any kind of portable storage device (e.g. laptop, USB storage, removable hard drives) unless the file or device is encrypted.*
- *The data will be stored for a minimum of five years. The data will not be transferred to other individuals or parties outside the members of the research team listed above.*
- *The researcher(s) will tell participants explicitly how the data will be used, including that they may be identified from the data.*
- *The researcher(s) will gain informed consent from participants to collect identifying data, including explicit consent for audio and/or visual recording.*

The researcher(s) will gain informed consent from participants to use identifying data in research outputs (e.g. reports, articles, recordings) including direct quotations.

References

See Appendix C: Preliminary Literature Review *for a summary of academic and industry references used in the development of this research project.*

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Notes:

- *An independent external review was conducted by University of Manchester Ethics Review Board. Approval received 7 February, 2017.*
- *The research does not involve:*
  - *socially sensitive topics*
  - *patients or other vulnerable populations as participants*
  - *the use of human tissue*
  - *the physical testing of participants*
  - *the use of psychological interventions on participants*
  - *the use of invasive techniques on participants*
  - *likelihood that taking part in the research will cause significant levels of embarrassment, distress or anxiety for participants*
  - *likely that taking part in the research will cause significant levels of fatigue for participants*
  - *participants to take part in activities that pose a significant risk of having an adverse effect on their personal well-being (e.g. physical and psychological health), social well-being (e.g. social standing, social connectedness) or economic well-being (e.g. employment, employability, professional standing)*
  - *significant likelihood that the research will uncover activities or events that should be reported to the authorities*

For further information contact:

- *PI: Alexander White,* alexander.white@postgrad.mbs.ac.uk
- *LPI: (Withheld)*
- *PI's Academic Supervisor: Prof. Anne Stafford,* anne.stafford@manchester.ac.uk

Appendix H: Article 3 - Participant information sheet & consent form

The University of Manchester
Alliance Manchester Business School

Participant Information Sheet

Relationships between facility management structure and their operations:
A Case Study of (Withheld) hospital facilities

You are being invited to take part in a research study as part of a doctoral programme in Accounting and Finance at the University of Manchester's business school. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Please ask if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part. Thank you for reading this.

Who will conduct the research?
The Principal Investigator is Alexander White. He is supervised by Professor Anne Stafford and Professor Pam Stapleton from the University of Manchester as well as (Withheld), in her role as the Local Principal Investigator.

What is the aim of the research?
The aim of the research is to understand and compare operations of hospital facilities under diverse management structures.

Why have I been chosen?
As a key participant in the operations of a (Withheld) facility being studied, it is important to include your perspective in order to have representative data to sustain the research.

What would I be asked to do if I took part?
You would be asked questions during a one-on-one interview, relating to the management and operations of hospital facilities and, perhaps, to provide a sample of documents relevant to the research. Interview duration is expected to be 60-90 minutes and will be audio recorded, if agreed to by the interviewee.

What happens to the data collected?
Data collected will be used for the sole purpose of the research. All data will be treated as confidential by the researchers and will be used in order to reach a clear understanding of the management structure and the facility operations. Audio recordings will be erased after transcription.

How is confidentiality maintained?
The interviewees involved in the research will not be individually identified in any published work. The evidence collected will be stored electronically in an encrypted environment.

What happens if I do not want to take part or if I change my mind?
It is up to you to decide whether or not to take part. If you decide not to take part, there is no requirement to give reason or risk of any detriment to yourself and any information collected

will be deleted upon request. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a consent form. If you decide to take part initially, you are still free to withdraw at any time.

Will I be paid for participating in the research?
You will not be paid, but participants will be offered a report with the findings from the research.

What is the duration of the research?
This research will mainly comprise one round of interviews, taking place between June and December of 2017. Subject to your agreement, follow up questions may be requested.

Where will the research be conducted?
The research will be conducted at the participant's place of work.

Will the outcomes of the research be published?
It is expected that the research will be used in a doctoral thesis and published in Academic Journals.

Who should I contact for further information?
The principle research contact is Alexander White. His contact details are: alexander.white@postgrad.mbs.ac.uk, 416-999-5054

The (Withheld) and The University of Manchester's Research Governance and Integrity Manager have also reviewed this study. *Participants requiring further assistance or advice can use the contact details below:*

The (Withheld) is responsible for ensuring that participants are informed of the risks associated with the research, and that participants are free to decide if participation if right for them. If you have any questions about your rights as a research participant please call the Office of the Chair, (Withheld)."

The University of Manchester's Research Governance and Integrity Manager, Research Office, Christie Building, University of Manchester, Oxford Road, Manchester, M13 9PL, by emailing: research.complaints@manchester.ac.uk or by telephoning 0161 275 2674.

Or

(Withheld).

MANCHESTER
1824
The University of Manchester
Alliance Manchester Business School

CONSENT FORM

Relationships between facility management structure and their operations: A Case Study of (WITHHELD) hospital facilities

If you are happy to participate, please complete and sign the consent form below

Please Initial Box

1. I confirm that I have read the attached information sheet on the above project and have had the opportunity to consider the information and ask questions and had these answered satisfactorily.

2. I understand that my participation in the study is voluntary and that I am free to withdraw at any time without giving a reason and without detriment to any treatment/service.

3. I acknowledge that the interview may be audio recorded.

I agree to take part in the above project

Name of participant	Date	Signature
Name of person taking consent	Date	Signature

Appendix I: Article 3 - Semi-structured interview questions

Target: Group 1 - (Withheld) Management

Introductory

1. Please confirm that it is ok that I record the audio of this interview.
2. Please explain your own role at (Withheld) in general terms, and your involvement with the (Withheld) Campuses in particular.
    a. Organisation, Department/ sector of employment, Position in organisation, Number of years in health sector, Number of years working with P3s
    b. Tell me about how you interact with the management of the facilities?

Operations (for each facility they use)

3. Is the facility effective & are the various hospital functions in the site sufficiently connected to each other spatially?
4. Compare the following processes at the facilities, including administrative and budgeting aspects. What works well and what does not:
    a. General maintenance
    b. Ad hoc work
    c. Construction projects/ Variations
    d. Life Cycling
    e. Energy management
5. Do you find building user (e.g. staff, contractor, tenant, visitor) orientation and communication/information flow is effective at the facility? Do users understand how to interact with the facility and who to contact/ what process should be followed to have aspects of the facility adjusted/ repaired/ cleaned/ replaced/ modified?
    a. Are the facility management manuals effective for this facility?
6. Are clinical staff aware of the facility management model used at the sites? Are they supportive/unsupportive/indifferent?
7. Is there much or little attention in the media of the facility? Is the media positive/negative, accurate/inaccurate, informative/sensational. How does it impact operations?

Design/ Construction

8. Were the facilities' conditions/quality verified adequately at construction completion?
    a. Was this kind of inspection activities ongoing during the operations? Did these inspection reports (if any) become the core documents to determine the assets' remaining useful life during the handover process?
9. Have you come across latent defects that may be related to risks unidentified at the point of substantial completion? If you could go back in time, what actions would you take to ensure these risks are properly managed at the point of procurement for the project?
10. If defects or problems surface now which are the consequences of the organisations' operations and management, who is held responsible? Who pays to fix these problems?

