The impact of public-private partnership on facility management costs: Evidence from healthcare in England

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September 2023

Abstract

Private Finance Initiatives (PFI) represent a form of Public-Private Partnership (PPP) extensively used in England since the 1990s. This study employs the ERIC panel dataset from 2018-2021 to evaluate how hospital procurement type affects hard and soft Facility Management (FM) costs. Employing OLS and 2SLS estimations, followed by propensity score matching and Hausman-Taylor estimations, the findings reveal that PFI is associated with increases in both hard and soft FM costs of up to 37.1% and 20.3%, respectively. This effect is more pronounced for sites with pre-existing buildings before PFI contract signatures, while the trend reverses for soft FM costs. Partial PFI financing is associated with higher costs compared to entirely PFI-procured hospital sites. However, this study suggests the potential for limited cost savings by considering moderate- and low-risk backlog maintenance costs, as well as capital investments in new construction.

Keywords: PPP, PFI, Hospitals, Facility Management Costs
JEL Classification: I13, I18, L32, L33

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1 Introduction

Public-Private Partnership (PPP) contracts and long-term contractual arrangements between government and private partners have become increasingly popular ways to build major public infrastructure projects (Hodge & Greve, 2017; Saussier, De Brux, et al., 2018). The effectiveness of such contracts has been assessed across various dimensions, including, among others, cost savings.[1] Since the 1980s, there has been an ongoing debate regarding the cost efficiency of PPPs as an alternative form of public service delivery (De Vries & Yehoue, 2013).

This study focuses on the healthcare sector in England and its use of Private Finance Initiatives (PFIs), which are a type of PPPs. The UK's first PFI hospital, designed for frail elderly patients and those with dementia, known as Ferryfield House, began operating in North Edinburgh in 1996 (McKendrick & McCabe, 1999). The purpose of this type of contract is to optimize government costs by easing budgetary constraints on public expenditure (Buso et al., 2017), partly reallocating risk (Bing et al., 2005), delivering projects on time, encouraging innovation, and incentivizing better performance (House of Commons Treasury Committee, 2011). By 2018, England had 109 hospitals and social care facilities funded through PFI, along with approximately 1000 financed through non-PFI means.

However, the PFI financing scheme appears less efficient than expected (Comptroller and Auditor General, 2018). As a result, the UK government banned the PFI in 2018, stating that the model was "inflexible and overly complex" (HM Treasury, 2018, p. 29). Nevertheless, ongoing PFI contracts remain maintained until hospitals are returned to the authority. The UK currently faces a wave of PFI expirations, with the National Audit Office (NAO) predicting a peak in 2036-2037 (Comptroller and Auditor General, 2020).

This paper enriches the literature that compares alternative procurement methods of public projects, PPP and Traditional Procurement (TP), across various dimensions and industries.[2] Several related studies have been dedicated to cost efficiency. These are, to name a few, Pollock et al. (2007), Blanc-Brude et al. (2009), Raisbeck et al. (2010), and Hoppe et al. (2013). A straightforward comparison of whole-life cycle costs is typically not feasible, owing to the longevity, variety, complexity, and commercial confidentiality of PPPs data. Therefore, existing academic studies have mainly assessed projects based on their key stages: construction (Blanc-Brude et al., 2006; Hoppe et al., 2013; Raisbeck et al., 2010) and maintenance (Devapriya, 2006; Ng & Wong, 2006).

The literature explaining the variations in hospital facility management costs is mainly

[1] Other performance measures are time (Comptroller and Auditor General, 2003, 2009; HM Treasury, 2022), quality (Gutacker et al., 2016; Hong, 2016; Yaya, 2017) and value for money (Bain, 2010; Daito & Gifford, 2014; Reeves, 2013).

[2] See literature review in Välilä (2020).

qualitative. To the best of our knowledge, the only available empirical study is conducted by Elkomy et al. (2019). This study utilizes panel data with trust-specific fixed effects to establish the relationship between outsourcing cleaning services and cleaning costs. Several qualitative studies have identified factors that impact facility management costs. These are, for instance, hospital bed use, space (Boussabaine et al., 2012), and staff wages (Sliteen et al., 2011). It is worth noting that most related studies are based on surveys. For example, Hassanain et al. (2013) interviewed managers from 20 public and 20 private hospitals in Saudi Arabia. In a study focusing on Scotland, El-Haram and Horner (2002) identified 24 factors that influence maintenance costs to varying degrees. Another widespread approach is to look for Key Performance Indicators (KPIs) for expenditures monitoring and optimization rather than investigating factors leading to the higher facility management costs.[3]

One notable novelty of this study is the use of granular and sparse data from the healthcare sector in England. This paper relies on the Estates Returns Information Collection (ERIC) dataset provided by the National Health Service (NHS) Digital. This rich collection of data covers the costs of providing and operating facility management services for NHS trusts from 2018 to 2021. The dataset also includes detailed information about NHS foundation trusts aggregated to PFI and non-PFI estate levels. Based on these data, it appears that PFI hospitals are typically newer, larger, and fewer in number than traditional hospitals. In addition, these hospitals tend to be geographically concentrated in major urban areas.

To the best of our knowledge, this study is the first to apply panel data empirical analysis to a comparison of public project procurement types (i.e., PPPs and TPs) in the healthcare sector. Our dependent variables are hard Facility Management (hard FM) and soft Facility Management (soft FM) service costs. Hard FM services are responsible for maintaining the physical assets of NHS buildings, including both the internal and external elements. On the other hand, soft FM services provide an extensive set of other amenities, including but not limited to catering, cleaning, security, postal services, and waste management.

Our main independent variable of interest is a dummy indicating whether the hospital procurement type is a PFI or non-PFI. We further differentiate the PFI procurement method into several subtypes. First, we distinguish PFI projects based on their tenure: full or partial. A full PFI signifies that the entire hospital was constructed under a PFI contract. In contrast, a partial PFI means that only a fraction of hospital buildings were built using the PFI. In a separate exercise, we distinguish between "old" and "new" PFI hospitals. The "old" category includes hospitals that had existing buildings before the initiation of the PFI contract. The "new" category includes hospitals that have been

[3]Follow Yousefli et al. (2017) for a literature on this topic.

freshly constructed under a PFI contract.

Our analysis starts with simple OLS regressions. We control for various characteristics that fall into five categories: labor, areas, energy, backlog costs, catering, and laundry services. The tested empirical specifications include alternative sets of fixed effects: hospital profile $\times$ year, the UK region $\times$ year, and trust $\times$ region + FE_{year}.

Potential endogeneity issues can occur if a PFI contract is granted to a hospital that already has an existing building. Factors such as the size of the hospital and its current hard and soft FM costs might influence the government's decision to allocate PFI funding. To tackle this endogeneity problem, we employ a 2SLS estimator using two instruments: the London Interbank Offered Rate (LIBOR) and public sector net debt (percent of GDP).

The key results show that hard FM and soft FM costs are systematically higher for PFI than for traditional hospitals, augmenting hard FM and soft FM service costs by up to 37.1% and 20.3%, respectively. This coefficient for hard FM service costs is larger for PFI hospitals with old buildings, while the opposite is true for soft FM service costs. Similarly, the difference between PFI and traditional hospitals is larger for hospital sites that are partially delivered under PFI contract, while the difference in soft FM service costs is larger for fully delivered ones.

Our general conclusion, consistent across all the tested specifications, is that PFI procurement leads to an increase in facility management costs. However, we have also identified the possibility of limited cost savings associated with PFI. This piece of the evidence is based on the interaction terms of PFI with backlog maintenance costs and capital investments.

The rest of the paper is organised as follows. Section 2 describes our data and variables. In section 3, we provide details on the OLS and 2SLS estimations and the corresponding results. Section 4 introduces propensity score matching and Hausman–Taylor estimations, an alternative approach to address endogeneity. In section 5, we conduct additional estimations to help interpret the main results. Finally, section 7 briefly concludes the paper and discusses directions for further research.

2 Data and variables

2.1 Sample and stylized facts

This paper uses a rich collection of publicly-available data about the costs of providing, maintaining, and servicing the NHS trusts.[4] Specifically, we use the annually released

[4]The data is made public by NHS Digital (see https://digital.nhs.uk). NHS Digital is the UK's national information and technology partner that collects, processes, and publishes data from England's health and social care system.

ERIC dataset dating back to 1999.[5] The PFI procurement method has been applied to UK hospitals since the late 1990s, and the ERIC dataset contains data on PFI sites, including hospitals, health centers, clinics, ambulatory diagnostic centers, mobile units, and treatment centers, since 2015. We further narrowed the sample to a panel of hospital sites in England between 2018 and 2021. Note that there is a significant mismatch in the convenience definition and computation of the employed variables between 2015 and 2017. For instance, in 2016-2017 any received income was offset by costs.

In the raw ERIC dataset, the unit of observation is a "site", defined as "any building or associated group of buildings, including administrative buildings within a specified area for which a trust incurs a cost to occupy".[6] Note that all sites provide secondary care. For this research, we employ a subsample in which we keep sites of two types: (i) having more than nine beds and (ii) with 1-9 beds and a total Gross Internal Area (GIA) of at least 500 m^2.[7] Therefore, our sample contains exclusively "inpatient" sites, and we remove from analysis "outpatient" sites, i.e. the ones mainly treating patients without overnight stays (see Appendix E1 and Table E1). Hereafter, in the remainder of this paper, we operate with the word "hospital" to refer to an "inpatient" site.

The subsamples used in our analysis varied depending on the specifications tested. In this paper, we provide descriptive statistics for the subsample used in the regression of soft FM services. Information on the other subsamples is available upon request. Our dataset covers 965 hospitals in 2018, 956 hospitals in 2019, 934 hospitals in 2020, and 1263 hospitals in 2021.[8] The initial sample consists of approximately 4000 hospital $\times$ year observations.[9] After data preprocessing, the sample size gets reduced to 2903 and 2911 observations for soft FM and hard FM service estimations, respectively. The sharp drop in the number of observations is primarily due to missing data for some components compounding hard and soft FM service costs. To ensure consistency across the years, the computation of some variables has been consolidated.

This paper aims to distinguish between sites built using the PFI procurement method (referred to as "PFI hospital sites") and those that did not use this financing method

[5]Previously disseminated via the Hospital Estates and Facility (HEFS) website.

[6]For more details, see https://digital.nhs.uk/data-and-information/publications/statistical/estates-returns-information-collection/england-2018-19.

[7]In our data, the GIA of a hospital is defined as the combined GIA of all buildings, whether they are occupied or vacant. This includes temporary structures, educational and training facilities, university accommodations, and areas temporarily used by building contractors. Areas that are leased out and open car parks, however, are not included in this calculation.

[8]The sharp increase in the number of observations in 2021 is due to changes in reporting. Sites without inpatient beds and with a GIA of more than 500 m^2 are now reported individually. Of the newly reported sites in 2021, 71% are mental health sites. To ensure data consistency, we have excluded these sites from the 2021 subsample. See Appendix E1 for more details.

[9]It is important to note that the source data is reported for the UK fiscal year, which runs from April 1st to March 31st of the following calendar year. This is slightly different from the standard fiscal year definition, which runs from April 6th to April 5th.

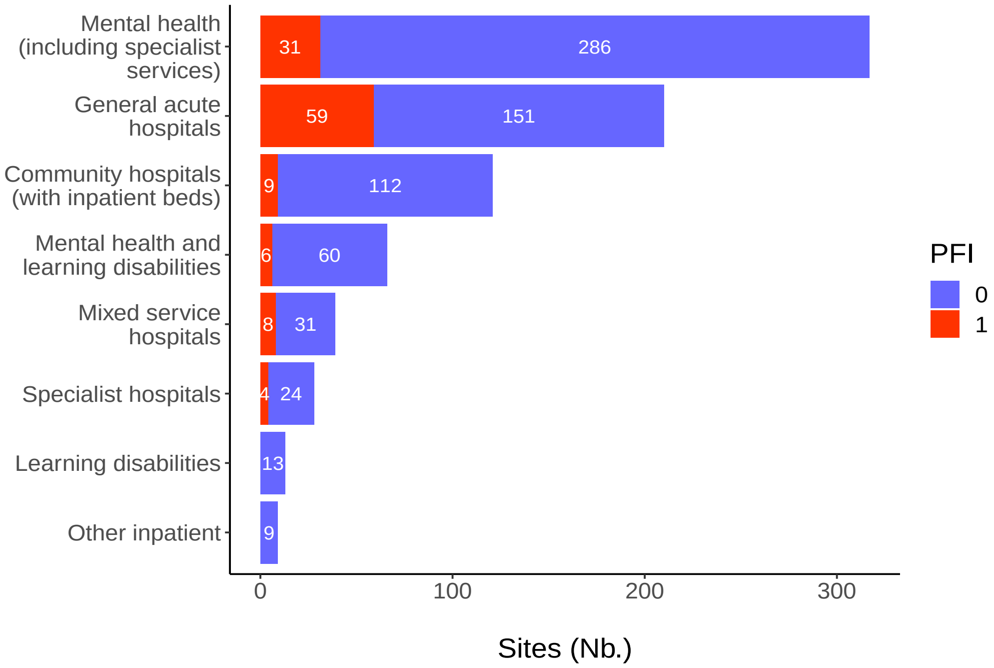


Figure 1: Unique sites in the hard FM sample: types, profiles and procurement method.

(referred to as "traditional hospital sites"). In the rest of the paper, we refer to hospital site types as "PFI hospital sites" opposed to "traditional hospital sites". Additionally, within the dataset, these two types are further differentiated into eight profiles (Fig. 1 and B1 in the Appendix). Of the PFI and non-PFI hospital sites in our data, 83% fall into one of three profiles: general acute (211/210 for soft FM/hard FM subsamples), mental health (233/317), and community hospital sites (116/121). General acute hospitals provide a range of inpatient medical care and related services for surgery, acute medical conditions, or injuries, usually for short-term illnesses or conditions. Mental health sites exclusively provide mental health services. Community hospitals offer an alternative to acute general hospital care by providing services closer to people's homes and tailored to local needs.[10] Fig. B1 compares the profiles and types of hospital sites in the soft FM subsample. In the hard FM subsample, the share is approximately the same. Traditional hospital sites form the majority (80%) and systematically dominate across all hospital site profiles. In total, there are 121 and 117 unique hospital sites for soft and hard FM subsamples, respectively, delivered using the PFI mechanism. Note Fig. 1 shows that Overall, NHS is more likely to attract private financing for the construction of general acute hospitals.

The geographical location of hospitals in our sample is shown on the map (Fig. B2). We conclude that PFI hospitals are uniformly distributed over the territory of England. It is worth noting that a large fraction of PFI supplied hospitals are concentrated around London. We further account for this geographical heterogeneity in the empirical analysis.

[10]The definition for all site profiles is given in the Appendix A1.

In fact, the factors related to urbanization and development of the regions should impact facility management costs.

