

# *Job Tenure and Unskilled Workers before the Industrial Revolution: St Paul's Cathedral 1672–1748*

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How were unskilled workers selected and hired in preindustrial labor markets? We exploit records from the rebuilding of St Paul's Cathedral, London (1672–1748), to analyze the hiring and employment histories of over 1,000 general building laborers, the benchmark category of “unskilled” workers in long-run wage series. Despite volatile demand, St Paul's created a stable workforce by rewarding the tenure of long-standing workers. More senior workers received more days of work each month, preference when jobs were scarce, and the opportunity to earn additional income. We find the cathedral's strategy consistent with reducing hiring frictions and turnover costs.

Just over 350 years ago, St Paul's Cathedral was destroyed in the Great Fire of London. Under the guidance of Sir Christopher Wren, the Cathedral was entirely rebuilt between 1672 and 1711. This pre-industrial mega-project left not only a legacy on the London skyline, but also detailed individual-level records of the employment and remuneration of building laborers. With these records, unparalleled in continuity and scope for this period, we reconstruct and analyze the employment histories of over 1,000 workers employed as general laborers during a 70-year period. We find that St Paul's hiring practices encouraged retention and reduced turnover, giving a core group of laborers more work, priority in rehiring after slow-downs, and access to additional ways to earn. Despite the volatility that characterized pre-industrial labor demand, St Paul's was able to establish a stable workforce by incentivizing tenure and rewarding long-standing laborers. These patterns of organizing worker hiring and retention have not been recognized in earlier studies of early modern labor markets.

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Preindustrial urban unskilled laborers are often believed to have been casual workers employed on transient, short-term contracts, usually by the day, with wage rates that responded to supply and demand (Woodward 1995, pp. 96, 100–6; Ashton 1964, pp. 77–87; Grantham 1994, pp. 12–15; Williamson 1987; Rule 1981, pp. 49–73; Wallis 2014, pp. 189–43; Allen 2009, pp. 113–15).<sup>1</sup> As Elizabeth Gilboy noted, “The rule of employment was over-work for a few days and then no work at all” (1934, p. 5). Urban laboring work was never regulated by craft guilds nor organized in annual service contracts as some agricultural labor was (Boulton 1996, p. 271; Kussmaul 1981). The implication is that urban unskilled workers were essentially indistinguishable to employers who simply drew the numbers they needed each day from the pool gathering at the gate of any site.<sup>2</sup> It was in this vein that the seventeenth-century political economist, William Petyt, spoke of labor as “capital material ... raw and undigested...committed into the hands of supreme authority, in whose prudence and disposition it is to improve, manage, and fashion it to more or less advantage.”<sup>3</sup> Unskilled laborers have featured more prominently in literature on mobs, unrest, and disputes in pre-industrial London than in economic analysis (George 1965, p. 124; Harrison 1986; Landes 1987; Gilboy 1934). Although some studies suggest laborers might have more complex relationships with their employers (Woodward 1995; Yamamoto 2004; Schwarz 2007), economic historians have generally agreed that more structured approaches to hiring arose later (Clark 1984, 1994), when firms eventually “rejected the market... to secure a reliable and productive labor force” (Huberman 1996, p. 6).

Our study offers the first in-depth econometric analysis of pre-industrial hiring practices for laborers in construction work in England. We examine the characteristics of unskilled hiring and employment at St Paul’s Cathedral through the main period of construction, 1672–1711, and up to 1748, when laborers were used for maintenance. The Cathedral’s employment records encompass almost every day of work that general

<sup>1</sup> Our data are for urban laborers, as discussed in this literature. In agriculture, annual contracts were agreed on the spot at large hiring fairs, during which mobility between employers was the norm (Kussmaul 1981). See Bowley (1900, pp. 59–60) for the fundamental assumptions of a competitive market, which underpin the law of one wage and wage series. Clark and van der Werf (1998) take the assumption of spot market conditions through to labor market arbitrage between these markets. See Humphries and Weisdorf (2019) for the application of labor market arbitrage to real wage series. Skilled labor markets were sometimes regulated by guild or corporative systems that set different norms, as discussed in Wallis (2014).

<sup>2</sup> See Boulton (2017, pp. 310–13) for a summary of the questions of intermittency, seasonality, and by-employment.

<sup>3</sup> Quoted in Furniss (1965, p. 41).

laborers supplied over these 76 years.<sup>4</sup> They are unusual because they list each laborer by name in each period they were active, allowing us to reconstruct the individual employment histories, including days worked, earnings, absences, and the overall duration of employment of the 1,011 general laborers hired during these years.

The literature indicates construction work is notoriously volatile, and at St Paul's, many laborers appeared briefly on the site and never returned. However, as we show, the recruitment and retention of laborers during the rebuilding did not fit a pattern of casual, transient, short-term employment. Over the period we observe, we find that the workforce stabilized, hiring and separation rates fell, and the average length of employment increased. These changes occurred without laborers gaining contracts, and most still faced periods when they were laid off temporarily. Nonetheless, a core set of long-serving laborers developed, and it was this group that supplied most of the general labor work during the rebuilding of St Paul's.