Contract Management (for each facility)

11. Are key contracts simple to understand and execute?
12. Do key facility management contracts have appropriate target to effectively drive high performance?

a. Is there a strong focus on realizing of the project within pre-formulated aims of scope, time and money?
b. Or do you find the contractual clauses inadequate or too rigid during contract management? In what areas?
c. Does the contract offer much space for negotiation?
    i. What was easy to agree on and what had to be negotiated?

13. Does the contact have effective means to impose incentives or sanctions in the case the contract is not abided?
    a. Can you give us some examples on incidences where Project Co was awarded bonuses or penalised?
14. Were there practical/accountability problems on the ground, e.g., in relation to repairs and maintenance?
    a. What was and wasn't included in the contract, please give an example.
15. Describe the level of trust between the parties?
    a. Is it rising or falling as the contract matures?
    b. Do the parties in this project generally live up to the agreements made with each other?
    c. Do the parties in this project give one another the benefit of the doubt?
    d. Reliability, do the parties in this project keep in mind the intentions of the other parties?
    e. Opportunistic behaviour, do the parties use the contributions of other actors for their own advantage?
    f. Can parties in this project assume that the intentions of the other parties are good in principle?
16. What is the level of alignment of activities between parties?
    a. Is there sufficient sharing of financial risks?
    b. Are there common long-term and short-term goals between parties?
    c. How much interdependency is there between organizations in the network?
17. How are operational/strategic and reputational risks managed?
    a. Is there any joint management of risks? Are there problems managing risks across the private/public boundary? How are different capabilities of partners drawn on to manage risk? Also how do you cope with uncertainties?
18. Do you have the information you need to manage the contract? Is this of sufficient quality? Is it timely?
    a. Are you aware of any information gaps anywhere?
    b. If you could have one new piece of information what would that be?
19. Is the amount of contact between the parties involved in the project sufficient? If not, prefer more or less?
    a. What is the approximate frequency of interactions? [e.g. Daily, weekly, monthly]
    b. The project receives adequate support from involved organizations?
    c. Are interactions between the various organizations involved in the contract effective?
    d. Are the level of people present appropriate to build and maintain sustainable relations with different organisations? Is turnover a problem?
    e. Are the points of contact clearly defined? Would you know where to go for a definitive answer that will not get over-turned?
20. Are there big differences in opinion between actors in the network about content and nature of the contract?

a. When deadlocks are reached or problems arise, does management try to find common ground between the conflicting interests
b. Is decision-making characterized by low or high transparency, predictable and characterized by few unexpected events?

21. Is the approach to dispute resolution well defined and if used, was it effective?
22. Please explain what governance and oversight of the project takes place? Were there any areas of governance that you were concerned about?
    a. How have governance processes reconcile competing interests and accountability to different stakeholder groups? Have you had any difficulties posed by conflicts/different perspectives from different stakeholders?

Procurement

23. Were you involved in major procurement processes at (Withheld)'s facilities (e.g. the (Withheld) facility and/or major element at the (Withheld) Facilities like the (Withheld))?
    a. If yes, how does your knowledge of the procurement process, in particular, help in understanding how risks were allocated in the procurement, help in your ongoing risk management throughout the operations? (If not involved in the procurement process, do you feel that you have adequate information for risk management during operations? And how?)
    b. How would you rate the level of competition between providers in the tender process?
        i. Were all proposals of a similarly high standard?
    c. How would you rate the level of technological complexity of the project?
    d. How would you rate the number of external stakeholders and external conditions involved with the project?
        i. Was much time spent in communicating between contract and external parties?
    e. In advance of the tender, how much contact had your organisation had with the parties with whom you cooperate in this project?
    f. Is the length of the contract appropriate? If not, would you prefer it to be longer or shorter?
    g. Would you prefer to add or remove aspects of contract [Design, Build, Finance, Maintain, Operate]?
24. Describe your level of working knowledge of Public Private Partnerships (P3s).
25. What is your general impression of the use P3s in Canada?
    a. Do you feel that the P3 model is appropriate for designing and building hospitals as well as the provision of nonclinical services?
    b. Do you feel that the design, construction and operation of public infrastructure projects are better executed under traditional procurement methods or P3s?
    c. What aspects of hospital development and operations do you feel should NOT be transferred to the private-sector?
        i. E.g. construction, parking services, design, project financing, Project planning, Food services, Plant maintenance, Housekeeping, Contract negotiation, Hospital operations, Non-nursing clinical services, Nursing services, Quality control, Project scope/ oversight, Environmental/ Contract/ Building code compliance, Independent certification, Subsequent project work, Retail.
26. Rate the competitiveness of the Canadian marketplace in terms of comprehensive P3 tendering for hospital infrastructure projects.

    a. What improvements do you feel need to be made in Canada to improve the decision-making process, tendering and execution of P3s?
27. Why do you believe the West 5th campus was delivered as a P3?
    a. What are the greatest strengths of the P3 model at the site? Weaknesses?

Accounting and accountability (as applicable)

28. Can you tell us how (Withheld) determined its accounting treatment for the facilities?
    a. Is the same approach used for the (Withheld) sites?
29. Do your accounting methods affect your approach to managing the project in any way? [e.g. budget, costing, affordability etc.]
30. How are operating and maintenance costs budgeted and accounted for (including required ad hoc work)? Is this straightforward or have there been problems?
31. Do the costs of the facilities' construction and operations stay within the limits that have been set?
32. What process do you have in place to evaluate and monitor the risks taken by your organisation?
33. Do any third parties conduct annual review of P3 and/or non-P3 hospitals? What information do they require of you for the annual review? What other forms of scrutiny have taken place?
34. How is asset value determined at your facilities? Was there agreement on acceptable asset condition in accordance with engineering standards – are these standards determined by an independent party? What negotiation took place and which professionals agreed it?
    a. How is life cycling of assets addressed at the different facilities?
    b. How did you agree on the reasonable lives of the assets, on what basis?
35. How do you interpret value for money (VfM)? Have you been given a set of criteria either formally in the contract or informally through your ongoing working relationships to assess your delivery of value for money? What actions do you take to ensure you meet those criteria?
36. Has any post construction evaluation been conducted of IO's initial VfM models?
37. Does your organisation benchmark the costs of managing these sites against others within or outside your organisation's portfolio? In what way you would use the benchmark? What are the sources of information?
    a. Have third party organisations made arrangement with you to share such knowledge?

Performance

38. How would you rate the success of the facilities?
    a. Does (Withheld) feel it got a good deal on handover?
    b. Do the benefits of the site/project - in general - exceed the costs?
39. What are the best attributes of each facility? The worst? Why? What aspect of your interaction with the facility works best at the New (Withheld) Campus?
    a. Which facility functions better today? Which facility is aging better? How/why?
40. In this project, compared to similar projects, were many new innovative solutions created? Examples?
    a. Were many new technologies developed or used in the realization? Examples?
    b. Were various functions well connected to each other? Examples?
    c. Were innovative forms of financing developed for this project?

    d. Was the innovative character of the project above or below the expectations you had before?