2.2 Key variables

Regression analysis aims to explain the variation in two outcome variables: soft FM and hard FM service costs. These variables were computed as the sum of the corresponding components. Soft FM services costs include cleaning, food and beverages, laundry and linen, portering, and others.[11] Hard FM service costs include maintenance costs of estates and property, grounds and gardens, and electro-biomedical equipment. Another important components are the utilities of energy, water, sewerage and waste disposal. Note that since 2018 car parking and hard FM management costs are reported as separate components within hard FM costs.[12]

We present the distribution of soft and hard FM costs across the profiles of hospital sites in the Appendix, Fig. B3 and Fig. B4, respectively. We observe that site profiles with the largest number of observations tended to be normally distributed.

Our principal variable of interest is the dummy PFI, which takes a value of one if the site is built with a PFI contract. Such contracts are typically granted to Special Purpose Vehicles (SPVs) for a period–25-30 years. Four PFI contracts were terminated during the study period (2018-2021). More precisely, these are Whittington Hospital, Birmingham Childrens Hospital, Rosberry Park FKS St Luke's Hospital, and Goodmayes Hospital. We removed these observations from the dataset.

The boxplots in Fig. B5 in the Appendix show that soft FM is less expensive for traditionally supplied hospitals.[13] We further note that this pattern dominates in the hard FM dataset (see Fig. B6 in the Appendix). On average, PFI spends 138 and 108 million GBP/m^2 on soft FM and hard FM services, respectively, while non-PFI expenditures are 131 and 86 million GBP/m^2 for the same services. These boxplots call forth the hypothesis that a meter squared of hospital surface is more costly to maintain for PFI hospital sites as compared to traditional ones. We further note that after the COVID-19 pandemic, the average hospital site spending on hard FM and soft FM services slightly increased, while the ratio of PFI to non-PFI hospital site spending did not change.

[11] The "other" category could not be neglected in the computation of the total soft FM services costs. This category includes, for instance telecommunications, residential accommodation, art in hospital, stores services and courier and postal services.

[12] The "other" non-negligible costs include supplier management costs, insurance (except buildings insurance), and cots of compliance services.

[13] This figure reveals a number of outliers. The majority of them correspond to three hospital profiles: general acute hospitals, mental health hospitals and community hospitals.

2.3 Controls

This study employs a number of control variables that serve to identify the causality between public-private partnerships (in the form of PFI) and facility management costs. Table A1 in the Appendix provides summary statistics of all the variables for two panel datasets used in the regressions for soft FM and hard FM costs. The remainder of this section describes control variables.

Hospital age is one of the key characteristics. We expect that the hospital's age largely impacts the level of soft FM and hard FM service costs. For instance, older hospitals may require the regular maintenance of their buildings. Because the employed dataset does not contain information on the age of hospitals, we construct its proxy, a syntetic metric. To this end, we used the age profile reported in the ERIC dataset for each hospital site. This vector maps selected decades of the 20th century, with the share of hospital sites built during that period. The weighted foundation date of each hospital was calculated using the following formula:

$$Foundation\ date = \frac{\sum_{i=1}^{n}(s_i \cdot d_i)}{\sum_{i=1}^{n} s_i} \tag{1}$$

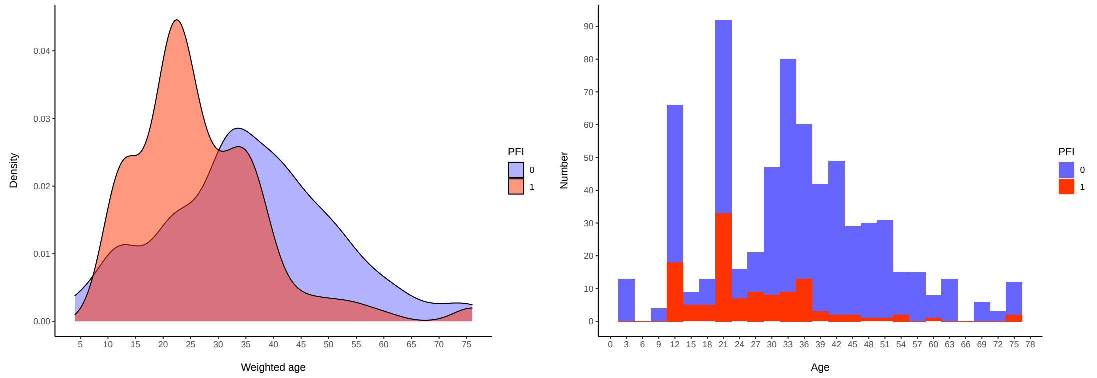
where i represents the index of each decade in the 20th century, d_i is the center year of the i-th decade, s_i is the weight of the i-th decade (i.e. share of buildings) and n is the number of decades in the data (9 in total).[14]

We plot the computed foundation date in Fig. B7 in the Appendix. This graph suggests that some buildings belonging to PFI hospitals were constructed before 1996, that is, the year when the first PFI hospital site was finalized.

Based on the weighted foundation date, we computed the age of each hospital site as a simple difference between the current year in the dataset and the aforementioned foundation date. In Fig. 2, we plot the computed weighted age of hospitals for the 2021 subsample. Subfigure 2(a) shows the distribution of the weighted age. Two immediate conclusions emerge. First, the PFI hospital sites are systematically younger in age. PFI hospital sites were built between 1995 and 2005, whereas non-PFI hospitals were constructed in the majority between 1980 and 1990. Second, both distributions have long tails and that of PFI hospitals is smoother. The bar chart in Figure 2(b) suggests that, as of 2021, most PFI hospitals are 21 years old. At the same time, a significant number of non-PFI hospitals are approximately 33 years old.

The size of a hospital site, measured by its GIA, is expected to have a significant impact

[14] The hospitals' foundation date from HOSPREC dataset is a possible alternative. This dataset was developed by the Welcome Library and The National Archives and is no longer maintained since 2012. We do not employ it due to the low rate of successful matches between datasets.



(a) Weighted age distribution.

(b) Age of sites by PFI procurement type.

Figure 2: Age of sites, subsample for 2021.

on the cost of facility management services. According to a study by Sliteen et al. (2011), 76% of the variance in maintenance costs per square meter can be attributed to the size of the hospital site. Furthermore, Gomez-Chaparro et al. (2020) established that hospital sites with areas exceeding 10,000 m^2 tend to experience reduced per-unit maintenance costs. Sliteen et al. (2011) also identified a significant correlation between the operational costs of utilities, maintenance, and operational maintenance staff and the GIA in square meters. Given these insights, we accounted for differences in size among hospital sites in our analysis. We normalize all the included variables relative to the GIA of each hospital.

The first group of controls we include is labor costs. They account for a significant fraction of the costs associated with soft FM services. Unfortunately, the dataset at our disposal does not contain information related to healthcare staff such as doctors and nurses. Nevertheless, in this study, we account for the employment of auxiliary staff, specifically porters and cleaners. These variables were measured in terms of whole-time equivalent (WTE) units.[15] The cleaning staff comprises both in-house and outsourced workers performing on-site cleaning duties. Meanwhile, the portering staff is responsible for both patient and nonpatient transportation and relocation services, as well as security services. We hypothesize that an increase in auxiliary staff employment positively correlates with the costs of soft FM services.

The clinical space in a hospital includes various areas dedicated to different aspects of patient care. These are private patient service areas, spaces directly devoted to the provision of pathology services, and those for sterile clinical procedures, among other patient-related spaces (Department of Health, 2013). However, it is important to note that clinical spaces do not include outdoor or multi-level parking facilities, which are leased or

[15]The Whole Time Equivalent (WTE) is calculated by dividing the number of required hours for the role by the standard full-time hours (37.5 hours). This method is a traditional way of estimating labor costs (Miguel Cruz & Guarín, 2017).

licensed out.

The size of clinical spaces in hospitals may significantly impact their costs. Larger clinical areas require more comprehensive maintenance and cleaning routines, thereby elevating expenses related to supplies, equipment, and labor. They also impact utility costs due to increased energy requirements for heating, cooling, and lighting. Additionally, larger spaces may demand more medical equipment and supplies to cater to patients' needs. Moreover, upgrading or renovating these spaces to meet standards or integrating new technologies can further escalate costs. Therefore, we control for the clinical space, which is defined as the share of the hospital's estate floor area that is directly related to patient care. We foresee a positive correlation between the proportion of clinical space and costs of soft FM services. For instance, Gomez-Chaparro et al. (2020) found that hospitals with larger usable floor areas tend to incur higher maintenance costs.

Another important control variable is the number of single bedrooms with en-suite facilities provided for use by patients. These facilities may range from just a WC and washing the hand basin to a more comprehensive setup, including a shower or bath. We postulate that this control variable should positively affect soft FM service costs. This is because an increase in the number of such rooms would likely result in a higher workload for the portering and cleaning staff, more frequent use of laundry services, and increased meal provision demand.

We further aim to directly control the hospital workload. We do so by considering the use of catering and laundry services. We include a control variable for the total annual quantity of inpatient meals ordered from wards and departments. These meals are breakfast, midday, evening meal, or any substitute or alternative for such meals. It is worth noting that this variable not only reflects the hospital's workload but also indicates the intensity of patients' allocation in the hospital.

Another control for workload is the number of laundry and linen pieces per hospital. Items laundered by external organizations or personally by clients and patients are not included in this count. This variable is a proxy for patients' hospital stay duration and should increase with higher hospital capacity. Our dataset allows us to distinguish between the outsourcing of laundry and linen services. We create a corresponding dummy variable that equals unity if an external contractor provides these services, whether under one-time or repetitive contracts. It takes a value of zero if both services are delivered in-house or at another hospital within the same trust.

Energy consumption significantly affects hospital costs because of the continuous nature of their operations. Energy is required for lighting, heating, cooling, and powering diverse equipment.

The total electricity consumption is computed using the following summation formula:

$$\text{Tot. electr. cons.} = \text{Electr}_{\text{def. rate}} + \text{Electr}_{\text{green rate}} + \text{Electr}_{\text{loc. renew.}} \tag{2}$$

Here $Electr_{def.\,rate}$ and $Electr_{green\,rate}$ denote electricity supplied by national, regional, or local electricity suppliers at the default and "green" rates, respectively. The default rate pertains to electricity generated from fossil fuels, whereas the "green" rate corresponds to renewable energy sources. $Electr_{loc.renew.}$ is the total annual electricity derived from local renewable sources, excluding those supplied through the national power grid. This category encompasses sources, such as onsite renewable rent-a-roof schemes, community-funded renewable energy projects, and renewable supplies procured through a private wire.

The total consumption of other energy is expressed with the following formula:

$$\begin{aligned}\text{Tot. oth. energ. cons.} = {} & Gas + Oil + Coal + Renewable\,Energy \\ & + HotWater + Steam\end{aligned} \tag{3}$$

Here the total consumption of other energy equals to the sum of energy in kilowatt-hours (KWh), stemming from a variety of sources. These include fossil fuels, such as gas, oil, and coal, alongside renewable energy sources, as well as hot water and steam.

Based on the aforementioned calculations, we introduce two energy-specific variables into the regressions. First, we include the total energy consumption, which is measured in kilowatt-hours per square meter (kWh/m^2). This metric is derived by summing the total electricity consumption, as calculated in equation 2, and the aggregated consumption of all other forms of energy, as defined by equation 3. Second, we introduce a binary variable indicating whether Combined Heat and Power (CHP) units are present within the hospital premises.

Combined Heat and Power (CHP) units serve as additional sources of electricity and energy. Utilizing either renewable or non-renewable fuels, these units not only generate electricity, but also capture residual heat, transforming it into useful thermal energy (steam or hot water). These are particularly beneficial for facilities that require both electricity and thermal energy.

3 OLS and 2SLS estimations

This section presents the results of the empirical analysis. We explain the estimation strategy in section 3.1. Most importantly, we detail the use and construction of the instruments and fixed effects. In section 3.2, we discuss the results for hard FM costs. The results for soft FM costs are in section 3.3. We then disassemble the FM costs into their components and test the impact of the PFI procurement method on each component. The results are reported in section 3.4.

3.1 Estimation strategy

We begin the empirical analysis with a series of simple OLS estimations to explore the causal relationship between a hospital site's procurement type and the variation in costs related to hard and soft FM services. An empirical OLS specification in general form looks as following:

$$log(Costs_{ht}) = \alpha_0 + \alpha_1 PFI_h + A'_{ht}\gamma + FE_{hti} + \epsilon_{ht}, \tag{4}$$

where the dependent variable $\log(Costs_{ht})$ corresponds to either hard or soft FM service costs. The panel data consists of H hospital sites ($h = \{0, 1, 2, ..., H\}$) observed over period t, ranging from 2018 to 2021. The key variable of interest is the dummy variable PFI_h which captures the hospital site's procurement type.[16] Vector A_{ht} includes a range of site-specific controls. For a comprehensive review of these variables, refer to the detailed discussion in section 2.3 prior to this. Finally, we augment the estimations with three interchangeable sets of fixed effects (FE_{hti}, where $i = s, p, r$) to capture time-varying unobservable factors that are specific to the UK regions, site and foundation trust profiles.[17]

The first set of fixed effects is $FE_{\text{site profile}} \times FE_{\text{year}}$, which adjusts for time-varying unobservable factors that remain consistent across all sites within a specific profile.[18] For instance, we can consider patient volume, infection control, safety measures, workplace strategies and technology innovations as changes uniquely associated with sites of a certain profile.[19]

The second fixed effect is $FE_{\text{region}} \times FE_{\text{year}}$. It captures location-specific unobservables that vary over time. Derived from the site location postcodes, these regional dummy

[16] After the expiration of PFI contracts, the hospital sites are returned to the authority. However, during the observable dataset period, only five instances of the PFI dummy variable were changed from one to zero. Due to this limited occurrence, we remove these cases, ensuring that our variable of interest remains invariant over time.

[17] We can't control for the site fixed-effect due to invariability of our endogenous variable over time.

[18] Detailed definition of hospital site profiles in Table A1 in the Appendix.

[19] The definition for all site profiles is given in the Appendix A1.

variables align each site with one of the nine greater regions within England.[20] As a result, we are able to control region-specific economic and administrative shifts. These may include decisions by regional authorities to modify budget allocation within a specific region.

The third set of fixed effects is $FE_{\text{trust}} \times FE_{\text{region}} + FE_{\text{year}}$. This fixed effect allows us to control for the possible dynamic factors inherent to facilities within sites affiliated with the same foundation trust and allocated to similar regions, where time variation is captured separately.[21] Foundation trusts, like other healthcare providers, receive funding from the NHS, and they participate in discussions and negotiations about resource allocation at the Strategic Integrated Economy System (SIES) level. As a decision-maker, trust policy directly impacts its functioning, that is, a combination of centralized decision-making and site-based management. Hence, it is crucial to isolate its impact on FM services to accurately measure the effect of a site's procurement type on FM service costs. Introducing an additional year-specific fixed effect also allows us to control for time-specific factors such as macroeconomic trends, changes in healthcare policies, technological advancements, or other time-specific effects that may be common to all sites within a given year. This control is necessary to ensure that any observed changes in FM service costs are not solely influenced by external factors that affect all sites uniformly. It should be noted that a fraction of macroeconomic shocks are partially captured by the temporal aspect present in all sets of fixed effects.