To explore how this happened, we examine econometrically the relationship between laborers' tenure and the number of days of work awarded, the consistency of employment, and access to additional income-earning opportunities. Our results indicate that St Paul's incentivized and rewarded tenure. The Cathedral privileged a core group of workers whose access to additional and more consistent income increased with the length of time they were employed there. These core laborers were given more days of work each month than others—workers with the most tenure were more than three times as likely as those with the least to be fully employed within a month. These effects do not diminish as tenure increases, suggesting that this is not explained by on-the-job learning or the employer discovering worker productivity, as one might expect.

Tenure was rewarded in several additional ways. Tenured laborers had more consistent access to employment. Long-standing laborers were less likely to have periods in the year in which they were not hired at all and were more likely to be rehired after seasonal breaks in construction. Finally, the laborers with the longest tenure were twice as likely as newer laborers to be given the benefit of additional shifts as watchmen, which increased earnings in a month by up to 15 percent.

While the day wage at St Paul's remained the same for 70 years, we find that long-standing laborers at the Cathedral received an income premium through tenure-related opportunities. At the largest building site in early-modern England, these results indicate that tenure was incentivized and

<sup>4</sup> Recorded in monthly or quarterly accounting periods.

rewarded, leading to a stabilization of the workforce despite volatile labor markets. Long-standing relationships and seniority appear to define how the employer distributes opportunities to laborers.

Our findings for unskilled laborers complement an emerging body of work identifying institutional adaptability in the economy and organizational innovation in skilled labor markets in the centuries before the industrial revolution (de La Croix, Doepke, and Mokyr 2018; Kelly, Mokyr, and Ó Gráda 2014). Recent studies have argued that large organizations operating in a pre-industrial context were capable of creating internal labor markets for skilled workers (García-Zúñiga and López-Losa 2021; Murphy 2010, 2015; Rosenband 2016). In a related vein, studies have revealed strong performance-related incentives in eighteenth-century navies (Allen 2002). That a major building project should introduce similar mechanisms is consistent with arguments about the creative potential of early-modern administrative elites in the face of shocks (Dittmar and Meisenzahl 2020) and novel challenges in scale and scope (Harris 2020). Our findings also contribute to an emergent theme in the economic history of real wages and labor markets, which examines varying types of employment contracts, duration of employment, and working days per year (Humphries and Weisdorf 2019; Gary 2019; Stephenson 2020b; Ridolfi 2019).

The paper proceeds as follows. In the next section, we provide historical background on the reconstruction of St Paul's and describe the dataset sourced from the project. Then we describe employment churn and turnover at the Cathedral, demonstrating the stabilization of St Paul's workforce over the construction phase. Next, we analyze the relationship between tenure and the number of days worked each month, the consistency of employment, and access to watchmen shifts. We then discuss explanations for the patterns identified and conclude.

## HISTORICAL CONTEXT AND DATA

St Paul's was the largest construction site in London from 1675 to 1711. The Cathedral had been destroyed by the Great Fire of 1666, and, after several years of planning and demolition work, Sir Christopher Wren's design for the new Cathedral was finally approved in 1675. The project took place against the backdrop of a rapidly expanding rebuilt city that was experiencing substantial long-term growth and high labor demand (Boulton 1996), driven by trade and services (Broadberry et al. 2015), and a prolonged construction boom (Barras 2009). As Surveyor to the Crown, Wren was also responsible for the management of many

other projects around London: the City Churches, Greenwich Hospital, and, later, Westminster Abbey.

The Cathedral's accounts are exceptionally detailed and well maintained, largely because of its funding model.<sup>5</sup> The project was paid for by a new tax on coal imported into the city. Parliament and the City expected strict oversight and auditing. The formal accounts were compiled from journals and call books that recorded weekly pay. These were countersigned as an accurate record of payments and were subject to audit, giving some reassurance about their quality. The records from 1672–1748 that we use cover the main period of construction from 1674 to 1711, the period to 1720 when some masonry and other work were still being carried out, and nearly three decades to 1748 when a small group of laborers were hired for general maintenance.

In each account book, the laborers who were hired directly by the Cathedral's clerk-of-works were listed by name, along with the number of days they worked and the rate they were paid. The records give the number of days that each man worked per accounting period (month or quarter) but do not indicate who was working on each day of the week. They describe laborers carrying out general tasks such as moving stone, dragging goods, and sorting and carrying rubbish, as well as demolition work; mixing mortar; watching doors; ramming and cutting walls; stripping tiles; plumbing; and assisting specialist contractors. The accounts do not give details about the most skilled craftsmen on the site. Most specialized tasks, such as brickwork, masonry, and plastering, were supplied by skilled subcontractors who hired their own workers directly and kept separate, private accounts for wages.<sup>6</sup> This system, where general laborers paid on day rates worked alongside skilled subcontractors, was common in the building industry in this period, as it still is.<sup>7</sup>

St Paul's was operational every week of the year, and the normal working week was six full days, as at other sites in London. However, not all active laborers worked every day. The number of days worked and laborers hired varied with project intensity and with the seasons. The number of laborers employed in January was about 60 percent of the number employed in July.