41. What does (Withheld) do well in managing their facilities/ what could they do better?
    a. What does Project Co do well/could do better?
42. How do you feel the quality of health care service delivery at the site compares to other similar hospitals in Ontario?
43. Were there unexpected risks? If yes, how were they managed?
44. How successful do you feel the (Withheld) project would have been if it was executed using a traditional procurement method? Or (Withheld) as a P3?
45. To what degree do you believe the management structure impacts the building performance?
    a. Do you feel that the P3 arrangement used to design, build, finance and maintain (Withheld) have resulted in issues with the delivery of care?

--

Is there anything else you would like to add?

Group 2 - (Withheld) Management

Introductory

1. Please confirm that it is ok that I record the audio of this interview.
2. Please explain your own role at (Withheld) in general terms, and your involvement with (Withheld) Campus in particular.
    a. Organisation, Department/ sector of employment, Position in organisation, Number of years in health sector, Number of years working with P3s
    b. Tell me about how you interact with the management of the facilities?

Operations

3. Is the facility effective & are the various hospital functions in the site sufficiently connected to each other spatially?
4. Compare the following processes at the facilities, including administrative and budgeting aspects. What works well and what does not:
    f. General maintenance
    g. Ad hoc work
    h. Construction projects/ Variations
    i. Life Cycling
    j. Energy management
5. Do you find building user (e.g. staff, contractor, tenant, visitor) orientation and communication/information flow is effective at the facility? Do users understand how to interact with the facility and who to contact/ what process should be followed to have aspects of the facility adjusted/ repaired/ cleaned/ replaced/ modified?
    a. Are the facility management manuals effective for this facility?
6. Are clinical staff aware of the facility management model used at the sites? Are they supportive/unsupportive/indifferent?
7. Is there much or little attention in the media of the facility? Is the media positive/negative, accurate/inaccurate, informative/sensational. How does it impact operations?

Design/ Construction

8. Were the facilities' conditions/quality verified adequately at construction completion?
    a. Was this kind of inspection activities ongoing during the operations? Did these inspection reports (if any) become the core documents to determine the assets' remaining useful life during the handover process?
9. Have you come across latent defects that may be related to risks unidentified at the point of substantial completion? If you could go back in time, what actions would you take to ensure these risks are properly managed at the point of procurement for the project?
10. If defects or problems surface now which are the consequences of the organisations' operations and management, who is held responsible? Who pays to fix these problems?

Contract Management (for each facility)

11. Are key contracts simple to understand and execute?
12. Do key facility management contracts have appropriate target to effectively drive high performance?

    a. Is there a strong focus on realizing of the project within pre-formulated aims of scope, time and money?
    b. Or do you find the contractual clauses inadequate or too rigid during contract management? In what areas?
    c. Does the contract offer much space for negotiation?
        i. What was easy to agree on and what had to be negotiated?
13. Does the contact have effective means to impose incentives or sanctions in the case the contract is not abided?
    a. Can you give us some examples on incidences where Project Co was awarded bonuses or penalised?
14. Were there practical/accountability problems on the ground, e.g., in relation to repairs and maintenance?
    a. What was and wasn't included in the contract, please give an example.
15. Describe the level of trust between the parties?
    a. Is it rising or falling as the contract matures?
    b. Do the parties in this project generally live up to the agreements made with each other?
    c. Do the parties in this project give one another the benefit of the doubt?
    d. Reliability, do the parties in this project keep in mind the intentions of the other parties?
    e. Opportunistic behavior, do the parties use the contributions of other actors for their own advantage?
    f. Can parties in this project assume that the intentions of the other parties are good in principle?
16. What is the level of alignment of activities between parties?
    a. Is there sufficient sharing of financial risks?
    b. Are there common long-term and short-term goals between parties?
    c. How much interdependency is there between organizations in the network?
17. How are operational/strategic and reputational risks managed?
    a. Is there any joint management of risks? Are there problems managing risks across the private/public boundary? How are different capabilities of partners drawn on to manage risk? Also how do you cope with uncertainties?
18. Do you have the information you need to manage the contract? Is this of sufficient quality? Is it timely?
    a. Are you aware of any information gaps anywhere?
    b. If you could have one new piece of information what would that be?
19. Is the amount of contact between the parties involved in the project sufficient? If not, prefer more or less?
    a. What is the approximate frequency of interactions? [e.g. Daily, weekly, monthly]
    b. The project receives adequate support from involved organizations?
    c. Are interactions between the various organizations involved in the contract effective?
    d. Are the level of people present appropriate to build and maintain sustainable relations with different organisations? Is turnover a problem?
    e. Are the points of contact clearly defined? Would you know where to go for a definitive answer that will not get over-turned?
20. Are there big differences in opinion between actors in the network about content and nature of the contract?

a. When deadlocks are reached or problems arise, does management try to find common ground between the conflicting interests
b. Is decision-making characterized by low or high transparency, predictable and characterized by few unexpected events?

21. Is the approach to dispute resolution well defined and if used, was it effective?
22. Please explain what governance and oversight of the project takes place? Were there any areas of governance that you were concerned about?
    a. How have governance processes reconcile competing interests and accountability to different stakeholder groups? Have you had any difficulties posed by conflicts/different perspectives from different stakeholders?

Procurement

23. Were you involved in the bid, design and contruction phases of the (Withheld) facility?
    a. If yes, how does your knowledge of the procurement process, in particular, help in understanding how risks were allocated in the procurement, help in your ongoing risk management throughout the operations? (If not involved in the procurement process, do you feel that you have adequate information for risk management during operations? And how?)
    b. How would you rate the level of competition between providers in the tender process?
    c. How would you rate the level of technological complexity of the project?
    d. How would you rate the number of external stakeholders and external conditions involved with the project?
        i. Was much time spent in communicating between contract and external parties?
    e. In advance of the tender, how much contact had your organisation had with the parties with whom you cooperate in this project?
    f. Is the length of the contract appropriate? If not, would you prefer it to be longer or shorter?
    g. Would you prefer to add or remove aspects of contract [Design, Build, Finance, Maintain, Operate]?
24. Describe your level of working knowledge of Public Private Partnerships (P3s).
25. What is your general impression of the use of P3s in Canada?
    a. Do you feel that the P3 model is appropriate for designing and building hospitals as well as the provision of nonclinical services?
    b. Do you feel that the design, construction and operation of public infrastructure projects are better executed under traditional procurement methods or P3s?
    c. What aspects of hospital development and operations do you feel should NOT be transferred to the private-sector?
        i. E.g. construction, parking services, design, project financing, Project planning, Food services, Plant maintenance, Housekeeping, Contract negotiation, Hospital operations, Non-nursing clinical services, Nursing services, Quality control, Project scope/ oversight, Environmental/ Contract/ Building code compliance, Independent certification, Subsequent project work, Retail.
26. Rate the competitiveness of the Canadian marketplace in terms of comprehensive P3 tendering for hospital infrastructure projects.

    a. What improvements do you feel need to be made in Canada to improve the decision-making process, tendering and execution of P3s?
27. Why do you believe the (Withheld) campus was delivered as a P3?
    a. What are the greatest strengths of the P3 model at the site? Weaknesses?