We continue the empirical analysis by addressing potential endogeneity issues caused by omitted variables. Endogeneity problem might be due to the fact that uncaptured various management practices, a certain level of technological adoption depending on the share of funds allocation on research and development, or The quality control measures employed in the production process impact both endogenous PFI variable and outcome variable.

We use two instruments. We selected LIBOR as our first instrumental variable, based on the financing mechanism used in PFI projects. An SPV company is uniquely created to execute a project when the government chooses a PFI contract to deliver public services. The SPV, established by a private sector consortium, raises capital through a combination of equity and debt financing, with banks providing around 90% of funding as senior debt and around 10% from equity investors (Comptroller and Auditor General, 2012).

[20]The choice of regions is driven by their role in the decision-making process of the government. In particular, each greater region is ruled by Combined Authorities, Regional Assemblies (es RRB-, or similar bodies. At the greater regional level, each of them decides to make decisions on various matters that affect the region as a whole, such as economic development, transportation, health, and social care. We assume that the choice of seven NHS regions or forty two regions according to integrated care systems in England would not be able to catch properly region-specific characteristics.

[21]It is important to note that some foundation trusts may have sites in different regions. For example, the Oxleas NHS Foundation Trust has sites in both London (Queen Mary's Hospital and Memorial Hospital) and the South East region (Bracton cente), all of which fall under the London commissioning region. Our dataset includes fifteen trusts of this kind.

The interest rate in the market directly affects the cost of bank debt allocated to the SPV for building a public project. The 2008-2009 financial crisis resulted in shifts in market conditions, reduced credit availability, and changes in the regulatory frameworks for PFIs (Demirag et al., 2015). This led to a decline in the number of lenders participating in PFI projects (Vazquez & Federico, 2015). Moreover, PFIs have undergone significant revisions in their regulatory frameworks (Ang & Marchal, 2013).

To capture the impact of market conditions on loan accessibility for SPVs, we use the LIBOR rate as an indicator of companies' participation in bidding processes and the government's choice of procurement type for sites. If the LIBOR rate during PFI contract bidding fails to meet private sector lending requirements, the likelihood of procuring the public contract through the PFI diminishes. We also believe that the LIBOR rate plays a significant role in shaping hard FM service costs through variations in the construction material prices in the market.

Another instrumental variable is the public sector net debt (percentage of GDP). The choice of the second instrument is driven by the PFI finance debt off-balance sheet accounting.[22] Following Comptroller and Auditor General (2018), we hypothesize that the UK government was more inclined to use PFI when the public sector net debt was higher. The rationale behind this assumption is that by employing the PFI, the government could potentially reduce the apparent debt burden by allocating certain expenses off the balance sheet, which might have appeared as traditional public debt if financed through conventional means (Comptroller and Auditor General, 2018). This approach allowed the government to present a more favorable fiscal outlook and maintain the debt-to-GDP ratio.

We compute the instrumental variables as a weighted average of the LIBOR and age profile of the sites. Further, we denote the instrumental variable Z_h interchangeably as L_h or D_h for the LIBOR and public-sector net debt rates, respectively.

We do the same for the second IV, the public sector's net debt rate. This approach is chosen because of the absence of an explicitly defined site foundation and decision date in our dataset. Specifically, we employ the following formula to compute the instrumental variables:

$$Z_h = \sum_{i=1}^{n} K_{hi} \cdot Z_{D_{hij}}, \tag{5}$$

where i represents the decision date categorized into ten-year periods ($i = 1, \ldots, n$ with

[22] Comptroller and Auditor General (2018) discloses that "Most PFI debt is scored as off-balance sheet under the European system of accounts (ESA), which determines government debt levels. However, under the International Financial Reporting Standards (IFRS), used to produce departmental financial accounts and the Whole of Government Accounts, most PFI debt is on-balance sheet".

$n = 9$). K_{hi} denotes the proportion of new construction or renovation for the site within each ten-year period with $\sum_{K_{hi}} = 1$. Z_i refers to the average LIBOR rate for a specific age profile period i. The LIBOR or public sector net debt rate is taken on the decision date $D_{hij} = M_i - C_{hij}$, which we treat as the site's procurement choice date by the government. This date for each decade is computed by deducting the average number of construction years for each hospital, C_{hij}, depending on its site profile j from the mean year of each i-th decade, M_i.[23]

To eliminate the omitted variable bias, we proceed with the system of equations below that illustrates the first and second stages of the Two-Stage Least Squares (2SLS) estimation procedure:

First stage:

$$PFI_{ht} = \beta_0 + \beta_1 L_h + \beta_2 D_h + A'_{ht}\delta + FE_{hti} + \eta_{ht}. \tag{6}$$

Second stage:

$$\log(Costs_{ht}) = \phi_0 + \phi_1 PFI_h + A'_{ht}\psi + FE_{hti} + \zeta_{ht}. \tag{7}$$

In these equations, the first instrumental variable, the weighted London Interbank Offered Rate (LIBOR) rate, is denoted as L_h, while the second instrumental variable, net government debt as a percentage of GDP ratio, is defined as D_h. In our panel dataset, the instruments do not vary over time for the same hospital. We assume that higher government net debt-to-GDP ratios and higher LIBOR rates could have been contributing factors that inclined the UK government to opt for PFI projects as a means to manage apparent debt levels and capitalize on potential cost savings during certain periods.

In the first stage (eq. 6), we estimate the relationship between the instruments and hospital's procurement type. The estimated PFI_{ht} is then used in the second-stage equation (eq. 7) to examine the impact of the procurement type on the logarithm of costs. The equations also include other control variables, denoted as A'_{ht} and fixed effects, FE_{hti}.

3.2 Results for Hard FM services costs

We begin the empirical analysis by estimating the impact of hospital procurement type (PFI or non-PFI) on hard FM service costs per square metre. The corresponding results are presented in Table 1. We run OLS and 2SLS estimations across specifications, with different fixed effects. The columns (1) - (3) report estimates with $site\ profile \times year$ fixed effects, whereas (4) - (6) with $region \times year$ fixed effects, and finally (7)–(9) include the most comprehensive set of fixed effects: $trust \times region + year$.

[23] j refers to eight profiles mentioned in Section 2.

Table 1: Impact of hospital site's procurement type on hard FM costs

	log Hard FM costs (GBP/m^2)								
	OLS	2SLS		OLS	2SLS		OLS	2SLS	
		First stage	Second stage		First stage	Second stage		First stage	Second stage
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
PFI (1/0)	0.125***		0.099	0.163***		0.048	0.134***		0.371*
	(0.017)		(0.076)	(0.017)		(0.088)	(0.020)		(0.191)
LIBOR (%)		−0.053***			−0.037***			−0.027***	
		(0.004)			(0.004)			(0.003)	
Public sector net debt (% of GDP)		−0.004***			−0.003***			−0.002***	
		(0.000)			(0.000)			(0.000)	
log Age	0.011	0.034*	0.007	0.012	0.012	-0.004	−0.001	0.009	0.022
	(0.011)	(0.019)	(0.009)	(0.011)	(0.019)	(0.018)	(0.011)	(0.017)	(0.027)
Clinical space (%)	0.002***	−0.001*	0.002***	0.001*	−0.002***	0.001	0.001***	−0.001***	0.002**
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)
log Single bedrooms (Nb/m^2)	0.002***	−0.000	0.002***	0.003***	0.002**	0.004***	0.003***	0.002***	0.002*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
log Total energy cons. (kWh/m^2)	0.235***	0.044***	0.237***	0.290***	0.087***	0.301***	0.232***	0.022*	0.226***
	(0.014)	(0.015)	(0.019)	(0.013)	(0.014)	(0.031)	(0.013)	(0.013)	(0.035)
Usage of CHP units (1/0)	−0.102***	−0.108***	-0.106***	0.023	−0.005	0.021	−0.009	−0.011	−0.004
	(0.019)	(0.020)	(0.018)	(0.017)	(0.019)	(0.017)	(0.022)	(0.021)	(0.027)
Cragg-Donald F stat		94.5			56.5			41.5	
Kleibergen-Paap rk Wald F stat		14.6			34.6			6.4	
Site profile x year FE	✓	✓	✓						
Region x year FE				✓	✓	✓			
Trust x region FE							✓	✓	✓
Year FE							✓	✓	✓
Observations	2 911	2 911	2 911	2 911	2 911	2 911	2 911	2 911	2 911

Notes: This table reports ordinary least squares (OLS) and two-stage least squares (2SLS) estimates of the effect of hospital procurement type on log soft FM services costs normalized to its GIA. Columns (1) - (3) specifications include *site profile* × *year* fixed effect, columns (4) - (6) specifications correspond to *region* ×*year* fixed effect, while columns (7) - (9) specifications introduce by *trust* ×*region* + *year* fixed effect. Columns (1), (4) and (7) show coefficients from OLS regressions of log soft FM services costs on sites' procurement type. Columns (2), (3), (5), (6), (8) and (9) display coefficients from two-stage least squares models instrumenting sites' procurement type with the UK bank rate, LIBOR, and Public Sector Net Debt (PSND) as a percent of GDP. Columns (2), (5) and (8) show first-stage specifications. Columns (3), (6) and (9) display the second stage excluding the instrument. ***, ** and * denote significance at the 1%, 5% and 10% level, respectively. Heteroskedasticity-robust standard errors are reported in parenthesis.

In line with the descriptive statistics, the OLS results in columns (1), (4), and (7) suggest that PFI hospital sites have higher hard FM service costs than non-PFI sites.[24] The corresponding statistically significant effect ranges between 12.5% and 16.3% depending on the included set of fixed effects.

The results of the second-stage instrumental variable (IV) estimations are reported in columns (3), (6), and (9). It is worth noting that the corresponding first-stage estimations yield Cragg-Donald and Kleibergen-Paap F statistics, which reject the weak identification of the instrumental variables. In the specification with trust fixed effects, the coefficient of PFI is estimated to be 37.1%, and this result is weakly statistically significant at the 10% significance level. Thus, the substantial and positive impact of PFI on hard FM costs is robustly supported by the use of IV techniques, further strengthening the credibility of our OLS findings.

The results for control variables represent a certain interest from the point of view

[24] Detailed specifications with progressively added control variables can be found in Table C1 and Table C2 in the Appendix. Our findings indicate that the estimated effect of PFI diminishes as more confounding factors are incorporated into the analysis.

of the organization of hospital management. First of all, we note that across all tested specifications, all control variables except hospital's Age have a statistically significant impact on hard FM service costs.

We find that the size of hospital, as proxied by the share of clinical space and number of single bedrooms for patients with en-suite facilities, positively impacts hard FM costs. This result is consistent with previous theoretical and empirical findings (Franco et al., 2017; Van de Glind et al., 2007). The corresponding effects are estimated to be around 0.2%.

Energy consumption is expected to significantly affect hard FM costs in hospitals. This is largely due to the maintenance and potential upgrades required for the infrastructure, such as HVAC systems, lighting, and medical equipment, which consume substantial amounts of energy. Indeed, the healthcare sector in the UK ranks among the largest energy consumers. As energy usage rises, maintenance costs escalate owing to increased wear and tear, and the need for more energy-efficient systems may arise, necessitating significant upfront investments. Although these upgrades can potentially reduce long-term costs, they contribute to initial expenses.

Moreover, utility costs, which constitute a significant portion of hospital operating expenses, tend to escalate in tandem with energy consumption. Compliance with energy efficiency and environmental regulations can further impact costs by mandating changes or modifications to the existing infrastructure. Additionally, the implementation and maintenance of mandatory backup power systems, which are vital for ensuring uninterrupted care during power outages, add to the FM costs.

In this study, we have taken into account two crucial energy-related variables: total energy consumption and usage of CHP Units. Our empirical analysis reveals that total energy consumption has a robust and statistically significant impact on hard FM costs. The estimated effect size falls within the range of 23.2%–29%, indicating that the energy factor plays a substantial role in determining hospital costs.

The usage of Combined Heat and Power (CHP) units is expected to have a negative impact on hospitals' hard FM costs. Bhandari et al. (2018) documented that they play a significant role in lowering operating costs and enhancing the reliability of uninterrupted services in healthcare facilities. For instance, Organic Rankine Cycle (ORC) - based biomass-fueled CHP systems offer excellent controllability, high automation levels, and low maintenance costs, thereby resulting in reduced operating expenses (Dong et al., 2009). Our 2SLS results suggest that a hospital site using a CHP unit face has a 10.6% lower hard-FM costs.

The Appendix tables provide evidence of how hard FM service costs are influenced by various regressors. Table C1 and Table C2 display the estimates of introducing regressors sequentially into the model. Table C3 and Table C4 show the results of adding each regressor individually into the model, where we employ GIA as a regressor rather than dividing the outcome variables by the GIA, thus controlling for the hidden effect of the economy of scale. Indeed, the GIA has significant explanatory power for hard FM service costs (column (2) in Table C3 and Table C4).

3.3 Results for Soft FM services costs

We continue the empirical analysis by estimating the impact of PFI status on soft FM costs. The main results are presented in Table 2. The structure of this table is similar to that in Table 1. According to the OLS results in columns (1), (4), and (7), a hospital site built under PFI procurement has 4.2% to 7.2% higher soft FM costs.[25] The second-stage 2SLS estimations are statistically significant for all the fixed effects. The corresponding magnitudes were higher, up to 11.1%–20.3%. The values of Cragg and Donald (1993) and Kleibergen and Paap (2006) rk Wald F statistics reported in columns (2), (5) and (8) allow us to reject the hypothesis of joint instrument weakness.

[25] Detailed specifications with progressively added control variables can be found in Table C5 and Table C6 in the Appendix. Our findings indicate that the estimated effect of PFI diminishes as more confounding factors are incorporated into the analysis.