<sup>5</sup> Full records of the series in London Metropolitan Archives, CLC/313/I/B/25473.

<sup>6</sup> See Stephenson (2020b) for the most detailed descriptions of these.

<sup>7</sup> See Woodward (1995) and Stephenson (2020b). Trade-specific laborers hired by specialist sub-contractors worked alongside general laborers employed centrally at Westminster Abbey (1712–1719) and Greenwich Hospital (1696–1706). There are not comparable named records at either site, however. Labor organization was similar in private housebuilding (McKellar 1999). For studies of similar employment records in other parts of Europe, see Rota and Weisdorf (2020) and García-Zúñiga and López-Losa (2021).

Decisions about who to hire to meet these rapidly changing demands for labor and other aspects of the organization of employment were in the hands of the clerk-of-the-works, a position held by John Tilson until 1685 and by Lawrence Spencer thereafter. The clerk was responsible for the day-to-day coordination of materials, contractors, and workers on site, cost management, and record-keeping. He hired at will from an available pool of potential laborers. Employment seems to have been agreed upon verbally on a weekly or daily basis—there are no surviving contracts for laborers, and probably none ever existed. Laborers thus had no contractual expectation of ongoing employment, but there is ample evidence that they freely entered the employment relationship.<sup>8</sup>

Our dataset contains all 402 surviving sets of accounts from 1 October 1672 to 24 June 1748. There are full accounts for all periods from 1672 to 1748, with the exception of two short breaks lasting for two years in the construction period and three years in the maintenance period.<sup>9</sup> The dataset ends with the cessation of accounts containing nominal data. The majority of accounts (73 percent) cover periods of one month. The rest run over longer periods, with 5 percent covering full years.<sup>10</sup> The shorter-duration accounts are all from the construction period, giving us finer-grained information for that time.

We extracted the laborers' names, number of days worked per period, and pay for all 402 accounting periods. We identify 1,033 unique laborers whose employment histories on the project appear in 21,793 entries;<sup>11</sup> 4.69 percent of entries lacked names or were excluded because two active laborers share the same name;<sup>12</sup> 69 laborers are identified as disabled; and there are no female names in the dataset. Most entries report days of laboring work, but 14 percent are for shifts as night watchmen on the site, a common practice intended to prevent trespass and theft and a useful supplement to day wages for those who were given them.

<sup>8</sup> Some men signed up for task work, indicating they had the opportunity to contract independently and work for others. Campbell (2007, pp. 35–39) describes various types of work undertaken by laborers even before the rebuilding began.

<sup>9</sup> October 1674 – October 1675 and June 1710 – June 1714.

<sup>10</sup> Unfortunately, the books do not run neatly in yearly runs. Accounts were kept quarterly at first, monthly from 1674 to January 1683, quarterly from January 1683 to April 1686, monthly for a decade from April 1686 to 1696, quarterly from October 1696 to June 1701, monthly from June 1701 to June 1710, bi-annually from June 1710 to December 1726, and then annually.

<sup>11</sup> The small sample and consistent format allowed us to manually identify repeat appearances based on unique forename and surname combinations with a high degree of confidence. We restrict linkage to allow individuals a maximum period of absence of five years, after which we assume we are observing two same-named individuals.

<sup>12</sup> 14 entries were unnamed; 1,022 entries are ambiguous, in that two individuals may have been active simultaneously, based on the repetition of names within an account. These ambiguous entries relate to 19 distinct names, and almost half (537) are from one, John Scott.

Laborers were paid a day rate that was almost entirely uniform across workers and did not change during the 76 years we observed. During the winter months (late October through early March), laborers earned 16d. per day. During the spring, summer, and early autumn (March to early September), they earned 18d. per day. These rates were similar to those recorded at a number of sites around the city at this time, including for laborers working directly for independent sub-contractors at St Paul's.<sup>13</sup> A laborer's income was a simple function of how many days he worked. The Cathedral spent nothing on beer, food, or other perks or provisions for laborers. While laborers used the Cathedral's drogues, ramps, barrows, scaffold, and rope, we do not know whether the tools they dug with were their own or the Cathedral's. Nominal day wages at the Cathedral were rigid for three-quarters of a century despite moderate price inflation, sustained growth in GDP per capita, and sharp economic shocks (see Online Appendix 2.3; also Allen (2009), Broadberry et al. (2015, pp. 239–42), Hatcher (1998, pp. 70, 74), and Boulton (2000)).