Accounting and accountability

28. Can you tell us how (Withheld) determined its accounting treatment for the facility?
    a. Is the same approach used for other sites?
29. Do your accounting methods affect your approach to managing the project in any way? [e.g. budget, costing, affordability etc.]
30. How are operating and maintenance costs budgeted and accounted for (including required ad hoc work)? Is this straightforward or have there been problems?
31. Do the costs of the facilities' operations stay within the limits that have been set?
32. What process do you have in place to evaluate and monitor the risks taken by your organisation?
33. Do any third parties conduct annual review of P3 and/or non-P3 hospitals? What information do they require of you for the annual review? What other forms of scrutiny have taken place?
34. How is asset value determined at your facilities? Was there agreement on acceptable asset condition in accordance with engineering standards – are these standards determined by an independent party? What negotiation took place and which professionals agreed it?
    a. How is life cycling of assets addressed at the different facilities?
    b. How did you agree on the reasonable lives of the assets, on what basis?
35. Does your organisation benchmark the costs of managing these sites against others within or outside your organisation's portfolio? In what way you would use the benchmark? What are the sources of information?
    a. Have third party organisations made arrangement with you to share such knowledge?

Performance

36. How would you rate the success of the facility?
    a. Does (Withheld) feel it got a good deal on handover?
    b. Do the benefits of the site/project - in general - exceed the costs?
37. What are the best attributes of the facility? The worst? Why? What aspect of your interaction with the facility works best?
    a. How does the facility functions compared to others in your portfolio? Which facility is aging better? How/ why?
38. In this project, compared to similar projects, were many new innovative solutions created? Examples?
    a. Were many new technologies developed or used in the realization? Examples?
    b. Were various functions well connected to each other? Examples?
    c. Were innovative forms of financing developed for this project?
    d. Was the innovative character of the project above or below the expectations you had before?
39. What does (Withheld) do well in managing their facilities/ what could they do better?
    a. What does Project Co do well/could do better?

40. How do you feel the quality of health care service delivery at the site compares to other similar hospitals in Ontario?
41. Were there unexpected risks? If yes, how were they managed?
42. How successful do you feel the (Withheld) project would have been if it was executed using a traditional procurement method? Or (Withheld) as a P3?
43. To what degree do you believe the management structure impacts the building performance?
    a. Do you feel that the P3 arrangement used to design, build, finance and maintain (Withheld) have resulted in issues with the delivery of care?

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Is there anything else you would like to add?

Appendix J: Article 3 - Summary of Exploratory Semi-Structured Elite Interviews

Primary Author: Alexander White, P. Eng. - Doctoral Candidate (University of Manchester, UK) | (Withheld)

Recording and Transcription

- *Recorded using Sony IC Recorder ICD-PX370.*
- *Manual transcription of points of interest*

Interview 1: *Former Project Company Representative & Former Facility Management Committee Member. October 28, 2017 at Interviewee's home.*

Interview 2: *Former Hospital Representative & Current Facility Management Committee Member. November 2, 2017. Conference room at P3 site.*

Highlights of Interviewees' Responses:

- *Procurement - Why P3 (General)?*
    - *31:40 I think [P3s are], absolutely, appropriate for hospitals and anything else we've touched. As a taxpayer, I personally think is one of the best thing that's ever happened. It's starting to put accountability were accountability should be and it's taking away the hospital's option to defer maintenance that needs to be done. Look, if you want to go to the [Kitchener-Waterloo] hospital that was built in the Fifties … If you want to see a piece of shit, I'll show you a piece of shit. It's the same wire hanging through the same ceiling tile that's been there for five years, the same face plate off an old electrical outlet where they pull the wires back and didn't bother putting a faceplate on, the same torn up floor tile. Nobody fixes things and they're not held to that accountability.*
    - *32:45 I became a believer in P3s when I toured the Abbotsford facility, that Johnson Controls had, which was the first P3 hospital in Canada, and it was three and a half years in. I was amazed at the general condition of the place; only minor nicks and scrapes on the wall. I asked the guy "Jesus what do you do you have someone walk around with a paintbrush every day? and he said "every week more or less (Withheld) 's, that's what I've got to do."*
    - *14:08 I don't think clinical functions should be [transferred to the private-sector] but for anything that's currently outsourced now, there's no reason why not. The question is when one person is responsible for many different aspects of the service and you have an issue with one area of the service, how can you separate that and bring in someone else? It may be harder to break up a contract where there's more players. I don't think that in general it's bad, anything that you would want to outsource, outside of clinical care, is fine.*
- *Procurement - Why P3 (Withheld)?*
    - *35:30 [(Withheld) was built as a P3 because] it was a mandate of the Ministry of Health. It was the only way [(Withheld)] were getting funding for the new*

project. There was no choice. The Ministry of Health said, "this is our model, if you want a new hospital it will be built under this model".

- *8:20 [(Withheld) was delivered as a P3] Because of the dollar value of the capital requirement. It was a ministry funding requirement. Literally, we were ready to award an architect, we had already done all of the work and were ready to award a contract and the ministry said "(screech), put on the breaks. This is going to be a DBFM" and we had no choice in the matter. If we wanted Ministry funding that is.*
- *12:09 So the question really is, if the government or if the Ministry of Health had the funds available and didn't have to go to an external developer to raise funds, would we still want to do a DBFM? Is it a truly better model for care? And "I don't know", is the answer. The selling features for moving the risk into the Project Co was that "we're going to design, we're going to build it and any issues are going to be ours". I found that in the operations phase that's not necessarily the case. If we have an issue with the parking lot gate not being long enough, then it's (Withheld). like this [pointing at (Withheld)] and (Withheld) are doing this [pointing at (Withheld)] and the hospital gets stuck with it. I'm thinking "that was not how this was sold to me, this is your problem fix it". I don't think that that relationship between Project Co, Service Co and then the construction manager is good, there's got to be a better way of getting that relationship so that there isn't all of this pointing. When I look at a lot of things, I think "OK I didn't expect the hospital was going to have to pay for that".*
- *1:03:30 Did we get a better value for money for this [than a traditional procurement? I am still not really convinced but I haven't really looked into what Infrastructure Ontario put out but it basically says that in the construction phase we would save this much but did we actually end up with the product that we wanted? Well I would say mostly we did, but we didn't get to make some changes that we might have wanted to because of the methodology. We may not have ended up with the exact product we wanted because of that. Then in terms of the Variations, we're not sure that we are getting value for money there.*