Table 2: Impact of hospital site's procurement type on soft FM costs

	log soft FM cost (GBP/m^2)								
	OLS	2SLS		OLS	2SLS		OLS	2SLS	
		First stage	Second stage		First stage	Second stage		First stage	Second stage
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
PFI (1/0)	0.042**		0.170***	0.054***		0.111*	0.072***		0.203*
	(0.017)		((0.053)	(0.016)		(0.040)	(0.019)		(0.120)
LIBOR (%)		−0.056***			−0.038***			−0.032***	
		(0.004)			(0.004)			(0.003)	
Public sector net debt (% of GDP)		−0.004***			−0.004***			−0.003***	
		(0.000)			(0.000)			(0.000)	
log Age	0.010	0.052***	0.030**	−0.008	0.023	-0.001	−0.008	0.034**	0.006
	(0.011)	(0.019)	(0.012)	(0.011)	(0.019)	(0.008)	(0.011)	(0.017)	(0.020)
Inpatient main meals requested (Nb/m^2)	0.030***	0.001	0.030***	0.028***	−0.005***	0.029***	0.031***	−0.003**	0.031***
	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.003)
Laundered pieces per annum (Nb/m^2)	0.008***	0.001	0.008***	0.008***	0.003***	0.008***	0.008***	0.002***	0.008***
	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
Outsourced laundry and linen services (1/0)	0.103***	0.048**	0.097**	0.057**	0.017	0.053	0.010	0.004	0.009
	(0.023)	(0.024)	(0.037)	(0.023)	(0.025)	(0.031)	(0.034)	(0.034)	(0.049)
log Cleaning staff (WTE/m^2)	0.021***	−0.013***	0.022**	0.032***	−0.018***	0.033***	0.039***	−0.006	0.040***
	(0.003)	(0.004)	(0.009)	(0.003)	(0.004)	(0.005)	(0.004)	(0.004)	(0.008)
log Portering staff (WTE/m^2)	0.014***	−0.004	0.014***	0.020***	0.007**	0.020**	0.020***	0.007**	0.019***
	(0.003)	(0.003)	(0.004)	(0.003)	(0.003)	(0.004)	(0.003)	(0.003)	(0.006)
Cragg-Donald F stat		102.6			61.5			56.9	
Kleibergen-Paap rk Wald F stat		24.5			141.1			12.5	
Site profile x year FE	✓	✓	✓						
Region x year FE				✓	✓	✓			
Trust x region FE							✓	✓	✓
Year FE							✓	✓	✓
Observations	2 903	2 903	2 903	2 903	2 903	2 903	2 903	2 903	2 903

Notes: This table reports ordinary least squares (OLS) and two-stage least squares (2SLS) estimates of the effect of site procurement type on log soft FM services costs normalized to its GIA. Columns (1) - (3) specifications include *site profile* × *year* fixed effect, columns (4) - (6) specifications correspond to *region* ×*year* fixed effect, while columns (7) - (9) specifications introduce by *trust* ×*region* + *year* fixed effect. Columns (1), (4) and (7) show coefficients from OLS regressions of log soft FM services costs on sites' procurement type. Columns (2), (3), (5), (6), (8) and (9) display coefficients from two-stage least squares models instrumenting sites' procurement type with the UK bank rate, LIBOR, and Public Sector Net Debt (PSND) as a percent of GDP. Columns (2), (5) and (8) show first-stage specifications. Columns (3), (6) and (9) display the second stage excluding the instrument. ***, ** and * denote significance at the 1%, 5% and 10% level, respectively. Heteroskedasticity-robust standard errors are reported in parenthesis.

Our analysis reveals several empirical patterns regarding the influence of specific aspects of hospital site operations on soft FM costs. We account for labor employment, which is an important factor influencing soft FM costs. Since the employment of medical staff is not included in our dataset, we control for auxiliary labor. The results suggest that an increase in the use of cleaning labor by 1% augments soft FM costs by 2.1%-4%, depending on the specification. The impact of portering staff is moderate, with a coefficient of 0.2%. Note that, in our data, the average employment of porter staff is seven times lower than that of cleaners (see Table Table A1 in the Appendix). Furthermore, small hospitals prefer not to recruit porters or delegate their responsibilities to cleaners or medical workers.

The results in column (1) of Table 2 suggest that the site's soft FM costs increase by 0.8% and 3% for each additional laundered piece and requested meal, respectively. We note that this effect is consistent across specifications with alternative fixed effects, and is very similar in the 2SLS estimations. These variables are proxies for patient volume,

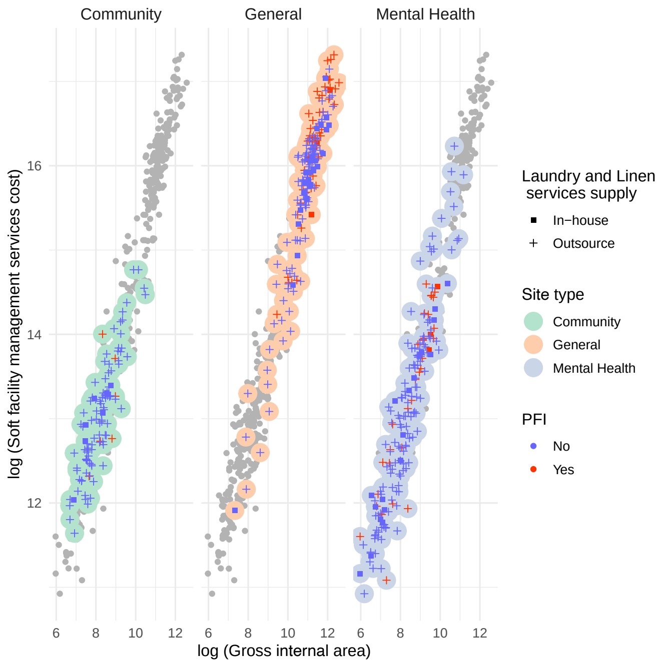


Figure 3: Laundry and linen outsourcing across sites' profiles.

that is, the number of patients that a hospital site serves within a given period. Therefore, according to our estimations, management costs increase with larger number of patients. This result might be crucial for understanding the costs during periods of higher demand, such as during the COVID-19 pandemic.

In our sample, approximately 80% of hospitals, regardless of their procurement type, opt to outsource laundry and linen services (refer to Fig. 3). A survey conducted by Moschuris and Kondylis (2006) focusing on Greek hospitals reveals that the decision to outsource these services primarily arises from factors such as personnel shortages, the need for flexibility, and enhancing customer satisfaction, rather than being primarily driven by cost savings. Our estimations demonstrate that this outsourcing practice is likely to increase soft facility management costs. These outcomes are statistically significant within the specifications, including $site\ profile \times year$ fixed effect (ranging from 9.7% to 10.3%) and $region \times year$ fixed effect (5.7%).

However, the literature provides mixed evidence. Ciarapica et al. (2008) demonstrate that smaller hospitals experience higher costs when employing outsourced personnel compared to internal staff. Conversely, for larger hospitals, outsourcing services prove to be more cost-efficient because of the transfer of risk associated with complexity. Shohet (2003), on the other hand, advocates that the effectiveness of maintenance outsourcing depends on the hospital's occupancy level. Hospitals with high occupancy rates face accelerated facility deterioration, which necessitates the use of available in-house resources for corrective maintenance. Conversely, in cases of lower occupancy rates, outsourcing could yield enhanced cost efficiency by delegating non-core facilities management activities to an external workforce.

In Tables C7 and C8 in the Appendix, we demonstrate the individual effects of each regressor on the soft FM costs. Notably, instead of normalizing each regressor using GIA, we include it as a control in these estimations. Given the substantial joint explanatory power (as measured by R^2) ranging from 0.673 to 0.789 when including the GIA and each of the other controls, it becomes evident that floor areas play a significant role in explaining the variance in soft FM costs.

3.4 Results for subcategories of costs

In this section of our study, we endeavor to identify distinct subgroups of hard and soft FM service costs that are statistically significantly impacted by the hospital site's procurement type. Thus, we aim to gain insights into potential cost-saving opportunities for facilities management.

Table 3 reports estimated impact of PFI procurement method on hard FM costs (columns 1-3) and soft FM costs (columns 4-6). The costs elements are listed in descending order based on their relative contributions to the total. Our results highlight that the estates and property maintenance costs of PFI-procured hospital sites are statistically significantly higher. The coefficients are 8.8% and 11.5%, respectively, while controlling for $site\ profile \times year$ and $region \times year$. Furthermore, when considering the fixed effects of $region \times year$ and $trust \times region + year$, PFI hospital sites experience higher costs in categories such as energy, electro-biomedical equipment servicing, waste disposal, water and sewerage, as well as car parking. This trend is particularly pronounced for electro-biomedical equipment and car parking costs, with variances ranging from 27.6% to 49.2% and from 21.7% to 26.8%, respectively, depending on the specific set of fixed effects included in the analysis. In contrast, PFI sites demonstrate lower management costs, with effect ranging from 36.2% to 47%. This result aligns with the cost-reduction potential of bundling services under PFI procurement.

Among the components of soft FM costs, cleaning expenses account for the largest share (33 %). However, our findings do not reveal statistically significant differences in cleaning costs between PFI and non-PFI sites. Instead, the major variation in soft FM costs across sites of distinct procurement types primarily arises from laundry and linen service costs, ranging from 18.3% to 23.4%, contingent on the specific set of fixed effects. Moreover, we find an analogous pattern as observed previously in hard FM costs, wherein the "management" component of soft FM costs is statistically significantly lower for PFI sites. Finally, other soft FM costs are higher for PFI sites (ranging from 12.7% to 33.5%). However, the identification of specific sources of cost savings poses challenges, as the "other" component comprises the various factors mentioned in Section 2.2.

Table 3: Results for the components of facility management costs

Hard FM costs	(1)	(2)	(3)	Soft FM costs	(4)	(5)	(6)
Estates and property maintenance (36%)	0.088**	0.115***	0.010	Cleaning service (33%)	0.011	−0.013	−0.009
Energy (28%)	0.041**	0.068***	0.045*	Other soft FM services (25%)	0.127*	0.335***	0.223***
Electro bio medical equipment (17%)	0.084	0.492***	0.276***	Inpatient food service (21%)	0.048*	−0.012	0.053*
Waste (5%)	0.018	0.094***	0.117***	Portering service (11%)	0.037	0.057	0.103**
Water and sewerage (4%)	−0.040	−0.029	−0.029	Laundry and linen service (7%)	0.183***	0.234***	0.187***
Car parking (3%)	0.007	0.268***	0.217**	Management (3%)	−0.446***	−0.396***	−0.312***
Management (3%)	−0.470***	−0.408***	−0.362***				
Other hard FM services (3%)	0.295***	0.144	−0.057				
Grounds and gardens maintenance (1%)	0.216***	0.068	−0.048				
Site profile × year FE	✓				✓		
UK region × year FE		✓				✓	
Trust × region + year FE			✓				✓

Notes: Each variable in the table represents a specific subgroup of costs within the hard FM or soft FM services. To ensure consistency and comparability, the costs are presented as logarithmic values in GBP, which have been normalized to the respective site's GIA. We take ***, ** and * denote significance at the 1%, 5% and 10% level, respectively. The calculation of hard FM and soft FM management shares is limited to a three-year period, specifically from 2019 to 2021. This constraint arises from the fact that the costs associated with these services were distributed among other components in the overall hard FM and soft FM service costs during the year 2018.

4 Propensity score matching and Hausman–Taylor estimations

The assignment of PFI financing might be endogenous, as it might be influenced by factors internal to hospitals. To address the issue of non-random selection, we utilize a combination of Propensity Score Matching (PSM) techniques and an Ordinary Least Squares (OLS) estimator with fixed effects. PSM is a non-parametric method widely used in the evaluation and experimental literature and has been adopted in observational studies in economics and management (Imbens, 2015; Li, 2013). The method relies on pairwise comparisons between treated and untreated individuals or entities that are very similar in their pre-treatment observable characteristics. After matching, the only difference between the treated and untreated samples lies in their treatment status (Caliendo & Kopeinig, 2008).

We closely follow the approach of Hijzen et al. (2011). In the first step, we estimate the propensity scores, denoted by $Score_{ht}$, using a logit estimator as follows:

$$Score_{ht} = e(X_{ht}) = \frac{1}{1 + \exp(-\alpha - \beta X_{ht})} \tag{8}$$

where α and β represent the estimated parameters and X_{ht} refers to the vector of observed covariates for hospital h in year t. This includes the most crucial factors determining the assignment of PFI: site age and GIA. We iterate this estimation separately for each year. $Score_{ht}$ stands for the estimated at the first step PSM score and represents the propensity of the hospital to receive treatment.

In the second step, we utilize these scores to pair up the sites. To accomplish this, we employ the widely used nearest-neighbor matching algorithm commonly used in PSM-based studies (Austin, 2014). The matching process is conducted without replacement, which means that each treated observation (PFI) can only be associated with one hospital site in the control group (non-PFI). Therefore, our aim is to match sites that exhibit similarities in their pre-treatment observable characteristics but have been assigned different PFI statuses. We further refine the sample by selecting only the comparable dyads. Once we have this subsample, we proceed with the OLS estimation of equation (4).

Moreover, as an alternative technique to address the endogeneity issue arising from the presence of unobserved (or omitted) variables, we utilize Hausman-Taylor (HT) transformation. We prefer the HT transformation over the Generalized Method of Moments (GMM) due to the invariability of endogenous variable over time. Following Hausman and Taylor (1981), we transform eq. (4) to distinguish three sets of variables: time-varying exogenous ($X_{ht} = A_{ht}$), time-invariant exogenous ($Z_{1h} = \{L_h, D_h\}$), and time-invariant endogenous ($Z_{2h} = PFI_h$) variables.[26] We proceed to estimate:

$$\log(Costs_{ht}) = X'_{ht}\beta + Z_{1h}\gamma_1 + Z_{2h}\gamma_2 + \mu_h + \epsilon_{ht}. \tag{9}$$

First, to perform the "within" transformation, we remove Z_{1h} and Z_{2h}, obtaining the "within" estimator and "within" the residual. From this residual, we compute idiosyncratic error term $\hat{\sigma}^2_\epsilon$. Subsequently, we regress "within" residual on Z_{1h} and Z_{2h} using X and Z_{1h} as instruments to obtain consistent estimates of γ_1 and γ_2. These estimates, along with $\hat{\sigma}^2_\epsilon$, allow us to obtain $\hat{\sigma}^2_\mu$. Finally, we perform a random effects transformation for each variable, leading to the final HT estimator.

[26] Our model does not include time-varying endogenous variables. Exogenous and endogenous variables refer to their correlation with μ_h, not with ϵ_{ht}.

Table 4: Matching methods and Taylor

	log hard FM costs			log soft FM costs		
	PSM no caliper (1)	PSM caliper = 0.1 (2)	Hausman - Taylor (3)	PSM no caliper (4)	PSM caliper = 0.1 (5)	Hausman - Taylor (6)
PFI	0.132*** (0.021)	0.148*** (0.028)	0.287** (0.004)	0.015 (0.015)	0.000 (0.013)	0.368*** (0.000)
Other controls	✓	✓	✓	✓	✓	✓
Site profile x year FE	✓	✓	✓	✓	✓	✓
Observations	1 019	652	2 911	1 009	650	2 903
Adjusted R^2	0.304	0.291	0.063	0.560	0.530	0.137

Notes: This table reports Propensity Score Matching (PSM) estimates without caliper (columns (1) and (4), for hard FM and soft FM costs respectively) and with 0.1 caliper (columns (2) and (5), for hard FM and soft FM costs respectively). Columns (3) and (6) show estimates of the Taylor regression model, for hard FM and soft FM costs respectively. ***, ** and * denote significance at the 1%, 5% and 10% level, respectively. Heteroskedasticity-robust standard errors are reported in parenthesis.

Our findings are presented in Table 4. The results concerning hard FM costs (columns 1-3) are statistically significant across PSM subsamples as well as Hausman-Taylor estimations. It is worth noting that the estimates for PSM without a caliper (13.2%) are consistent with the OLS results from the full sample (12.7% in Table 1, column 1). By contrast, the coefficient for the more restricted sample (with a caliper) is higher (14.8%). The Hausman-Taylor coefficient of 28.7% surpasses OLS estimates, indicating the presence of endogeneity. Concerning the impact of PFI on soft FM costs, the OLS results on PSM-matched samples are not significant, whereas the coefficient for the Hausman-Taylor estimate is strongly significant at the 1% interval. Therefore, we conclude that OLS estimates for soft FM costs are likely to be biased.