We might imagine this rigidity was tolerated as the price of accessing better opportunities, but laboring work offered limited progression. A very small number of laborers worked as foremen, receiving higher wages (20 to 24d.).<sup>14</sup> They seem to have been used during periods in which the greatest amount of work was being carried out. Forty-four laborers also acted as sub-contractors for laboring tasks that required more skill or were more dangerous during the demolition phase.<sup>15</sup>

Evidence on the external labor market is limited. We know the period under investigation saw a great deal of construction across the city and high labor mobility (Brett-James 1935; Barras 2009, pp. 6–14; Wrigley 1967).<sup>16</sup> It is likely that laborers were able to find work at any number of building sites, albeit none that equaled the scale and duration of St

<sup>13</sup> One contractor paid 18d. per day all year round to most of his laborers and 16d. per day to a smaller number of men assisting layers (Stephenson 2020a, ch. 6).

<sup>14</sup> Only 10 men over the 35 years of the main construction period earned above 18d. per day, and all for short periods associated with specialist or supervisory work.

<sup>15</sup> These laborers agreed to task contracts worth between £1 and £150 between 1676 and 1690, acting as petty entrepreneurs. The contracts specified the length or volume of material to be removed without the difficulty of the work being known, offering a chance for profit if it could be done in fewer days work than estimated, or loss or lower pay per day if not. Many of them signed their contracts, indicating relatively high human capital in a period where male literacy was still low.

<sup>16</sup> While the Great Fire created a rebuilding boom until, initially, 1675, there is evidence that activity was maintained until the late 1720s. Between 1670 and 1686, expenditure at the Office of King's Works increased from £20,000 to £45,000 per annum (Colvin 1976, p. 32). Data for the 1690s are not available, but the Middlesex land registry shows a sharp increase in building from 1706 to 1721 and a steady rate from 1721–1730, after which there was a sustained decline until after the late 1740s. See Barras (2009, p. 7) and Stephenson (2020a, pp. 41–49).

Paul's.<sup>17</sup> Construction accounted for about 10 percent of male employment in the city.<sup>18</sup> The share of laborers within that is unclear, but if they made up a quarter of the male workforce in the sector, that would be just over 4,000 men.<sup>19</sup> Although it was the largest construction project in the city, St Paul's was not a dominant employer—the Cathedral never employed more than 200 men in a month and rarely more than 50. In this period, skilled and unskilled construction work was not subject to guild restrictions on access (Beier 1986), and even at the Cathedral itself, laborers were able to work directly for specialist contractors and suppliers.<sup>20</sup> Laborers thus had many options, and we cannot observe or exclude the effect of their preferences on the hiring patterns we observe at St Paul's. However, the scale and longevity of the Cathedral project offered the potential for more continuous work than on other projects. Therefore, a higher position in the queue for work at the Cathedral was a potentially important incentive.

#### THE ST PAUL'S WORKFORCE

How many general laborers were employed at St Paul's and how long were they employed for? The employment records reveal that, over time, the Cathedral stabilized its workforce, despite the generally precarious nature of pre-industrial employment relations. Although there was significant variation in demand for laborers, monthly hiring and separation rates trended downward over the construction period, and the share of laborers new to the project each year declined through 1710. When we explore the data on an individual level, large differences in the total length of time that laborers worked at the Cathedral emerge—some workers were employed only briefly at St Paul's, while other workers served for many years.

##### *Variation in Demand for Labor at St Paul's*

The amount of labor available at the Cathedral varied greatly throughout the construction period, with multi-year peaks and troughs of labor demand in addition to regular seasonal patterns. This high level of

<sup>17</sup> The surviving records of other major sites, such as Westminster Abbey and Greenwich, indicate a maximum of 10 laborers hired per week, paid on day rates. More were presumably hired on task contracts.

<sup>18</sup> See Beier (1986), Schwarz (1992, pp. 12, 13, 15), and Keibek (2017, p. 175).

<sup>19</sup> This back-of-the-envelope calculation assumes a London population of 575,000, of which 57.5 percent were aged 15–59, and half were male, in line with standard estimates (Allen 2019, p. 743).

<sup>20</sup> For example, 11 of the 68 men working for the specialist mason William Kempster from 1708 to 1709 also worked as laborers at the Cathedral (Stephenson 2018, pp. 120–21).