- *Procurement - Delivery model (DBFM):*
  - *10:30: The DBFM [model] is what saved [the hospital], quite frankly, because had this been a Design-Build, with that receivership it would have been just horrific for the hospital to try and go back to the [constructor]. Just think of how many resources the hospital would have had to marshal to understand the technical nature of the problems and to be able to take the design-builder to task. Now they just look at it and say "it's broken, we've got penalties, you fix it and I don't care what the technical part of it". So I think DBFM in this case serves them very well as opposed to a Design-Build.*
  - *23m As a traditional procurement, I think it would have run over budget and over the timelines. Knowing the way the hospital users think they know what they want, without having to take the pushback from a contractor who is trying to live within a certain financial model, you don't always get to the best solutions. So,, I think it would have been less successful, exactly as I said earlier with respect to the suggestion box. When everybody has to live within a certain balloon and you say you want something for $100 more then somebody else is going to take theirs for $100 less.*
  - *24:20 Having a service provider under the DBFM model, they cover their own risks and operate [the facility] reasonably well. Now obviously there is going to be a transition period where they don't fully understand what they've gotten themselves into, but due to that part of the management structure, they're motivated by performance penalties to make sure things are working.*
- *Procurement - Scope:*
  - *31m I think (Withheld) hit it right in that they didn't they didn't put retail in and they didn't put security in. In our other hospitals where we've got retail in, or*

security, it's not something that [Project Cos] do well and don't add any value. I would be leery of us taking over full janitorial cleaning responsibilities when you're scrubbing down the [operating rooms] because you've got the transmission of disease and pathogens and everything else and the risk is too great.

- *Procurement – Contract:*
  - *45m [The contracts are generally] well designed. IO did a lot of cut and paste in these contracts and there are confusing parts to it. They're generally well put together though there's always debates on the choice of words. For example where is says "free from", such as "free from graffiti". What does that mean, does that mean that every time someone writes with a magic marker on a wall you're going to get a penalty, or does that mean "substantially free from" or "we have a program to clean up graffiti every couple weeks or a month"? Or "free from leaves and litter", you're never going to be free from leaves and litter. So there's terminology in there that causes us all grief but people are aggressive on bidding these thinking they can negotiate their way out of it through the penalty structure.*
- *Design*
  - *8:30: The design of the building is great for people flow, and the location of departments within the building, the fact that it's split well between the secure and unsecure sides and the fact that all of the mechanical rooms are on the fourth floor isolated on a corner by themselves. It's just a great design in my mind because there's people that go up there they start their shift with Honeywell and spend their whole day up there and don't come down so they got everything there. Also, the fact that the service provider has ground level access for loading and unloading. They did a good job on the forensic intake coming into an elevator. The overall backup generation system is good and the way it flips over is really good.*
  - *17:40 The problem with [the AFP approach] is, by the time you award it to someone they've already done the design, or a lot of it, and during the design phase you're not able to say "I don't like this, I like this" or "I want to change this like this". You can't make any make design changes, whereas if you're hiring that architect you can make any changes you want. And why would those changes have a cost? Only because they went so far down the design trail.*
- *Construction:*
  - *12:40 I can't think of any [innovation] we brought in except the fact that we built it on the lot around the existing building; taking down a wing of the existing building and allowing them to continue to function with minor disruption. They then moved the people across the parking lot.*
- *Service Provider's involvement in D&C Phase*
  - *4m: The biggest [operational handover] issue was that Honeywell, despite the fact that they had a person on site, and they had a second person on site, were completely absent in [the design and construction phase] … to give feedback to the constructor or take information from the constructor and understand it. They had a person there who was literally lost in space. He was always just there but they missed it all and that's what caused us such problems at Substantial Completion, transition into patient move in and activating the building right. They just didn't have any of that information. He didn't contribute anything.*
  - *5:30: This guy was not a hard worker, was not motivated and it was really just a lost opportunity. (Withheld) had taken on too many projects at that time so they never had a Transition Manager to assist him and they never a good oversight to (Withheld) activities as to what was going on, so it was it was an*

absolute shit show. We knew this going into it though. I had spoken to his Manager eight months before that saying "you've got a disaster here".

- *6:30: As I brought this up multiple times to (Withheld), (Withheld) kept saying "it's (Withheld) problem". There seems to be a different attitude now at Plenary, in the fact that they're trying to help the Service Provider out with the Constructor. I would say that [the Humber River Regional Hospital project] was the turning point for that attitude being developed. Prior to that [operational input] was just the Service Providers problem during design and construction. "They signed off on it", "it's too fucking bad", "it's theirs". But things like the hydro systems and all the power monitoring controls were never installed properly. There's no way they would work with the wrong cables and everything. And yet these idiots excepted it.*
- *3:50 The selling feature of this kind of procurement model was meant to be the synergies between the operations component and the mechanical and electrical designers making things the way they should was supposed to be part of the process. I don't know if that actually happened because, although Honeywell sat at the table in all of the design meetings they literally didn't speak once, well, the only suggestion that was made in the period was in the penthouse to make the corridors wider. That was it. So, all of that expected expertise being brought during the design phase didn't happen. I think [this led to] some of those issues that we're having now in terms of quality of some of the hardware. Future projects like this, hopefully [will use this as] a bit of a lessons learned.*

- *Handover/ Transition:*
  - *47m On the build [scopes of time and money are] certainly locked in. They know exactly where they've got to be. The problem is the transition. Maybe the next one will be right don't know but the I look at (Withheld), (Withheld) 's and all the ones I've been involved with in the midst of the transition, and the service providers missed the transition. They were not ready for day one of Operations. And they were not ready for day three sixty five of operations.*
  - *8:20: **To answer your question, the building was not ready. OK. It was not ready [at Substantial Completion].** [Achieved FC over 4 years later after multiple issues, $2.4M in withheld payments and disputes initiated]*
- *Operations – Latent Defects*
  - *43:37 I would say [<u>latent defects</u>] are par for the course. These are past the warranty period and something that was working - was tested, tried and proven - and then broke some time later. We ran into some issues on the [heat] wheels, where they all started falling apart and the bearings coming out of them and they worked their way through the process. It's the ongoing P3 relationships between (Withheld) that allowed that process to work successfully. I believe you would be less successful in a design build type of environment because the design builder wouldn't have any liability so you'd have to end up taking the equipment manufacturer to task.*
  - *32:29 [Latent defects are] part of the problem. The hospital thinks that they shouldn't have to pay for anything because of the risk transfer. Depending on what it is, it becomes an issue if the Service Provider, and maybe rightly so, shouldn't be paying for it because it was a construction defect. But, by the time they get their act together and figure out who pays for it, the hospital loses because they have to wait to get it resolved. Which is why there's the payment deduction, but we haven't really instituted that in that manner to pay for some of those kinds of things.*
- *Operations - Demand Maintenance*
  - *36:10 I believe the <u>Demand Maintenance</u> works well because, they open a ticket, it's logged, subject to performance penalties and the like. And I believe the Preventative Maintenance works well, although they struggled to get*

some of it up and running. The life cycle replacement on the cosmetic or the finishes portion needs more oversight because they will continue to defer painting walls or replacing floors that are badly scored or stuff like that. But the oversight there can be from Project Co or by the hospital and the hospital is not doing their part on providing some oversight either.