5 Interpretations

In this section, we delve into the interpretation and explanation of the findings presented in the previous section. We specifically focus on the properties of hard FM costs. Further robustness checks could be found in the Appendix D.

5.1 Heterogeneity of PFI contracts

In this subsection, we complement the principal analysis by differentiating PFI contracts. We explicitly employ the ownership dimension of hospital sites. There are nine possible types of tenure. Two of them are related to PFI procurement type: "full PFI" and "part PFI". The former one alludes to the case where the whole site is under the PFI procurement, such as the Queen Alexandra site (Portsmouth Hospitals NHS trust, 2018). The "part PFI" tenure applies to a hospital site where only its fraction is supplied under PFI contract. For example, the Wycombe General Hospital site's estate has a total GIA of 55 367 m^2, of which only 11 992 m^2 is within the PFI buildings (Buckinghamshire Healthcare NHS Trust, 2021). In our dataset, approximately 55% of the PFI sites have

Table 5: Heterogeneity of PFI projects

	log hard FM costs			log soft FM costs		
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: PFI share of total						
PFI_{full} (1/0)	0.109***	0.129***	0.142***	0.052**	0.068***	0.099***
	(0.024)	(0.023)	(0.026)	(0.024)	(0.023)	(0.026)
PFI_{part} (1/0)	0.140***	0.191***	0.127***	0.034	0.043**	0.049**
	(0.022)	(0.021)	(0.024)	(0.023)	(0.021)	(0.025)
Adjusted R^2	0.266	0.278	0.476	0.312	0.356	0.508
Panel B: PFI time dimension						
PFI_{old} (1/0)	0.201***	0.354***	0.336***	0.094	0.122**	0.195***
	(0.056)	(0.056)	(0.069)	(0.060)	(0.058)	(0.073)
PFI_{new} (1/0)	0.225***	0.228***	0.183***	0.084**	0.065*	0.036
	(0.034)	(0.034)	(0.038)	(0.037)	(0.036)	(0.040)
Adjusted R^2	0.253	0.264	0.477	0.293	0.341	0.507
Site profile x year FE	✓			✓		
UK region x year FE		✓			✓	
Trust x region + year FE			✓			✓

Notes: This table reports ordinary least squares (OLS) estimates of the effect of hospital sites' procurement type on log hard FM services costs, columns (1) - (3), and log soft FM services costs, columns (4) - (6), normalized to its GIA. Columns (1) and (4) specifications correspond to *site profile* $\times$ *year* fixed effect, columns (2) and (5) specifications correspond to *region* $\times$ *year* fixed effect, while columns (3) and (6) specifications correspond to *trust* $\times$ *region* + *year* fixed effect. Columns specifications include PFIs grouped according to their tenure, fully or party build through PFI procurement type, PFI_{full} or PFI_{part} respectively. Another PFI grouping corresponds to the presense of buildings under the site built before PFI contract financial closure. Particularly, PFI_{old} variables refer to PFI hospital sites that owned buildings before the PFI contract financial closure, while PFI_{new} variables refer to PFI hospital sites that had no constructions before the PFI contract financial closure. ***, ** and * denote significance at the 1%, 5% and 10% level, respectively. Heteroskedasticity-robust standard errors are reported in parenthesis.

full tenure, whereas the remaining 45% have partial tenure. Consequently, we introduce two categorical dummy variables, PFI_{full} and PFI_{part}, in place of a single PFI dummy. Meanwhile, we maintain the benchmark group of non-PFI hospital sites.

We note that the assignment of tenure is independent of whether a site was constructed from the ground up or if the PFI project arose from the integration and renovation of previously established hospitals, as in the case of the Queen Alexandra hospital site. This observation prompts us to distinguish PFIs based on the presence of hospital structures before the financial closure date of the PFI contract.

Therefore, we introduce two categorical dummy variables, PFI_{old} and PFI_{new}. Specifically, the PFI_{old} dummy variable takes the value of one when the age profile of a hospital site indicates construction activities in the decades leading up to the financial closure date of the PFI contract. On the other hand, the PFI_{new} variable is set to one when constructions occur during or after the decade in which the financial closure of the PFI project is concluded. [27]

Panel A of Table 5 reports the estimation results, differentiating PFI contracts with respect to their tenure. Overall, these results align with the key findings presented in Table 1 and Table 2. We further conclude that the impact of PFI_{part} on hard FM costs (columns 1-3) is typically larger (12.7%–19.1%) than that of PFI_{full} (10.9%–14.2%). This might be attributed to the higher coordination costs arising from the need to coordinate activities and management of hospital sites under PFI and the leftovers of a hospital. A similar pattern we observe for the soft FM service costs.

Panel B reports estimates for the time dimension of the PFI. We conclude that regardless of the employed set of fixed effects, both PFI_{old} and PFI_{new} are statistically significant and increase FM costs. However, the estimated effects of hard FM costs are systematically stronger for PFI projects applied to hospital sites with pre-existing premises. We hypothesize that this may be due to the additional costs associated with the maintenance and refurbishment of properties. Due to their historical nature, older hospital sites may need to adhere to stricter regulatory and compliance standards. Furthermore, hospitals with pre-existing premises are likely to have infrastructure and facilities that need to be integrated or adapted to the new PFI project. This integration process may involve extensive modifications, resulting in higher hard FM costs to ensure proper alignment and functionality.

Our empirical results suggest that the procurement of freshly constructed hospital sites through the PFI mechanism leads to a substantial increase in both hard FM costs (ranging from 18.3% to 22.8%) and soft FM costs (ranging from 6.5% to 8.4%). This can be attributed to several factors. Modern hospital facilities might demand specialized personnel for tasks, such as operating advanced medical equipment or managing sophisticated IT systems. This incurs additional setup and staff training costs. However, newer buildings often focus on sustainability and environmentally friendly practices. These initiatives might require additional monitoring and management, in addition to soft FM costs.

5.2 Role of backlog maintenance

As shown before, when PFI financing is employed for hospital sites with existing facilities, the impact on hard FM costs is more pronounced. We aim to dig deeper and provide an interpretation of this result. Pre-existing hospital sites might have a backlog of deferred maintenance that must be addressed during the implementation of PFI projects. A backlog refers to the portion of an asset that falls below the minimum acceptable performance

[27]The financial closure date of a PFI contract refers to the point at which the contract is finalized and all financial aspects are fully arranged. We sourced the financial closure dates of PFI projects from the "Private Finance Initiative and Private Finance 2 projects:2018 summary data" dataset obtained from the ERIC database. It's noteworthy that around 30% of PFI sites were successfully matched with their respective financial closure dates.

Table 6: Role of backlog maintenance costs

	log hard FM costs			
	No lag		1 year lag	
	(1)	(2)	(3)	(4)
PFI (1/0)	0.145***	0.132***	0.144***	0.131***
	(0.024)	(0.022)	(0.027)	(0.024)
log High and Significant risk backlog cost (GBP/m^2)	0.001		0.002***	
	(0.001)		(0.001)	
log High and Significant risk backlog cost (GBP/m^2) × PFI	0.000		−0.000	
	(0.001)		(0.001)	
log Moderate and Low risk backlog cost (GBP/m^2)		0.003***		0.002**
		(0.001)		(0.001)
log Moderate and Low risk backlog cost (GBP/m^2) × PFI		−0.003**		−0.002
		(0.001)		(0.001)
Other controls	Yes	Yes	Yes	Yes
Trust × region + year FE	✓	✓	✓	✓
Observations	2 911	2 911	2 020	2 020
Adjusted R^2	0.477	0.479	0.491	0.489

Notes: This table reports OLS estimates of the effect of sites procurement type on log hard FM service costs normalised to its GIA. Columns (1) - (4) specification includes trust × *region* + year fixed effect. Column (1) presents OLS regression results for the impact of high and significant backlog risk levels on hard FM costs. In contrast, column (2) examines the same relationship for moderate and low backlog risk costs. Both columns (1) and (2) do not incorporate any lags. In contrast, columns (3) and (4) introduce a one-year lag to the analysis, maintaining similar specifications. ***, ** and * denote significance at the 1%, 5% and 10% level, respectively. Heteroskedasticity-robust standard errors are reported in parenthesis.

condition of the building. Its resolution could require additional investments in maintenance activities.

We use backlog costs as an indicator of the risk and condition of hospital estates, based on the methodology developed by The Stationery Office (2004). This methodology evaluates the backlog cost needed to maintain all estate assets, specifically elements within all buildings, assigning a certain level of risk to each asset: high, significant, moderate, or low. High-risk assets require urgent repairs/replacement to prevent catastrophic failures and major disruptions in clinical services. Significant risk assets need priority management and expenditure in the short term, while moderate risk assets should be monitored closely and repaired in the medium term. Low-risk assets can then be fixed. We enhance the regression for hard FM costs with backlog costs by grouping them into two groups: (a) high and significant risk, and (b) moderate and low risk.

Some studies argue that maintenance backlog accumulation occurs because of facility management's lack of routine maintenance or neglect (Hopland, 2015), insufficient funding, and increasing maintenance demand (Valen & Olsson, 2012). As a result, there is the possibility of reverse causality, where the level of hard FM costs affects building conditions and, in turn, influences backlog maintenance costs. To address this issue of reverse causality, we follow Leszczensky and Wolbring (2022) and use one-year lagged values for the independent variable backlog maintenance costs.

We report the estimation results considering backlog maintenance costs in Table 6. Columns (1) and (2) contain estimations with the same-year backlog costs. In columns (3) and (4), these costs are lagged by one year. Considering the results without lag, we conclude that moderate- and low-risk backlog costs impact hard FM costs, whereas those of high and significant risk do not. We report the results for each of the four categories of backlog risk costs in Table C9 in the Appendix.

The interaction terms with PFI are statistically significant and negative in column (2). This suggests that PFI financing allows hospitals to reduce the impact of backlog costs of a certain type (moderate or low) on the total hard FM costs. This could be interpreted in a way that the public-private partnership shifts a fraction of risks to the private counter-party.

5.3 Capital investment

In this subsection, we consider the role of capital investment, which is another aspect that might serve to interpret the results for hard FM costs. Capital investment includes expenditures related to the construction of new buildings, renovation or modification of existing facilities, procurement of equipment or technology, and other investments aimed at improving the physical infrastructure and operational capabilities of an organization.

In contrast to backlog maintenance costs, which are rather past oriented, capital investments involve committing funds with the expectation of generating future benefits or returns. The terms of PFI contracts might include provisions related to capital investments and their impact on FM costs. A facility with higher upfront capital investments may have reduced ongoing maintenance costs, as stipulated in the contract.

Since data on capital investments are reported exclusively for hospital trusts, we examine the regression analysis at the level of hospital trust. We proceed to aggregation as follows. Our dependent variables, hard and soft FM costs, are summed across all hospitals owned by each trust. Our variable of interest is PFI_{share} which equals the proportion of the GIA of PFI-financed hospital sites to the total GIA of all hospitals in the trust's portfolio.

In this trust-level exercise, we center the analysis around interactions between heterogeneous capital investments and PFI_{share}. First, we distinguish between private investment and public investment. Private capital investments may involve funding received through PFI arrangements, whereas public capital investments comprise loans from the Department

Table 7: Role of capital investment

	log hard FM costs		log soft FM costs		log hard FM costs		log soft FM costs	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
PFI_{share} (%)	0.141***	0.240***	0.061**	0.327	0.100***	0.223***	0.040	0.675**
	(0.027)	(0.041)	(0.028)	(0.261)	(0.028)	(0.043)	(0.029)	(0.267)
log Private investment (GBP)	0.003		0.006**		−0.001		0.004	
	(0.002)		(0.003)		(0.003)		(0.003)	
log Private investment (GBP) $\times$ PFI_{share} (%)	−0.002		−0.010**		0.003		−0.006	
	(0.004)		(0.004)		(0.004)		(0.004)	
log Public investment (GBP)	0.000		−0.000		0.001		−0.000	
	(0.002)		(0.002)		(0.002)		(0.002)	
log Investment in new build (GBP)		0.004***		0.002		0.005***		0.003**
		(0.002)		(0.001)		(0.002)		(0.001)
log Investment in new build (GBP) $\times$ PFI_{share}		−0.009***				−0.010***		
		(0.003)				(0.003)		
log Investment in building upgrades (GBP)		0.009*		0.032***		0.001		0.028***
		(0.005)		(0.009)		(0.006)		(0.009)
log Investment in building upgrades $\times$ PFI_{share}				−0.018				−0.042**
				(0.017)				(0.017)
log Investment in equipment (GBP)		−0.002		0.002		−0.002		0.001
		(0.002)		(0.002)		(0.002)		(0.002)
log Gross Internal Area	0.950***	0.940***	0.863***	0.840***	1.079***	1.075***	1.000***	0.979***
	(0.017)	(0.017)	(0.019)	(0.019)	(0.011)	(0.012)	(0.012)	(0.013)
Trust profile x year FE	✓	✓	✓	✓				
UK region x year FE					✓	✓	✓	✓
Observations	811	811	811	811	811	811	811	811
Adjusted R^2	0.944	0.945	0.924	0.925	0.940	0.941	0.919	0.921

Notes: This table reports ordinary least squares (OLS) estimates, examining the impact of the proportion of PFI sites managed by a Trust on log hard FM service costs (columns (1), (2), (5), (6)) and log soft FM service costs (columns (3), (4), (7), (8)). Columns (1) - (4) specifications correspond to $trust\ profile \times year$ fixed effect, while columns (5) - (8) specifications correspond to $region \times year$ fixed effect. ***, ** and * denote significance at the 1%, 5% and 10% level, respectively. Heteroskedasticity-robust standard errors are reported in parenthesis.

of Health and Social Care (DHSC), public dividend capital, or internally generated funding received by trust.

We report these results in Table 7. The OLS estimates in columns (1), (3), (5), and (7) suggest that private investment is likely to result in higher soft FM costs while showing no significant impact on hard FM costs. The interaction terms in column (3) suggest that hospital trust could potentially reduce costs by integrating PFI-financed hospital sites. In fact, private capital investments are often driven by profit motives as private investors seek returns on their investments. This can lead to a greater emphasis on cost efficiency, including facility management costs. By contrast, public capital investments might prioritize social welfare and public service provision over financial returns. PFI projects often involve the transfer of risk from the public sector to private investors. Private capital investments may involve contractual arrangements that allocate specific risks, such as construction delays or cost overruns, to the private sector.

Finally, we categorize investments based on their purpose: those made in new construction, building upgrades, and equipment acquisition. Most importantly, we conclude that investments in new construction exhibit a cost-saving effect on hard FM service costs, which intensifies with an increased PFI share. The evidence for investment in building upgrades demonstrates a limited impact on soft FM costs, whereas investment in equipment has no effect.