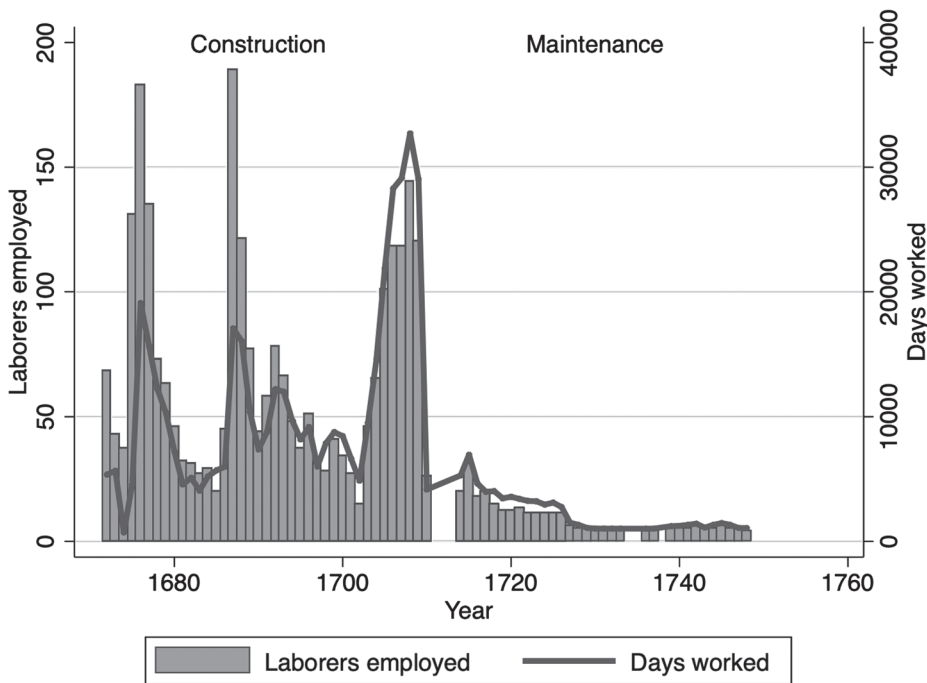


FIGURE 1  
TOTAL NUMBERS OF LABORERS ON SITE AND TOTAL NUMBER OF DAYS  
WORKED, PER ANNUM, 1676 TO 1748

Source: See text.

demand volatility is consistent with what we know about construction on other similar sites.<sup>21</sup> This was a period of sharp economic cycles, but they are only weakly associated with the pattern observed here (see Online Appendix 2.3), and the main driver of demand appears to be project-centered.<sup>22</sup> Figure 1 plots the total number of laborers on site and the number of days of work they provided during the rebuilding from 1674 to 1711. Laborers' work peaked in the late 1670s, between 1687 and 1693, and most notably between 1705 and 1709, when several years saw around 30,000 days of work by laborers costing the Cathedral more than £2,000 each year. By contrast, the demand for laborers in the early 1680s was low, with annual employment on-site at about one quarter of the

<sup>21</sup> See Stephenson (2020a, pp. 50–62, 173–92).

<sup>22</sup> Broadly speaking, from 1667 to the late 1670s, the foundations of the old cathedral were cleared and new foundations were laid (Campbell 2007). From the 1680s onward, the walls were raised and the west front and towers were added from 1694 to 1705. The Dome was erected and plastered between 1705 and 1709. See note 18 for references to literature on patterns of activity elsewhere. Time dummies in our model absorb these project changes and broader trends in the construction industry.

TABLE 1  
MONTHLY HIRING AND SEPARATION RATES AT THE CATHEDRAL

	Hiring Rate			Separation Rate			Months Observed (n)	Share of Months Observed (%)
	Mean	Std. Dev.	Max.	Mean	Std. Dev.	Max.		
1675–1679	14.23	13.42	51.43	16.77	14.75	48.78	50	83.33
1680–1684	9.79	14.83	74.19	12.34	13.32	52.83	32	53.33
1685–1689	11.04	13.13	57.94	12.96	14.05	54.95	41	68.33
1690–1694	8.03	6.35	34.78	5.5	7.6	38.6	45	75.00
1695–1699	3.68	4.22	13.33	6.96	10.09	28.57	15	25.00
1700–1704	6.41	9.48	42.11	4.69	10.55	60	41	68.33
1705–1709	9.42	21.46	120.61	8.06	21.61	134.18	60	100.00
Overall	9.58	14.26	120.61	9.83	15.19	134.18	284	67.61

*Notes:* Only for 284 periods with two sequential one-month accounts. Hiring rate is the percent of laborers who were brought on each month, and the separation rate is the percent who departed. Details in Online Appendix 1.

*Source:* See text.

level seen in 1676. Because construction work is stage-dependent, and subject to the vagaries of supply chains, weather, and finance, such peaks and troughs of demand are typical of any building site or large project.

### *Stabilization of the Workforce at St Paul's*

Despite this volatility in the amount of labor needed to rebuild the Cathedral, the workforce became more stable over time. Hiring and separation rates declined over the construction period, and the share of laborers who were new to the project each year fell. To measure worker turnover, we calculate monthly hiring and separation rates at the Cathedral, following Davis, Faberman, and Haltiwanger (2006).<sup>23</sup> Our “all transition” figures include all laborers who worked in an accounting period, no matter how long they stayed at the Cathedral. This means that workers who were only hired for a few days on one occasion count as a hire and a separation in these calculations. These figures also include temporary separations, as separated workers may have returned in later months.