  - *9:20 The strengths [of the DBFM model] were bringing in the CMMS that was tried, tested and true and having the maintenance staff start out right away with that. The ability to keep track of all the work orders is really good and to be able to time when they were called in, when they need to be responded to and when they need to be rectified, putting that whole rigor around it - I love that. And for the most part that's been its greatest success.*
  - *10:27 The part that isn't so good is the repeat maintenance demands, where you have the same issue [reoccurring] and it takes a while, and a number of those issues to happen, before the Service Provider will acknowledge that maybe there's a bigger issue than this one-off and get to it.*
  - *19:00 [For Demand Maintenance] because we're not as far ahead on our CMMS it's difficult to determine how the response and rectification times are different [between the (Withheld) sites] but I can say that the Demand Maintenance response times here are excellent, it's really good. It's more the repeating [Demands Maintenance items] that I'm not sure are getting the attention they didn't deserve, but that isn't really anything to do with the methodology, it's the folks in the positions.*

- *Operations - Energy*
  - *38:10 I think <u>energy management</u> is one of the big pluses for this P3 system but we struggled with (Withheld) on it. [Infrastructure Ontario] will tell you that (Withheld) 's is a textbook example of what should happen. Where in the first two years it was about $330k and $30k that [the Service Provider] paid out. And now they reduced their energy usage to the point where they're getting into positive performance. Quite frankly, what (Withheld) keeps missing is that she's getting that much money back. She says "I have to cut a check for $119-ish this year" but (Withheld) you were at risk of going five percent higher [than the target] and then, not doing so, that they really pulled down from 105% to 95% and then now it's 80% to 97.5% which they have to split. So (Withheld), you've saved a ton of money. It's one of the best things that's ever happened because it forces the hospital to getting engaged in it.*
  - *26:42 [Energy Management] is good as well. I don't like that for our D.B.F.M. [procurement] we had to agree on an energy target before the building was built. I don't think that's the right model. Whereas (Withheld) [Health System's Hospital] after three years they determined what their energy target should be [based on its performance].*

- *Operations - Life cycle*
  - *37:30 [<u>The Life cycle process</u>] is not perfect but it's better in the (Withheld) world than it is in the (Withheld) world because the (Withheld) world has got that bullshit arrangement with (Withheld) where (Withheld) holds the life cycle money and (Withheld)'s got a fixed price contract to maintain the building. So if the wall is scratched and they say it's life cycle and (Withheld) just says fuck you it's regular O&M pay for it out of your fixed price contract, (Withheld) says no and then it goes unfinished.*
  - *25:07 [for Life cycle] this is a much better model. Much, much better because you actually life cycles is built into the project. I know that my roof is going to be ok, I don't have to try to wrestle the money through [Ministry of Health] funding or through our capital funds through our hospital, which always go to patient care equipment before it goes to fixing the roof. So, there is no doubt it is far superior in this model.*

- *25:52 Honestly, I think the reason why we're doing this model is because the Ministry didn't have the funding. That's the only reason we're down this road. They didn't have all the money that they needed to pay for all the infrastructure we needed. But life cycle is a good a good piece of it. Again it could be improved on in terms of breaking down exactly what you're paying for so that when you know if you are making a Variation to reduce some of [the components] you know what number you're going to get back because it's been laid out in the Project Agreement. Right now we don't get that, we just get a [total] number of what our Life cycle cost is.*
    - *48:33 What I also don't like is my understanding is that life cycle is just meant to be at estimate of when things are required but if they're required more then that is at the risk of Project Co. So in my mind, if I should see that a door needs painting it should be done.*
- *Operations – Deferred Maintenance*
    - *16:15 You know the other one was that they had a major flood (Withheld) in the winter of 2014. They blew a two inch water line above the emergency department the operating rooms and it took out the emergency department operating rooms and sterile processing which was down below them. They had twenty five or twenty seven [maintenance] people on staff down there and over the years they have allowed the union to manipulate them so that everybody work days Monday to Friday and everything is a call in after that. Along with the fact that you know you just take a look at their facilities, I mean, they are poorly maintained to the point of being dangerous. Going in the parking garage right and there's an electrical conduits that are hanging off the wall that are down in pools of water. They should never have sitting water in a parking garage anyways, and this was like an inch deep water, and there's an electric conduit down into it. Now, I don't know if the conduit was alive or not but nobody pays any attention to it. There are door closures hanging down and a bungee cord on a door closure up to a bolt in the ceiling to pull the door closer so that it would actually start to close.*
    - *1:02:29 In terms of life cycle, we have access to ministry funding for life cycle at the (Withheld) site. We take all of our deferred maintenance, which is in the millions and millions and millions of dollars, and we prioritize it all based on criteria. We look at the most risky kinds of things to the hospital but that does leave us more at risk situation than we have here. We do an assessment of all the deferred maintenance [at (Withheld)] but we don't need to [at (Withheld)] and the ministry wouldn't give us any money anyway because it's newer than five years old and because it's a DBFM.*
- *Operations – Adhoc Work*
    - *14:15 So as you start understanding what they're trying to do, there's little fiscal accountability for some of the shit that's going on. Now there's fiscal accountability but when you stand back and look at it, things don't make sense. I'll give you a perfect example here. There was a gentleman by the name of (Withheld) that was the Maintenance Manager down at Charlton and he left after being there for about three years. … I knew him for the last year he and I sat down and had good conversations with him. He's a very smart man and he says "I'm really interested by this DBFM model (Withheld). I see the things that you're doing and I want to bring some of that discipline into what's going on, on my side because the way we waste money and the way this place is managed has got to change.*
      I'll give you two examples. One was, he had a request they granted. They are a traditional hospital so they had a carpenter shop, a welding shop and all that stuff. We don't do any of that stuff on a P3, we contract all of that out now. A department manager came down and said, "I want you to build a suggestion box". Now this is just a little box wooden box with a flip top, a slot

in the top and a lock on it, so (Withheld) sends it back and says "here's one you can buy at Staples for $50, it's going to cost me at least $300 to have someone build this in the carpenter shop". The guy very quickly responded and said "no, you build it for me because, I don't get charged for your time but, if I buy it from Staples, that $50 goes against my department budget".