6 Robustness checks

As a robustness check, we also re-estimate OLS and 2SLS restricting both soft FM and hard FM samples to only hospitals. We select the observations with the word "hospital" in the hospital site title. This reduces the sample size to approximately half of its original size and increases the share of the PFI in the sample from 17% to 20%. The results (Table D1 and Table D2 in the Appendix) are broadly in line with those of Table 2 and Table 1. Furthermore, the difference in hard FM and soft FM costs between PFI and non-PFI hospital sites increases. Notably, OLS estimates for the variation in soft FM service costs between hospital procurement types increase by 2% and 0.5% (columns (2) and (6) in Table D1), controlling for $site\ profile \times year$ and $region \times year$ fixed effects, respectively. Similarly, the 2SLS estimates for hard FM service costs expand by 16.2% and 3% (columns (4) and (8) in Table D2) and become statistically significant under both fixed effects.

The distribution of hospitals' ages prompted us to further differentiate between the PFI status of hospitals. In fact, a large fraction of PFI-procured hospitals possessed buildings before the actual kick-off of PFI contracts. We account for this and create two additional dummies, $PFI > 80\%$ of GIA and $PFI \leq 80\%$ of GIA. They correspond to cases in which a PFI hospital owns more than 80% of the construction built after 1995, and where it owns 80% or less. This threshold is chosen because 80% of the total constructions are owned by an average PFI after 1995 (see Fig. B7 in the Appendix). For the purposes of robustness, we test alternative subdivisions:90% or 70% (for the two groups), 20%-80%, and 33%-66% (for the three groups).

Another strategy to judge the robustness of our estimates to alternative interpretations is by changing thresholds for grouping PFIs based on the share of buildings constructed after 1995. The grouped PFIs confirm our findings. To examine the variation between PFI and non-PFI hospital sites, we alter the share of buildings built after 1995. In particular, OLS results with different PFI groupings, regardless of fixed effects, imply that PFI hospital sites have higher soft FM and hard FM service costs than non-PFI sites (Table D3 and Table D4). Moreover, as the share of constructions built after 1995 under PFI hospital site ownership decreases, the gap in hard FM service costs between hospitals of different procurement types widens. For example, the gap in hard FM service costs is larger for PFI with 70% of buildings constructed after 1995 than for those with 90% share, 13.6%, and 12%, respectively (columns (3) and (1) in Table D4). However, for soft FM services, this trend is reversed. Namely, PFI hospital sites with newer buildings have higher soft FM service costs than those with PFI that constructed a larger share of buildings before 1995 (for example, see columns (1) and (2) in Table D3).

7 Concluding remarks

This paper contributes to the understanding of the role of public–private partnerships. More precisely, we explore the effect of PFI procurement on cost efficiency in England's hospitals and sites. We employ a rich dataset that covers hospital sites in England between 2018 and 2021. Our empirical strategy involves a series of simple OLS and 2SLS estimations enhanced with fixed effects, capturing location-specific and hospital-specific unobservables. We include a diverse set of controls that account for the functioning of various supportive hospital departments. We validate the main findings using propensity score matching and Hausman–Taylor estimations.

The major result of this study is that the type of hospital site procurement, PFI or traditional, appears to be a significant determinant of the soft FM and hard FM costs of hospitals. The evidence suggests that PFI projects augment both hard FM (up to 37.1%) and soft FM costs (20.3%). This matches the discussion in the report by Comptroller and Auditor General (2010), who explain how PFI contracts demand that facilities be kept up to a certain high quality.

Our findings have important implications for cost efficiency and sustainability of the healthcare sector in England. They suggest that PFI projects may not be the optimal solution for delivering high-quality and low-cost facility management services. They also indicate that hospitals should consider the trade-offs between different procurement types, tenure arrangements, and outsourcing decisions when planning and managing their facility management activities.

Future research could explore the impact of additional factors on soft and hard FM costs, such as employee salaries, the presence of medical equipment, and the use of outsourcing for various FM services. A difference-in-differences analysis comparing active and expired PFIs, in which ownership has been transferred to local authorities, would also be valuable. Furthermore, investigating the effects of the COVID-19 health crisis on hard and soft FM costs, subject to data availability, would be worthwhile.

Acknowledgements

We thank Pierre M. Picard and seminar attendees of DEM lunch seminar (University of Luxembourg), for their comments, challenging questions and helpful suggestions. We obtained a number of invaluable suggestions at the 1st Croatian Health Economics Workshop (Opatija, Croatia). We appreciate the contributions of Antonio Cosma, Igor Francetic, Rachel Meacock, Alex Murray, Matthew Sutton, Gautam Tripathi, and Timo Välilä. Evgenii Monastyrenko acknowledges generous support of The Luxembourg National Research Fund (FNR), grant C20/SC/14755507. All remaining errors are our own.

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Online appendix for:

The impact of public-private partnership on facility management costs: Evidence from healthcare in England

August 2023

This document contains supplemental material organized in a series of appendices.

Appendix A. Descriptive statistics

Table A1: Summary statistics

	PFI (1)	Min (2)	Mean (3)	Max (4)	N (5)
	Soft FM sample				
Soft FM costs (GBP)	0	1 500	3 206 778	38 704 843	2 419
	1	63 248	8 357 110	38 973 467	484
Gross internal area (m^2)	0	347	24 835	23 451	2 419
	1	391	61 291	292 119	484
Cleaning staff (WTE)	0	0	39	444	2 419
	1	1	100	534	484
Portering staff (WTE)	0	0	13	172	2 419
	1	0	37	202	484
Inpatient main meals requested (Nb)	0	0	148 570	1 219 862	2 419
	1	0	355 572	1 394 073	484
Laundered pieces per annum (Nb)	0	0	560 046	5 712 061	2 419
	1	1 275	1 548 389	7 285 300	484
Outsourced laundry and linen services (1/0)	0	0	0.91	1	2 419
	1	0	0.9	1	484
	Hard FM sample				
Hard FM costs (GBP)	0	5679	2 252 827	26 752 279	2 443
	1	39 576	6 836 855	34 337 630	468
Gross internal area (m^2)	0	338	23 013	217 740	2 443
	1	387	60 428	292 119	468
Clinical space (%)	0	3.6	72	100	2 443
	1	2.7	70	100	468
Single bedrooms with en-suite facilities (Nb)	0	0	35	418	2 443
	1	0	102	594	468
Total energy consumption (kWh)	0	5564	10 155 340	160 887 976	2 443
	1	68 512	28 362 807	237 865 346	468
CHP Units (1/0)	0	0	0.18	1	2 443
	1	0	0.22	1	468
Low risk backlog cost (GBP)	0	0	1 227 401	35 871 444	2 443
	1	0	1 837 867	30 000 000	468
Moderate risk backlog cost (GBP)	0	0	3 904 148	544 088 864	2 443
	1	0	4 743 653	84 396 655	468
Significant risk backlog cost (GBP)	0	0	3 907 159	311 323 656	2 443
	1	0	3 802 901	61 807 966	468
High risk backlog cost (GBP)	0	0	1 854 935	155 027 487	2 443
	1	0	2 414 410	84 977 400	468

Notes: This table reports the mean, minimum, and maximum values of each variable in the soft and hard FM service cost samples. Column (1) defines the PFI and non-PFI subsamples, and column (5) reports the corresponding number of observations per subsample. Columns (2) and (4) show the minimum and maximum values of the variables, respectively, and column (3) displays the mean characteristics.

A1 Site profiles definition

There are eight site profiles: general acute hospital sites, specialist hospital sites (acute only), mixed service hospital sites, community hospital sites (with inpatient beds), mental health sites (including specialist services), learning disabilities sites, mental health and learning disabilities sites and other inpatient sites.

General acute hospital sites provide a range of inpatient medical care and other related services for surgery, acute medical conditions, or injuries (usually for short-term illnesses). Treatment centers providing inpatient facilities are also categorized as general acute hospitals.

Specialist hospital sites, limited to acute care only, focus on a single specific area, such as oncology, orthopedics, dental care, and maternity services for women and children's healthcare. However, this category excludes specialist hospitals in the mental health or learning disabilities sector.

Mixed service hospital sites offer a combination of different functions provided by the same provider, such as single specialty care, acute services, community services, mental health services, and learning disabilities services.

Sites that exclusively offer mental health services, including specialized ones, such as secure units, are categorized as mental health sites. Similarly, sites solely dedicated to providing learning disabilities services fall within the learning disabilities category. Sites that provide both mental health and learning disabilities services from one location by the same provider are designated mental health and learning disabilities sites.

Community hospital sites with inpatient beds serve as alternatives to acute, general hospital care. They are located close to people's homes and cater specifically to local needs. While they may not have emergency departments, they often have minor injury units along with services such as inpatient care for older individuals, rehabilitation programs, maternity services, outpatient clinics, day surgery/care facilities, and diagnostic options.

Other inpatient sites provide inpatient services but do not fit into the previously mentioned categories. These include hospices, intermediate or similar care units, nursing homes, residential care homes, and group homes.

Appendix B. Additional figures

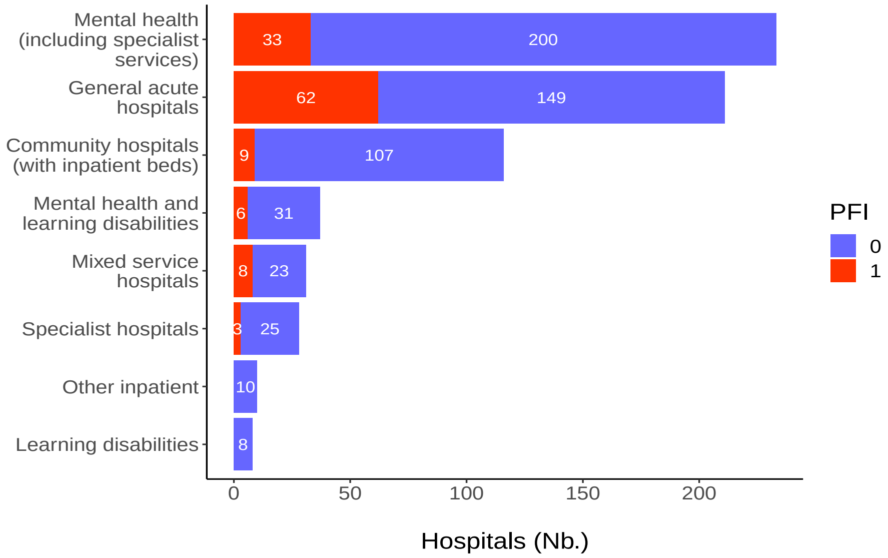

Figure B1: Unique hospitals in the soft FM sample: types, profiles and procurement method.

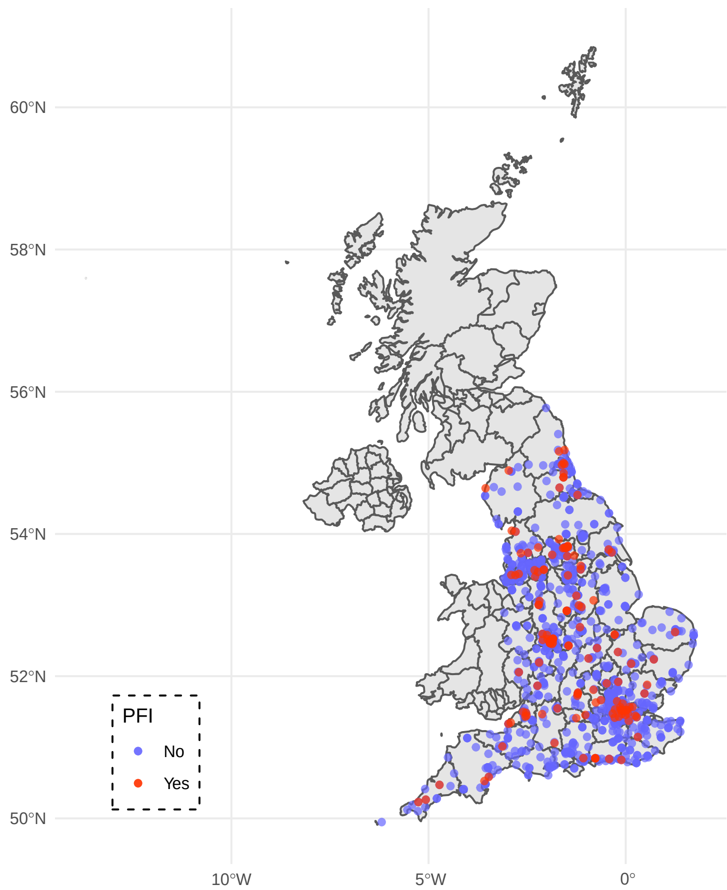

Figure B2: Hospitals location map.

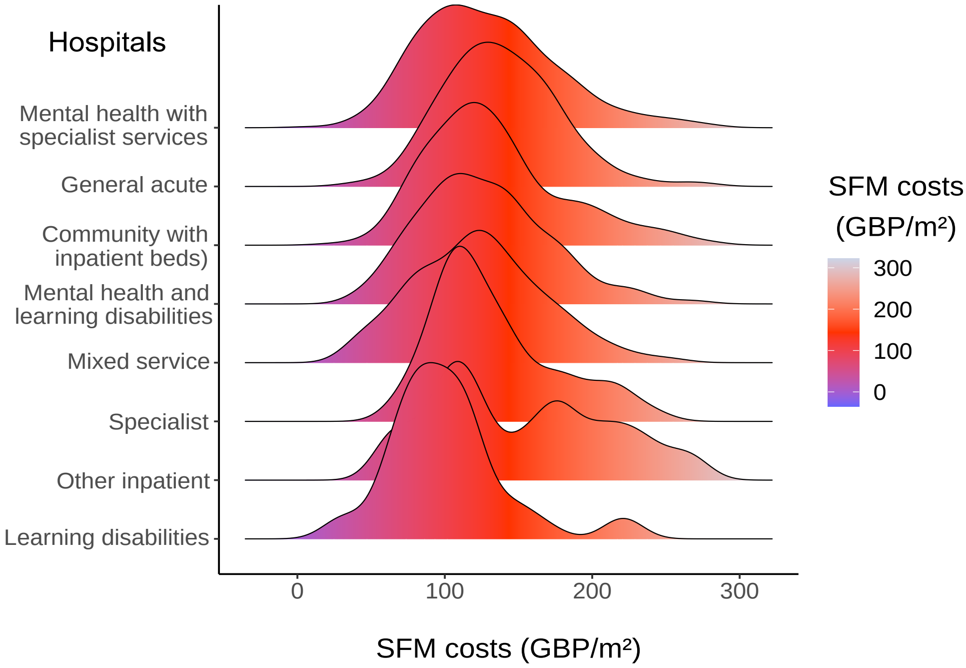

Figure B3: Distribution of soft FM costs by hospitals profiles.