Table 1 reports the average hiring and separation rates for the quinquennia that cover the construction of the Cathedral. The hiring and separation rates can be interpreted as the percent of laborers who were brought

<sup>23</sup> Further details are in Online Appendix 1. These calculations are restricted to periods for which two sequential accounts are of one-month duration, representing 295 account books in the construction period. Quarterly and quarterly quasi-census calculations are included in Online Appendix 1.

TABLE 2  
LABORERS NEW TO THE PROJECT EACH YEAR

Decade	New Laborers per Year (% of Total)			Mean Number of Laborers Employed per Year (n)
	Mean	Min.	Max.	
1675–9	40.75	12.70	79.23	116.80
1680–9	28.88	6.25	84.66	61.30
1690–9	27.98	13.51	46.15	47.90
1700–9	25.40	0.00	47.83	78.80
1710–9	10.42	0.00	29.03	20.29
1720–9	4.44	0.00	20.00	9.20
1730–9	10.00	0.00	25.00	4.14
1740–9	12.96	0.00	40.00	5.11

Notes: For the 1670s, we exclude the initial two years of data, where the entire workforce is new. Source: See text.

on or who departed each month. Over the whole period, an average of about 10 percent of laborers arrived or departed each month. Peak turnover was much higher—in some months, half or more of the workforce had not worked in the previous month, and in other months, a third of laborers were not employed in the following month.

Today, construction is a high-turnover industry, with worker flows three times higher than manufacturing firms (Davis, Faberman, and Haltiwanger 2006, pp. 7–8; U.S. Bureau of Labor Statistics 2020). Even without the effect of firms opening and closing, the monthly job flows for St Paul's are roughly twice the level seen in modern U.S. data, where the hiring and separation rates are about 4 to 5 percent on average (U.S. Bureau of Labor Statistics 2020).<sup>24</sup> Turnover trended downward during the construction of St Paul's. From 1675 to 1680, the average hiring rate was 14 percent, whereas from 1705–1709 the average hiring rate was only 9 percent. Likewise, the average separation rate decreased from 17 percent in 1675–1680 to 8 percent in 1705–1709.

Because these hiring and separation rates include laborers who had been temporarily separated from the Cathedral, we also examine the share of laborers who joined the St Paul's workforce for the first time each year. The share of newcomers among laborers at the Cathedral declined over time. Table 2 presents decadal averages (after the initial years) showing the gradual decline in the share of new laborers added to the project each year. This extended even to peaks of demand. For instance, in 1687, an early period of high activity, more than 80 percent of laborers were new

<sup>24</sup> The quarterly hiring and separation rates at St Paul's, presented in Online Appendix 1, are about 17 percent, compared to about 14 percent in modern U.S. data (Davis, Faberman, and Haltiwanger 2006, p. 8).

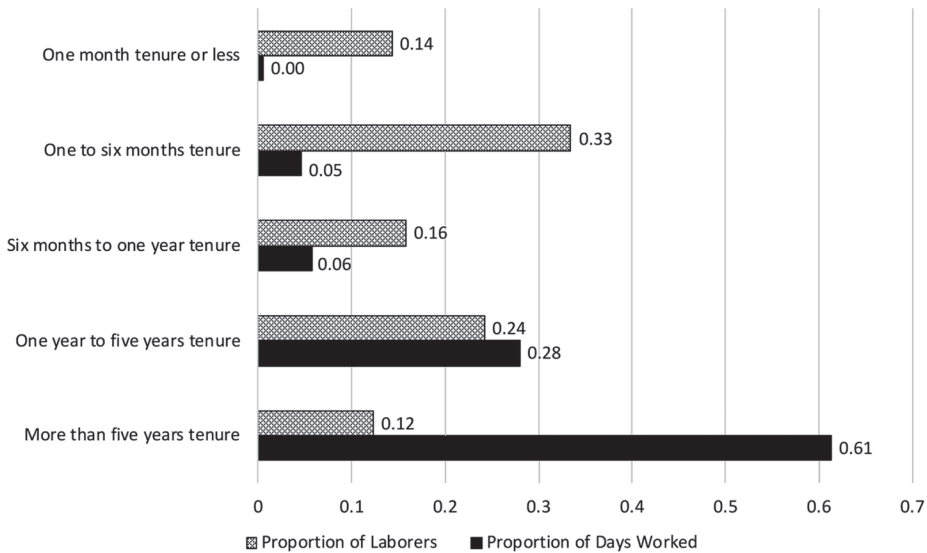


FIGURE 2  
PROPORTION OF LABORERS AND DAYS WORKED ACCORDING  
TO LENGTH OF TENURE

Source: See text.

to the project. Twenty years later, in 1708, which was the year with the largest single amount of work, only a quarter of laborers were new.