  - *20:15 Ad hoc work to me is another thing that I feel like when we ask for it, the Service Provider is doing us a favour when they do it. I have no question when I'm at Charlton, I say to the guys "I need this done" and "Boom" it's done. Whereas here, the response is "if we do that, then your demand maintenance may be affected". There's more of a negotiation and I don't like that. I feel like the maintenance guys work for (Withheld),I they don't work for (Withheld) and that's a big difference in these procurement model. At (Withheld) they work for me, here they don't work for me, they work for (Withheld). Do they get their Demand Maintenance responses done quicker because I don't interrupt them like at (Withheld)? I don't know, but eventually, when we get our C.M.M.S. working, I will know that. You should do a follow up study in a few years. Anecdotally, the manager at (Withheld) said there's no way that our guys could meet the response and rectification times [achieved at the (Withheld) site].*
  - *48:45 The green door got painted but I asked for it in May, it's freaking November. If I want a door painted at (Withheld), it gets painted. I don't have to pay extra to get a door painted I shouldn't here either. I have a painter on staff and we have similar paint sitting around.*
- *Operations – Construction projects/ Variations*
  - *40:50 Generally [the staff] are supportive [of the model]. There are problems where things haven't been fixed as timely as somebody wants or that they don't understand that they can't just tell you to do it and it's going to be charged to an account. So in other words, they want to check an extra electrical outlet well it's going to cost money so it's got to go through the redevelopment small works process and be approved. They used to just get away with stuff because they had in-house electricians. The perfect example was in one of my conversations with (Withheld) where she said "why should I pay you $800 to put in an electrical outlet if I've got an electrician down in (Withheld) sitting around doing nothing to do it for free". My question was "Why do you have an electrician in (Withheld) sitting around doing nothing? Because that's costing me money as a taxpayer."*
  - *6:50 I like the maintenance part in terms of the demand maintenance but the ongoing Variation component of it, I don't like as much because I don't feel like we're necessarily getting good value for money and that it's not a high priority for the service provider to make Variation. If we tendered out something we would get a much quicker response than waiting for the Service Provider to get to it. It seems like it's not a priority. So in that whole aspect of the agreement with regards to, if we don't make the change then you're accountable for all the risks, I don't like that either.*
  - *11:30 The only piece that I wonder, I really do wonder, if it is a value for money is the Variation component of it. I find that the cost of the Variations are higher and … we could do it quicker ourselves. We have a full redevelopment department whose job it is to do Variations and that's it.*
  - *22:10 [For construction projects and Variations] I feel like it takes longer to get anything done and that the Project Agreement is not written in a way that allows for clear direction in terms of Direct Costs. There seems to be a lot of cost at every level and, in the Variation department, I think we can do it for less money and with better oversight. But, again, that's based on the person not necessarily the procurement methodology. If the Honeywell person was a great Construction Manager, I might be saying it differently as it's really based on who you get. … You do seem to spend an*

awful lot of time trying to figure out what you're paying for. If you've got a person who's already working on site, why am I paying him more when I know he's not getting any more money, so I'm paying the company more. If the whole purpose of this is cost plus, then I'm paying more than I should because I've already paid the cost of doing the [base] work plus this [additional] work.

- *Operations, component - Security System (RTLS)*
  - *11:40: I can't think of a single big headache in the operations phase. If I point to anything it's the security system. The worst aspect of the facility would be the fact that they've got an only R.F. based (Withheld) system, without using any of the infrared technology. That's what is causing us the grief and will continue to cause us grief.*
  - *7m: The security system, though, was never accepted by the Service Provider, it has never been signed off. … We had maybe ten weeks in between Substantial Completion and patient move in and the security system was no more than a batch of wires at Substantial Completion. They rushed like hell to turn that thing on for the first time a couple of days before we did the patient move. It was not tried and tested, it was not installed in time and that was largely due to the receivership of (Withheld) [the electrical subcontractor]. We were not really sure what (Withheld). was doing. They were just trying to get things done as quickly as possible and obviously to get Substantial [Completion]. (Withheld). were not forthcoming in trying to fix the Security system. [10:23] They were rushing to get things and gave the quick stamp on acceptance.*
- *Operations, component - Temperature*
  - *12:05 Mechanically, the other problem would be the temperature control in the south side, and they've done some work on that. But that was not a commissioning thing, it was not something that they missed. They delivered all of it the way it was supposed to be and it still didn't work right.*
  - *33:30 The temperature issue, I honestly think that (Withheld) should've considered that as a latent defect as it's not performing as it should be. That's another problem with this model. If I was running this and it was my people I would have someone assess it and I would figure out what the problem was and I would fix it. Then, if it wasn't fixed, I would be on it again, not waiting for another person to come through.*
- *Operations, component - Landscaping*
  - *50:40 On the grounds keeping, they've missed the sanctions. There's response-based penalties but not rectification-based penalties. They've missed that.*
  - *27:27 The other issue is the whole landscaping, three years and we still have ugly landscaping. How come the Project Agreement doesn't fix that? [The FM at Charlton] would never leave the grass so it looked like here, would never have the flower beds too.*
- *Workforce/ HR/ Union*
  - *18:00 It's the attitude and it's the acceptance of "this is my job, I only do that". The output that they get from their manpower is probably half of what you're getting on the (Withheld) site. And I would say the West 5th guys are still not overworked by any means... Same union.*
  - *18:45 There were twelve people that were [available] to transfer [from the old (Withheld) site]. Well, on the books there were sixteen but [six] of them were on L.T.D. [Ultimately] there were nine people that transferred. [Then our team] hired three new employees. [totalling 12 employees for a facility double the size].*
  - *19:20 It's funny because the hospital messed up the union negotiations quite badly. The H.R. Department was completely fucked and didn't know what they were doing. … We had these people demanding things or they were not*

going to transfer. They had the right to stay with (Withheld) as employees and St Joe's couldn't reduce their workforce and so if St Joe's had twenty five people and nine more came down and didn't transfer (Withheld) would have to carry thirty four positions forever unless they justified doing one of them away. It wasn't like they [could] balloon their workforce up to thirty four and then through attrition they would get down to twenty five in ten years or so.
    - *20:40 So the mechanics were using it as leverage through the union to say, "unless you give me a good deal, I'm going to (Withheld) and that's going to cost (Withheld) half a million dollars a year forever" because of the way the Union arrangement was. The reality was, as we went through this thing, I got to understand the mechanics. There was only one of those twelve that wanted to transfer to (Withheld). They hated (Withheld). They hated the way (Withheld) was run, … Even the people who transferred, they did not want to go. As much as they put up this front that this is what they were going to do, they were trying to negotiate.*
    - *21:40 There's a separate contract with Honeywell employees but it's a subsection of the hospital's and all of the pay rates and everything like that are negotiated globally across the province. The stuff that's negotiated in the contract with Honeywell is local issues such as hours of work, shift preferences, vacation or status.*
- *Contract Management*
    - *13:45 We struggled, continue to struggle and will always continue to struggle with the fact that all of the functional department heads are at [(WITHHELD)'s (Withheld) facility]. If they're looking after security or really any basic department, health and safety, or anything - seventy five percent of their workload is based in a traditional hospital owned environment and twenty five percent of their workload comes up to this DBFM model and they don't understand it.*
    - *48:20 I wouldn't say there's too much space [for negotiation in the contract]. It happens but the downside is the risk that the hospital administrators take when they agree to not penalize you for something, to give you a longer period of time to fix it, or just to waive the penalty on something for that month. Then what's going to happen when the auditor general goes through this thing in five years and that's the shit that's going to hit the newspapers and say "they should have been penalised hundreds of thousands of dollars and the hospital is waiving it!" Well, there's all kinds of reasons why they're waiving it, maybe they created the situation in the first place, is it documented well enough as to why they're waiving it?*
    - *49m [the contracts] have the sanctions because it's got the penalty structure but it doesn't have the incentives, other than in the energy guarantee. The airport in Toronto had done the same thing, when they negotiated the contract with (Withheld) for the HVAC maintenance and services. They allowed for up to a 10% incentive bonus if the work was done and they had a scorecard with items like number of hot and cold calls, number of times where a unit has been out for longer than a certain period. Annually, they negotiate an incentive based on that. Otherwise, if something goes out and it's routine, you've got seven days to fix it. A lot of the times you don't need seven days but maybe you can do it a lot more efficiently if there's an incentive for them to do better in some cases.*
    - *51m There is that dubious theory of equipment, specifically category 2 and category four that's not really well understood. It's a great concept but how do you maintain the inventory levels right and how do you maintain these logs. It's a hell of a piece of work to administer.*