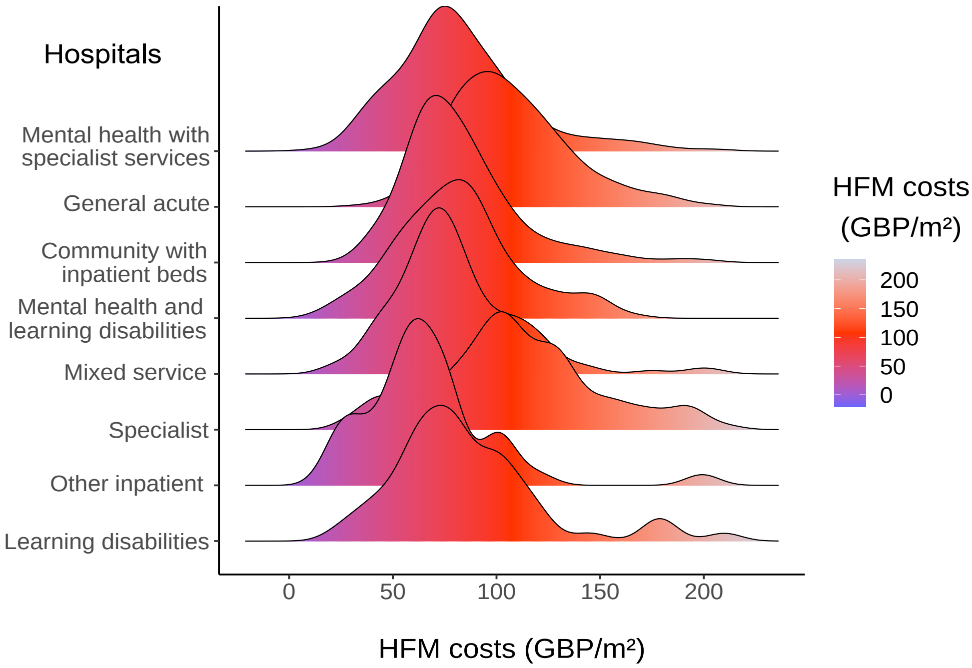

Figure B4: Distribution of hard FM costs by hospitals profiles.

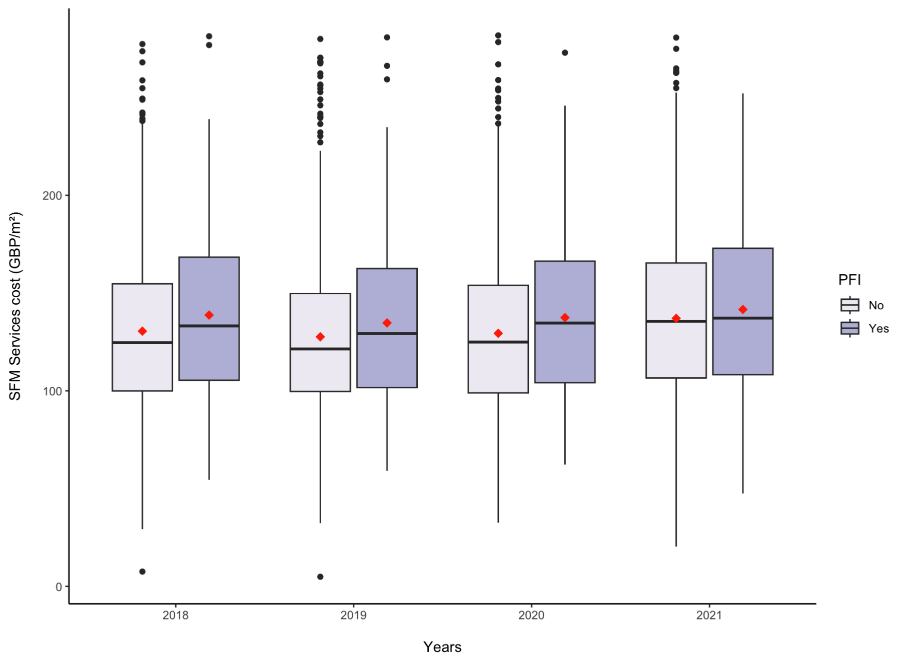

Figure B5: Boxplots of soft FM service costs, 2018 - 2021 years.

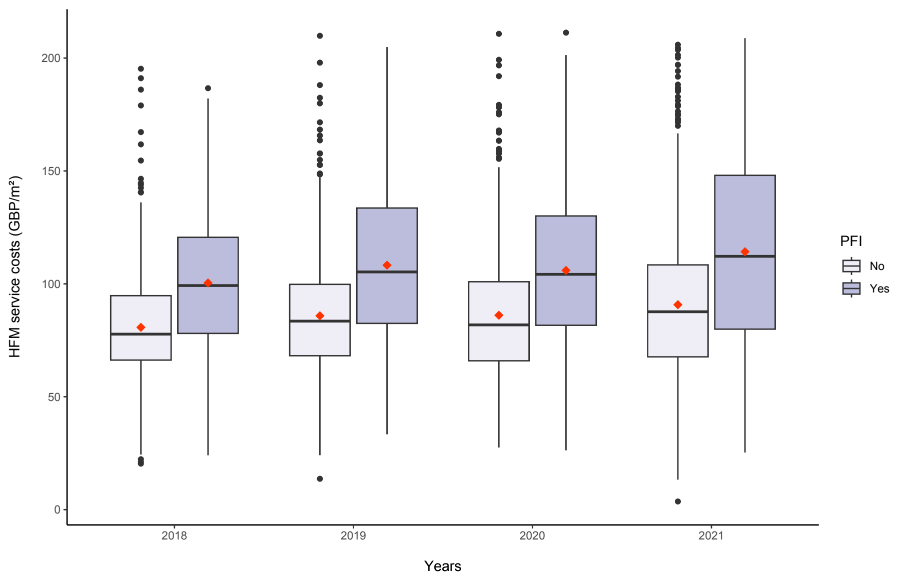

Figure B6: Boxplots of hard FM service costs, 2018 - 2021 years.

Figure B7: Weighted foundation date, all unique hospitals.

Appendix C. Additional regressions

Table C1: Site profiles fixed effect regressions, 2018-2021, hard FM subsampe

	log hard FM cost (GBP/m^2)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
PFI (1/0)	0.149***	0.149***	0.151***	0.146***	0.143***	0.125***	−0.548**
	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)	(0.017)	(0.265)
log Age		0.001	0.011	0.008	0.019	0.011	0.010
		(0.012)	(0.012)	(0.012)	(0.012)	(0.011)	(0.011)
Clinical space (%)			0.003***	0.003***	0.003***	0.002***	0.002***
			(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
CHP units (1/0)				−0.060***	−0.064***	−0.102***	−0.105***
				(0.020)	(0.020)	(0.019)	(0.019)
log Single bedrooms for patients with en-suite facilities (Nb/m^2)					0.003***	0.002***	0.002***
					(0.001)	(0.001)	(0.001)
log Total energy consumption (kWh/m^2)						0.235***	0.228***
						(0.014)	(0.014)
log Total energy consumption (kWh/m^2) · PFI							0.112**
							(0.044)
Site profile × year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2 911	2 911	2 911	2 911	2 911	2 911	2 911
Adjusted R^2	0.173	0.173	0.185	0.187	0.192	0.266	0.268

Note: This table provides empirical findings for OLS estimations of the impact of PFI on hard FM costs. Each specification includes *site profile* × *year* fixed effects. ***, ** and * denote significance at the 1%, 5% and 10% level, respectively. Heteroskedasticity-robust standard errors are reported in parenthesis.

Table C2: Regions fixed effect regressions, 2018-2021, hard FM subsampe

	log hard FM cost (GBP/m^2)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
PFI (1/0)	0.216***	0.223***	0.222***	0.217***	0.207***	0.163***	−0.443*
	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)	(0.017)	(0.265)
log Age		0.022*	0.021*	0.020*	0.035***	0.012	0.011
		(0.012)	(0.012)	(0.012)	(0.012)	(0.011)	(0.011)
Clinical space (%)			−0.000	0.001	0.001*	0.001*	0.001*
			(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
CHP units (1/0)				0.154***	0.135***	0.023	0.019
				(0.017)	(0.018)	(0.017)	(0.017)
log Single bedrooms for patients with en-suite facilities (Nb/m^2)					0.005***	0.003***	0.003***
					(0.001)	(0.001)	(0.001)
log Total energy consumption (kWh/m^2)						0.290***	0.283***
						(0.013)	(0.013)
log Total energy consumption (kWh/m^2) · PFI							0.101**
							(0.044)
Region × year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2 911	2 911	2 911	2 911	2 911	2 911	2 911
Adjusted R^2	0.114	0.115	0.114	0.138	0.154	0.278	0.279

Note: This table provides empirical findings for OLS estimations of the impact of PFI on hard FM costs. Each specification includes *region* × *year* fixed effects. ***, ** and * denote significance at the 1%, 5% and 10% level, respectively. Heteroskedasticity-robust standard errors are reported in parenthesis.

Table C3: Site profiles fixed effect regressions, 2018-2021, hard FM subsampe

	log hard FM cost (GBP)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
PFI (1/0)	0.586***	0.236***	0.216***	0.281***	0.265***	0.185***	0.138***
	(0.050)	(0.045)	(0.046)	(0.043)	(0.045)	(0.042)	(0.023)
Gross internal area (m^2)		0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
log Age			−0.051*				
			(0.028)				
Clinical space (%)				−0.017***			
				(0.001)			
CHP units (1/0)					0.227***		
					(0.050)		
log Single bedrooms for patients with en-suite facilities (Nb)						0.026***	
						(0.001)	
log Total energy consumption (kWh)							0.805***
							(0.009)
Site profile x year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2 911	2 911	2 911	2 911	2 911	2 911	2 911
Adjusted R^2	0.712	0.782	0.782	0.802	0.784	0.806	0.941

Note: This table provides empirical findings for OLS estimations of the impact of PFI on hard FM costs. Each specification includes *site profile* × *year* fixed effects. ***, ** and * denote significance at the 1%, 5% and 10% level, respectively. Heteroskedasticity-robust standard errors are reported in parenthesis.

Table C4: Regions fixed effect regressions, 2018-2021, hard FM subsampe

	log hard FM cost (GBP)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
PFI (1/0)	1.376***	0.128**	0.151***	0.190***	0.243***	0.063	0.131***
	(0.086)	(0.055)	(0.057)	(0.052)	(0.054)	(0.052)	(0.023)
Gross internal area (m^2)	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
log Age			0.058*				
			(0.035)				
Clinical space (%)				−0.022***			
				(0.001)			
CHP units (1/0)					0.772***		
					(0.058)		
log Single bedrooms for patients with en-suite facilities (Nb)						0.034***	
						(0.002)	
log Total energy consumption (kWh)							0.856***
							(0.007)
Region x year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2 911	2 911	2 911	2 911	2 911	2 911	2 911
Adjusted R^2	0.100	0.667	0.667	0.701	0.686	0.709	0.942

Note: This table provides empirical findings for OLS estimations of the impact of PFI on hard FM costs. Each specification includes *region* × *year* fixed effects. ***, ** and * denote significance at the 1%, 5% and 10% level, respectively. Heteroskedasticity-robust standard errors are reported in parenthesis.

Table C5: Site profile fixed effect regressions, 2018-2021, soft FM subsampe

	log soft FM cost (GBP/m^2)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
PFI (1/0)	0.043**	0.043**	0.040**	0.032*	0.035**	0.042**	0.008
	(0.020)	(0.021)	(0.018)	(0.018)	(0.018)	(0.017)	(0.064)
log Age		−0.000	0.001	0.009	0.005	0.010	0.010
		(0.013)	(0.012)	(0.011)	(0.011)	(0.011)	(0.011)
Inpatient main meals requested (Nb/m^2)			0.040***	0.031***	0.031***	0.030***	0.030***
			(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Laundered pieces per annum (Nb/m^2)				0.008***	0.008***	0.008***	0.008***
				(0.001)	(0.001)	(0.001)	(0.001)
Outsourced laundry and linen services (1/0)				0.088***	0.095***	0.103***	0.098***
				(0.024)	(0.023)	(0.023)	(0.025)
log Portering staff (WTE/m^2)					0.019***	0.014***	0.014***
					(0.003)	(0.003)	(0.003)
log Cleaning staff (WTE/m^2)						0.021***	0.021***
						(0.003)	(0.003)
Outsourced laundry and linen services (1/0) × PFI							0.037
							(0.066)
Site profile x year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2 903	2 903	2 903	2 903	2 903	2 903	2 903
Adjusted R^2	0.022	0.022	0.249	0.295	0.303	0.312	0.312

Note: This table provides empirical findings for OLS estimations of the impact of PFI on soft FM costs. Each specification includes *site profile* × *year* fixed effects. ***, ** and * denote significance at the 1%, 5% and 10% level, respectively. Heteroskedasticity-robust standard errors are reported in parenthesis.

Table C6: Regions fixed effect regressions, 2018-2021, soft FM subsampe

	log soft FM cost (GBP/m^2)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
PFI (1/0)	0.056***	0.054***	0.086***	0.046***	0.042**	0.054***	0.006
	(0.019)	(0.020)	(0.018)	(0.017)	(0.017)	(0.016)	(0.062)
log Age		−0.007	0.024**	0.003	−0.011	−0.008	−0.008
		(0.013)	(0.012)	(0.011)	(0.011)	(0.011)	(0.011)
Inpatient main meals requested (Nb/m^2)			0.032***	0.029***	0.031***	0.028***	0.028***
			(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Laundered pieces per annum (Nb/m^2)				0.009***	0.008***	0.008***	0.008***
				(0.000)	(0.000)	(0.000)	(0.000)
Outsourced laundry and linen services (1/0)				0.047**	0.054**	0.057**	0.050**
				(0.023)	(0.023)	(0.023)	(0.024)
log Portering staff (WTE/m^2)					0.026***	0.020***	0.020***
					(0.003)	(0.003)	(0.003)
log Cleaning staff (WTE/m^2)						0.032***	0.032***
						(0.003)	(0.003)
Outsourced laundry and linen services (1/0) × PFI							0.052
							(0.064)
Region x year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2 903	2 903	2 903	2 903	2 903	2 903	2 903
Adjusted R^2	0.048	0.048	0.223	0.319	0.338	0.356	0.356

Note: This table provides empirical findings for OLS estimations of the impact of PFI on soft FM costs. Each specification includes *region* × *year* fixed effects. ***, ** and * denote significance at the 1%, 5% and 10% level, respectively. Heteroskedasticity-robust standard errors are reported in parenthesis.

Table C7: Site profile fixed effect regressions, 2018-2021, soft FM subsampe

	log soft FM cost (GBP)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
PFI	0.462***	0.110**	0.117***	0.091**	0.102**	0.102**	0.141***	0.133***
	(0.048)	(0.043)	(0.044)	(0.042)	(0.043)	(0.043)	(0.040)	(0.040)
Gross internal area (m^2)		0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
log Age			0.020					
			(0.027)					
Inpatient main meals requested (Nb)				0.000***				
				(0.000)				
Launded pieces per annum (Nb)					0.000*			
					(0.000)			
Outsourced laundry and linen services (1/0)						0.197***		
						(0.057)		
log Portering staff (WTE)							0.134***	
							(0.006)	
log Cleaning staff (WTE)								0.140***
								(0.007)
Site profile x year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2 903	2 903	2 903	2 903	2 903	2 903	2 903	2 903
Adjusted R^2	0.676	0.760	0.760	0.769	0.760	0.761	0.791	0.789

Note: This table provides empirical findings for OLS estimations of the impact of PFI on soft FM costs. Each specification includes $site\ profile \times year$ fixed effects. ***, ** and * denote significance at the 1%, 5% and 10% level, respectively. Heteroskedasticity-robust standard errors are reported in parenthesis.