The increasing stability of the workforce was not just a function of the number of workers who had previously worked at St Paul's expanding as time passed. Given the short tenure of the great majority of laborers, there was no shortage of laborers to rehire after the earliest years of the 1670s, which we exclude in the calculations in Table 2. Further, the size of the pool of laborers who had previously worked at St Paul's had no effect on the hiring and separation rates in Table 1, which show the same general trend of stabilization.

### *Tenure at St Paul's*

How did this affect the employment of individual laborers? Our individual-level reconstructions of the employment histories of laborers at St Paul's allow us to examine differences in the length of time for which individuals worked at the Cathedral. These differences are given in Figure 2, which includes all laborers who worked during the construction phase at St Paul's. Tenure is calculated as the amount of time between a laborer's first and last appearance in the Cathedral's account books.

The patterned bars in Figure 2 give the proportion of all laborers with each length of tenure: 14 percent of all laborers stayed for less than one month, and almost half of all laborers (47 percent) stayed for six months or less. This accords with historical perceptions of fleeting, precarious employment relations. However, at the other end of the distribution, some laborers were involved for much longer periods. Almost one-quarter of laborers (24 percent) were associated with St Paul's for between one and five years. A further 12 percent of laborers worked at the site for over five years. Overall, 12 men appear in the accounts for a period of 30 or more years, with one, Simon Satchell, active for 43 years in total. Thus, for some workers, laboring at St Paul's was fleeting, while for others, it was a long-standing arrangement.

The vast majority of labor days were supplied by the group of longer-lasting workers. The black bars in Figure 2 indicate that the 12 percent of laborers who worked at St Paul's for more than five years provided over 60 percent of all laboring days at the Cathedral during the construction period. The laborers who appeared most briefly at the Cathedral accounted for less than 1 percent of all laboring days at St Paul's.<sup>25</sup>

Evidence that these longer-term workers were deliberately prioritized by the clerk exists in the accounts. The order in which laborers were literally listed on the page indicates that hiring occurred in a sequence. Long-term laborers were taken on first and are listed higher in the accounts than less tenured or new laborers. Often, the exact sequence of the upper section of the list of hires was repeated between months. Table 3 gives the position in the accounts for new laborers, those who had worked at the Cathedral for a number of months, and those who had worked at the Cathedral for over a year. Over four-fifths of new laborers were listed in the bottom quartile of the accounts. If they remained on site for the next few months, they shifted up the order, but three-quarters were still in the last quartile for the rest of their first trimester on site.<sup>26</sup> By the time laborers had accrued 9 to 12 months of experience at the Cathedral, most were in the middle of the list. Those laborers who stayed for over a year were most often found in the top quarter of the clerk's list. These patterns suggest that the clerk possessed a clear idea about who was to be hired

<sup>25</sup> We treat laborers as having been engaged in a month based on any number of days within a month (1 to 31) or any number of months within a year (so they could be employed in March and not appear again until February but would be considered active for one year in that case). These extremes are not patterns we observe in reality. The discussion here is based on this approach, as we see it as the best option. But these ambiguities in work patterns are why we use two different measures of tenure in the econometric analysis.

<sup>26</sup> That their position in the accounts was still low after their first appearance makes it clear that these patterns were not just contingent on the time within the month that a laborer was first taken on.

TABLE 3  
SHARE OF LABORERS IN EACH QUARTILE OF THE CLERK'S LIST BY ELAPSED  
TIME SINCE ENTRY TO WORKFORCE

Position in Account (Quartile)	New	2–3 Months	4–6 Months	7–9 Months	10–12 Months	>1 Year
0–25	4.91	6.62	8.27	8.76	9.09	33.01
26–50	3.80	5.62	11.87	11.02	12.46	32.33
51–75	6.18	14.54	16.97	35.73	39.73	26.73
76–100	85.10	73.22	62.88	44.49	38.72	7.93
Total	100	100	100	100	100	100
N	631	997	1,137	708	594	8,867

*Notes:* Calculations only include laborers recorded in non-alphabetical accounts produced during the period of construction, from January 1675. Details in Online Appendix 6.

*Source:* See text.

and in what order, with a well-defined preference for those laborers who had accrued more tenure at the site.<sup>27</sup>

The distribution of work at St Paul's was polarized. Much of the laboring workforce faced enormous instability in employment, with highly variable demand and high turnover rates. This is what was generally expected of employment arrangements in the pre-industrial period. However, some laborers were attached to the site for periods of several years or more, and it was this group that provided most of the labor needed for the reconstruction. This does not appear to be a pre-existing feature of general labor in London that was present from the start of the project, but rather a pattern that emerged over time. Taken with the downward trend in the hiring and separation rate at the Cathedral and the decline in the share of new workers in the Cathedral's workforce, it appears that St Paul's was able to stabilize its workforce over the 40-year construction period.