- *36:07 [In the PA] I find that there's lots of concerns with interpretation. The fact that we're still talking about classification for work orders means that it's not very well written because, honestly, the way it's written you could interpret almost every work order would be classified as an Availability Failure given the use and safety [conditions aren't met].*
- *45:52 When issues do happen, there's not the timing of the follow up. It isn't as fast as I thought it would be and due to a difference of interpretation [of the Project Agreement] again I think that the issue should remain open until we know exactly what's wrong with it and that it won't happen again. It doesn't always happen that way so things get left behind and it takes so long and it builds a little bit of resentment. That's another thing that's different between this model and a traditional model, I can go to the Facility Manager and say, "you find out what the issue is" and he will come and tell me.*
- *36:56 The contract in the construction phase was a bit simpler in that the constructor acted like a contractor. There were issues around what is in the contract and what's out but we had a means for dealing with changes. In the operations phase, the contract I think is a bit more prone to interpretation pressure, particularly around classification of work orders.*
- *38:19 There is definitely more rigor to adhering to KPIs than traditionally [procured] sites because you know we don't have to. At the (Withheld) site, we're less likely to make sure that we adhere to [KPIs].*
- *39:48 The thing that is not good in general is that we have a contract with Project Co not with Service Co, but Project Co stays out of a lot of things. Whereas from my C.E.O.'s perspective, I should only be dealing with (Withheld), as that's who my contract is with. That push puts Project Co in a bit of a difficult situation but you're the one that should be making the decision and then if Service Co doesn't agree with that, then it's with you to figure that out, not us.*
- *41:00 Because it's three parties it always going to be difficult and maybe it would be better if Service Co had a contract with the hospital but it's all that sort of messes it up a bit, I don't know how to make it better but it's something that I think needs to be looked at somehow.*
- *48:08 No [our goals don't misalign]. I don't think we have any long term goals, we don't have any goals like "this year we're going to focus on this".*
- *50:47 Generally we get more information and better information from the DBMF site in terms of monthly reports and sticking to KPIs is better with this because it's built into the contract.*
- *59:21 Without having the CMMS [at (Withheld), it's difficult to compare the sites]. One way to do so would be periods of downtime. We have way less downtime of elevators here than our (Withheld) site. And you're written reports are much more thorough but sometimes you just look at individual events and not the bigger picture.*
- *1:00:11 The difference [in budgeting between the sites] is easy. At the (Withheld) site my budget keeps getting reduced because we have budget constraints. Here the budget keeps going up because of CPI increases so I almost have to try to take more out of other sites' [budgets] to accommodate for the lack of reduction in the building services side. We might need to look at ways that we could reduce costs here as well. The downside is, it's not as easy to reduce the budget in this kind of methodology. In terms life cycle [it's good] but every hospital [has reductions]. We are able to stay within budget at [the (Withheld)] site as well because if we monitor it each month and find that we're going above then we just cut back on whatever we need to make sure we stay within the means.*

- *Contract Management - Trust*

- *51:40 [Generally and at (Withheld), the <u>level of trust between parties]</u> is good going through the construction phase until sometime in the year before Substantial Completion when the trust seems to go down. It starts to come back up a little bit at Substantial Completion and then starts going down with the Service Provider performance because they're not ready for transition. It then picks up dramatically through the Operation Term.*
- *42:27 The level of trust [between parties] is generally high. I trust that the tradesmen will do what they need to do to rectify any work orders to the best of their abilities. But I feel that because there's penalties associated with rectification timelines that are not met, that there is a risk that the FM folks take it personally. As we've seen. And I think that's difficult in building a cohesive group. It would almost be better if penalties were only given if it was a life-safety issue. It seems like these little piddly ones sometimes get to this distrust. I think that's also because the contract is with Plenary and not Honeywell and honestly, if we hadn't had all of the personal alarm issues it would be completely different. So it depends on any issues that occur early on.*

Appendix K: Article 3 - Study completion form

(WITHHELD) STUDY COMPLETION REPORT

Complete the form in NO smaller than 12 point font; handwritten submissions are NOT acceptable

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Use this form only if all data have been collected and all contact with participants has concluded.

The study may not be closed out until both are completed.

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1. REB Project # 2754

2. Local Principal Investigator: (Withheld)

3. Title of Project: Relationships between facility management structure and operations: A Case Study of (Withheld) hospital facilities

4. Is this study: Investigator Initiated ☒
   Industry Sponsored ☐ Sponsor Name:

5. Has the study been submitted to the US Food and Drug Administration (FDA) under an Investigational New Drug (IND), Investigational Device Exemption (IDE), or Pre-Market Approval (PMA) application?

   ☐ YES ☒ NO

   Investigational New Drug (IND)#:

6. Is this research supported by the United States federal government? ☐ YES ☒ NO

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1. Brief description of the results of the study:

2. PLEASE RESPOND FOR LOCAL SITE ONLY.

(a) How many participants have been enrolled? [2]

(b) How many participants have completed the study (i.e. have had their last study visit, including all follow-up visits)? [2]

(c) How many participants have dropped out or been withdrawn from the study? (Attach explanation re withdrawals and dropouts) [0]

(d) How many local serious adverse events have there been? [0]
Were all of these reported to the REB? [☐] Yes [☐] No

If NO, submit Local Adverse Events Report to the REB now. [☐] Attached

(e) Have all study-related data analyses been completed? [☒] Yes [☐] No

3. FOR INDUSTRY SPONSORED STUDIES ONLY.
Has your site had the final close out visit with the study sponsor? [☐] Yes [☐] No

If NO, indicate when this is expected to take place: _____

4. Have any articles been published or presentations given using the results of this study? [☐] Yes [☒] No

If YES, please submit a copy of the abstract(s) or a list of references. [☐] Attached

Explanation

5. Check [✓] all that apply re reason for study termination: Attached [✓]:

[☒] a. Study enrolment and protocol completed [☐]

[☐] b. Study never received funding [☐]

[☐] c. Principal Investigator or major Co-PI left the institution [☐]

[☐] d. Not enough participants for study to be completed [☐]

[☐] e. Study closed due to adverse event(s) – requires explanation [☐]

[☐] f. Study suspended due to …. – requires explanation [☐]

[☐] g. Procedure or drug/device now approved [☐]

[☐] h. Other - describe in a few words below or attach explanation [☐]

Explanation: _____

I certify that as of the date below, participants are no longer being studied or followed and that this study should be officially terminated by the REB.

_______________________________8/6/2018_

Signature of Investigator

Date

Scan and Email or Fax one (1) copy of the Annual Renewal Form and supporting documentation to:

(Withheld)