Table C8: Regions fixed effect regressions, 2018-2021, soft FM subsampe

	log soft FM cost (GBP)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
PFI (1/0)	1.184***	0.036	0.078	0.014	0.009	0.032	0.136***	0.096**
	(0.077)	(0.050)	(0.051)	(0.048)	(0.049)	(0.050)	(0.043)	(0.044)
Gross internal area (m^2)		0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
log Age			0.105***					
			(0.031)					
Inpatient main meals requested (Nb)				0.000***				
				(0.000)				
Launded pieces per annum (Nb)					0.000***			
					(0.000)			
Outsourced laundry and linen services (1/0)						0.094		
						(0.067)		
log Portering staff (WTE)							0.200***	
							(0.006)	
log Cleaning staff (WTE)								0.229***
								(0.008)
Region x year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2 903	2 903	2 903	2 903	2 903	2 903	2 903	2 903
Adjusted R^2	0.111	0.673	0.674	0.692	0.682	0.673	0.759	0.749

Note: This table provides empirical findings for OLS estimations of the impact of PFI on soft FM costs. Each specification includes $region \times year$ fixed effects. ***, ** and * denote significance at the 1%, 5% and 10% level, respectively. Heteroskedasticity-robust standard errors are reported in parenthesis.

Table C9: OLS estimation of the linear relationship between backlog costs and hard FM costs

	log hard FM costs (GBP/m^2)							
	No lag				1 year lag			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
PFI	0.116***	0.144***	0.134***	0.141***	0.104***	0.145***	0.133***	0.144***
	(0.029)	(0.024)	(0.023)	(0.023)	(0.033)	(0.028)	(0.026)	(0.026)
log High risk backlog cost (GBP/m^2)	0.002***				0.003***			
	(0.001)				(0.001)			
log Significant risk backlog cost (GBP/m^2)		0.001*				0.002***		
		(0.001)				(0.001)		
log Moderate risk backlog cost (GBP/m^2)			0.001				0.001*	
			(0.002)				(0.001)	
log Low risk backlog cost (GBP/m^2)				0.002***				0.002***
				(0.001)				(0.001)
log High risk backlog cost (GBP/m^2) · PFI	−0.001				−0.002*			
	(0.001)				(0.001)			
log Significant risk backlog cost (GBP/m^2)· PFI		0.000				0.000		
		(0.001)				(0.001)		
log Moderate risk backlog cost (GBP/m^2) · PFI			−0.000				−0.001	
			(0.001)				(0.001)	
log Low risk backlog cost (GBP/m^2) · PFI				−0.001				−0.000
				(0.001)				(0.001)
Other controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region x year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2 911	2 911	2 911	2 911	2 020	2 020	2 020	2 020
Adjusted R^2	0.478	0.477	0.477	0.480	0.495	0.490	0.488	0.492

Notes: This table reports ordinary least squares (OLS) estimates of the effect of hospitals procurement type on log hard FM services costs normalised to its GIA with region × year fixed effect specification. Columns (1) - (4) include high, significant, moderate and low backlog cost normalised to its GIA without lags, while columns (5) - (8) transform similar regressors with one year lag. ***, ** and * denote significance at the 1%, 5% and 10% level, respectively. Heteroskedasticity-robust standard errors are reported in parenthesis.

Appendix D. Robustness checks

Table D1: OLS and 2SLS estimates of the hospitals' procurement type on soft FM cost

	log soft FM costs (GBP/m^2)							
	OLS		2SLS		OLS		2SLS	
	No controls	Controls	First stage	Second stage	No controls	Controls	First stage	Second stage
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
PFI (1/0)	0.067***	0.059***		0.025	0.081***	0.041***		0.039
	(0.020)	(0.016)		(0.104)	(0.019)	(0.015)		(0.084)
LIBOR (%)			−0.039***				−0.030***	
			(0.004)				(0.004)	
log Age		0.029**	−0.197***	0.020		0.000	−0.204***	-0.001
		(0.013)	(0.019)	(0.035)		(0.013)	(0.020)	(0.031)
Inpatient main meals requested (Nb/m^2)		0.042***	−0.001	0.042***		0.038***	−0.002	0.038***
		(0.002)	(0.003)	(0.004)		(0.002)	(0.003)	(0.003)
Laundered pieces per annum (Nb/m^2)		0.007***	0.001	0.007***		0.009***	0.003***	0.009***
		(0.001)	(0.001)	(0.002)		(0.000)	(0.001)	(0.001)
Outsourced laundry and linen services (1/0)		0.082***	0.036	0.083***		0.061***	−0.028	0.061***
		(0.023)	(0.033)	(0.023)		(0.022)	(0.036)	(0.020)
log Portering staff (WTE/m^2)		0.003***	0.001	0.003***		0.004***	0.003***	0.004***
		(0.001)	(0.001)	(0.001)		(0.001)	(0.001)	(0.001)
log Cleaning staff (WTE/m^2)		0.051***	0.003	0.052**		0.044***	0.001	0.044**
		(0.006)	(0.008)	(0.019)		(0.005)	(0.008)	(0.017)
Site profile x year FE	Yes	Yes	Yes	Yes	No	No	No	No
Region x year FE	No	No	No	No	Yes	Yes	Yes	Yes
Individual FE	No	No	No	No	No	No	No	No
Observations	1 672	1 672	1 672	1 672	1 672	1 672	1 672	1 672
Adjusted R^2	0.049	0.438	0.194	0.413	0.084	0.488	0.134	0.449
Cragg-Donald F stat			94.60				54.70	
Kleibergen-Paap rk Wald F stat			20.60				50.90	

Notes: This table reports ordinary least squares (OLS) and two-stage least squares (2SLS) estimates of the effect of hospital procurement type on log soft FM services costs normalised to its GIA. Columns (1) - (4) specifications include site profile × year fixed effect, while columns (5) - (8) specifications correspond to region × year fixed effect. Columns (1), (2), (5) and (6) show coefficients from OLS regressions of log soft FM services costs on hospitals' procurement type. Columns (3), (4), (7) and (8) display coefficients from two-stage least squares models instrumenting sites' procurement type with the UK bank rate, LIBOR. Columns (3) and (7) show first-stage specifications. Columns (4) and (8) display the second stage excluding the instrument. ***, ** and * denote significance at the 1%, 5% and 10% level, respectively. Heteroskedasticity-robust standard errors are reported in parenthesis.

Table D2: OLS and 2SLS estimates of the hospitals' procurement type on hard FM cost

	log hard FM costs (GBP/m^2)							
	OLS		2SLS		OLS		2SLS	
	No controls	Controls	First stage	Second stage	No controls	Controls	First stage	Second stage
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
PFI (1/0)	0.152***	0.135***		0.413***	0.208***	0.165***		0.225*
	(0.019)	(0.019)		(0.068)	(0.020)	(0.019)		(0.119))
LIBOR (%)			−0.036***				−0.026***	
			(0.004)				(0.004)	
log Age		0.019	−0.185***	0.086***		0.000	−0.194***	0.014
		(0.015)	(0.019)	(0.021)		(0.015)	(0.020)	(0.031)
Clinical space (%)		0.001**	0.000	0.001		0.001*	−0.001	0.001*
		(0.001)	(0.001)	(0.001)		(0.001)	(0.001)	(0.001)
CHP Units (1/0)		−0.089***	−0.096***	-0.059***		0.010	−0.012	0.011
		(0.018)	(0.023)	(0.021)		(0.017)	(0.023)	(0.021)
log Single bedrooms for patients without en-suite facilities (Nb/m^2)		0.003***	0.001	0.003**		0.005***	0.003**	0.005***
		(0.001)	(0.001)	(0.001)		(0.001)	(0.001)	(0.001)
log Total energy consumption (kWh/m^2)		0.267***	0.051**	0.255***		0.368***	0.107***	0.362***
		(0.020)	(0.025)	(0.033)		(0.019)	(0.025)	(0.031)
Cragg-Donald F stat			82.7				40.7	
Kleibergen-Paap rk Wald F stat			17.1				41	
Hospital profile x year FE	Yes	Yes	Yes	Yes	No	No	No	No
Region x year FE	No	No	No	No	Yes	Yes	Yes	Yes
Individual FE	No	No	No	No	No	No	No	No
Observations	1 673	1 673	1 673	1 673	1 673	1 673	1 673	1 673
Adjusted R^2	0.251	0.335	0.187	0.040	0.160	0.348	0.115	0.270

Notes: This table reports ordinary least squares (OLS) and two-stage least squares (2SLS) estimates of the effect of hospital procurement type on log hard FM services costs normalised to its GIA. Columns (1) - (4) specifications include hospital profile × year fixed effect, while columns (5) - (8) specifications correspond to region × year fixed effect. Columns (1), (2), (5) and (6) show coefficients from OLS regressions of log hard FM services costs on hospital procurement type. Columns (3), (4), (7), and (8) display coefficients from two-stage least squares models instrumenting hospital procurement type with the UK bank rate, LIBOR. Columns (3) and (7) show first stage specifications. Columns (4) and (8) display the second stage excluding the instrument. ***, ** and * denote significance at the 1%, 5% and 10% level, respectively. Heteroskedasticity-robust standard errors are reported in parenthesis.

Table D3: OLS estimates of the hospital sites procurement type on soft FM costs

	log soft FM costs (GBP/m^2)									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
PFI (X > X_1)	0.042**	0.027	0.037**	0.028	0.032*	0.033	0.025	0.032*	0.026	0.028
	(0.021)	(0.019)	(0.019)	(0.019)	(0.018)	(0.020)	(0.019)	(0.018)	(0.019)	(0.018)
PFI ($X_1 \geq$ X $\geq$ X_2)	0.037*	0.053**	0.042*	0.061***	0.042*	0.038**	0.048**	0.041**	0.054**	0.044*
	(0.019)	(0.021)	(0.022)	(0.022)	(0.026)	(0.018)	(0.020)	(0.021)	(0.021)	(0.025)
PFI (X_2 > X)				0.015	0.064*				0.016	0.054
				(0.049)	(0.038)				(0.048)	(0.037)
X_1 % of GIA	90	80	70	80	66	90	80	70	80	66
X_2 % of GIA	0	0	0	20	33	0	0	0	20	33
Other controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Hospital profile x year FE	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No
Region x year FE	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
Observations	2 903	2 903	2 903	2 903	2 903	2 903	2 903	2 903	2 903	2 903
Adjusted R^2	0.363	0.363	0.363	0.363	0.363	0.392	0.392	0.392	0.392	0.392

Notes: This table reports ordinary least squares (OLS) estimates of the effect of hospital sites procurement type on log soft FM services costs normalized to its GIA. X is the percentage share of hospital buildings constructed after 1995 year. X_1 and X_2 define the affiliated hospital sites subgroups limits. For instance, column (1) includes hospitals that have 90% of buildings GIA constructed after 1995 (X > 90% of GIA) and hospital sites that have 90% of buildings' GIA constructed before 1995 ($X \leq$ 90% of GIA). Other columns vary in the subdivision of hospital sites in the corresponding groups. ***, ** and * denote significance at the 1%, 5% and 10% level, respectively. Heteroskedasticity-robust standard errors are reported in parenthesis.

Table D4: OLS estimates of the hospital sites procurement type on hard FM costs

	log hard FM costs (GBP/m^2)									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
PFI (X > X_1)	0.120***	0.129***	0.136***	0.128***	0.132***	0.117***	0.152***	0.164***	0.152***	0.164***
	(0.024)	(0.022)	(0.022)	(0.019)	(0.021)	(0.024)	(0.022)	(0.022)	(0.022)	(0.021)
PFI ($X_1 \geq$ X $\geq$ X_2)	0.133***	0.123***	0.113***	0.097***	0.086***	0.202***	0.178***	0.165***	0.171***	0.155***
	(0.022)	(0.024)	(0.025)	(0.026)	(0.030)	(0.021)	(0.024)	(0.024)	(0.025)	(0.029)
PFI (X_2 > X)				0.253***	0.188***				0.218***	0.188***
				(0.056)	(0.044)				(0.056)	(0.043)
X_1 % of GIA	90	80	70	80	66	90	70	80	80	66
X_2 % of GIA	0	0	0	20	33	0	0	0	20	33
Other controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Hospital profile x year FE	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No
UK region x year FE	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
Observations	2 911	2 911	2 911	2 911	2 911	2 911	2 911	2 911	2 911	2 911
Adjusted R^2	0.264	0.264	0.265	0.266	0.265	0.274	0.272	0.272	0.272	0.271

Notes: This table reports ordinary least squares (OLS) estimates of the effect of hospital sites procurement type on log hard FM services costs normalized to its GIA. X is the percentage share of hospital site buildings constructed after 1995 year. X_1 and X_2 define the affiliated hospital sites subgroups limits. For instance, column (1) includes hospital sites that have 90% of buildings GIA constructed after 1995 (X > 90% of GIA) and hospital sites that have 90% of buildings' GIA constructed before 1995 ($X \leq$ 90% of GIA). Other columns vary in the subdivision of hospital sites in the corresponding groups. ***, ** and * denote significance at the 1%, 5% and 10% level, respectively. Heteroskedasticity-robust standard errors are reported in parenthesis.

Appendix E. Data integrity and cleaning

E1 Site type choice

We remove all other sites that don't meet these two criteria. Notably, "other reportable" sites are the ones without inpatient beds at the lowest of 151 m^2, and those at most with nine inpatient bed pieces of size from 151 m^2 to 499 m^2 in 2018 and 2019. In 2019 ambulance trusts were obliged to report all sites of a size less than 1000 m^2 as "other reportable" sites, while other sites not having inpatient beds turned to be "ambulance services" sites. Therefore, we also cut out the latter ones. We follow up a similar rule for 2020. A change again came out in 2021, where:

- "Ambulance services" sites were renamed to "support facilities" sites;
- "Non inpatient" and "unoccupied" sites started being reported;
- Previously declared sites without inpatient beds and with the GIA more than 500 m^2 became individually reported at a site level rather than having a title of "other reportable" sites.

Thereby, to reach data consistency from 2021, we don't include in our dataset "support facilities", "non inpatient", "unoccupied", and sites without inpatient beds of size at least 500 m^2.

Table E1: Site types from 2017 to 2021

	Inpatient beds								
Site's GIA (m^2)	None				1-9				10 or more
IR	2018	2019	2020	2021**	2018	2019	2020	2021**	2018 - 2021**
up to 150	NR			NI	NR			NI	IR
151 - 499	OR				OR				IR
500 - 999	OR			IR & OR*	IR				IR
$\geq$ 1000	OR	OR & AS*		IR & SF*	IR				IR

Notes: This table reports the ERIC dataset subdivision of site types based on their Gross Internal Area (GIS) and inpatient beds availability from 2018 to 2021. In our paper, we use the sites coloured in grey.
Abbreviations: Ambulance Services (AS), Individually Reported (IR), Non Inpatient (NI), Not Reported (NR), Other Reportable (OR), Support facilities (SF).
* - it is a site type uniquely for ambulance trusts. ** - the new "unoccupied" site type was reported.