#### RESULTS ON HIRING, RETENTION, AND TENURE

How was St Paul's able to stabilize its workforce? In this section, we explore econometrically the hypothesis that stability was achieved by the employer incentivizing and rewarding tenure. We analyze the relationship between tenure and the number of days of work awarded, the consistency of employment, and access to additional income-earning opportunities. Our results indicate that the Cathedral privileged a core group of workers who were given priority in accessing work as their tenure increased.<sup>28</sup>

<sup>27</sup> See Online Appendix 6 for more analysis of the ordering of laborer's names in the account book, including evidence that gang labor was not present here.

<sup>28</sup> Data and replication files are available at <https://doi.org/10.3886/E182784V1>; see Paker, Stephenson, and Wallis (2022).

*Method*

How did a laborer's prior tenure affect the amount of work they received, the consistency of this work, and their access to additional earning opportunities? Our individual-level data allow us to explore these questions using a series of logit and conditional logit models.

We capture prior tenure in these models in two ways. Our first measure is based on the cumulative number of days a laborer had worked at the site before the date of the account in question. The absolute number of days previously worked strictly increases with time, so we model each laborer's tenure relative to that of the rest of St Paul's workforce who were active in each period. This gives a measure of a laborer's tenure relative to the other workers who may have been available within the pool of workers the clerk was hiring from. Specifically, we calculate the percentile rank according to cumulative days worked up to that point for all workers who were active at the Cathedral during the accounting period. This standardizes our measurement of relative prior tenure across time and over accounting periods of differing lengths. Our second measure is constructed in the same way, as a percentile rank, but is based on the elapsed time in days since the laborer first began working at the site. The percentile rank of elapsed time in days differs from the cumulative days worked because many workers had gaps in employment (seasonal or otherwise) or did not work the maximum number of days in prior account books.<sup>29</sup>

Throughout the analysis, we exclude the first three years of the accounts, before January 1675, to remove the attenuating effect that the earliest periods, when all workers had little experience, would otherwise have produced. We also limit our main analysis to the construction period that ended in 1711, which saw the majority of employment. Finally, we rely on a full panel construction of the dataset where all active workers are represented in each accounting period, including those given no days of work. We consider laborers to be active at St Paul's during an accounting period if that period was between the first and final dates, inclusive, that the laborer appeared in the Cathedral accounts over their career.

The dependent variable in our models is always a binary indicator. Our basic model is a logit model

$$y_{it} = \beta_0 + \beta_1 x_{it} + \beta_3 M_t + \beta_4 T_t + \epsilon_{it},$$

where  $y_{it}$  is a binary variable that equals 1 if a laborer worked over 85 percent of possible days in a period, if a laborer was given any work in

<sup>29</sup> Alternative measures of tenure that are cardinal rather than ordinal and continuous are considered in Online Appendix 7. The main results are robust to these alternative measures of tenure.

an accounting period, or if a laborer was given a watchman shift in each of the following subsections respectively.  $x_{it}$  is the laborer's tenure as a percentile rank of all active laborers in an accounting period, measured either by cumulative days previously worked or by elapsed time since beginning to work at St Paul's;  $T_t$  are year dummies and  $M_t$  are month dummies to control for seasonality. Laborer fixed effects are also included in some specifications to ensure that potential unobservable differences between laborers are not driving our results.

### *Work Allocation between Laborers*

The clerk-of-works hired laborers for different numbers of days in each accounting period. For example, in May 1687, a peak month of construction in which 71 laborers worked for 1,037 days, William Nelson was hired for just seven days and Anthony Minshaw for five days. This was the first of only two months Nelson was hired, while it was Minshaw's last appearance after eight months of consistent work on site. Conversely, four laborers each worked for 23 days, the maximum in the month; two of them, John Hudson and Dan Northam, would be active for more than 20 years. Only three of the 71 laborers who were active in the Cathedral labor force did not work at all during the month.

This inequality in the amount of work that laborers received gives us a simple and important test of the structure of employment at the Cathedral: were long-standing laborers given the most work? If laborers were undifferentiated (differentiated) in the eyes of the clerk, then the amount of work they were given should be uncorrelated (correlated) with prior experience. A strong visual indication that the clerk favored long-serving laborers when choosing who to hire can be found in Figure 3, which shows how the share of available work given to laborers varied according to the time they had worked on the site. The share of work is the ratio between the number of days each laborer worked and the maximum possible in the entire period they were active at St Paul's.<sup>30</sup> The laborers who were on site for the shortest periods, between two and three months, were given the least work. Some of these laborers were only on site for a few days each month; they were truly casual laborers. In

<sup>30</sup> To calculate this, we sum the total number of days that each laborer worked from their first to last appearance. We then divide this by the sum of the maximum number of laboring days worked by a laborer in each accounting period in which the laborer was active. Note that this analysis is conducted only for laborers in the construction period of the Cathedral who worked for more than one accounting period.



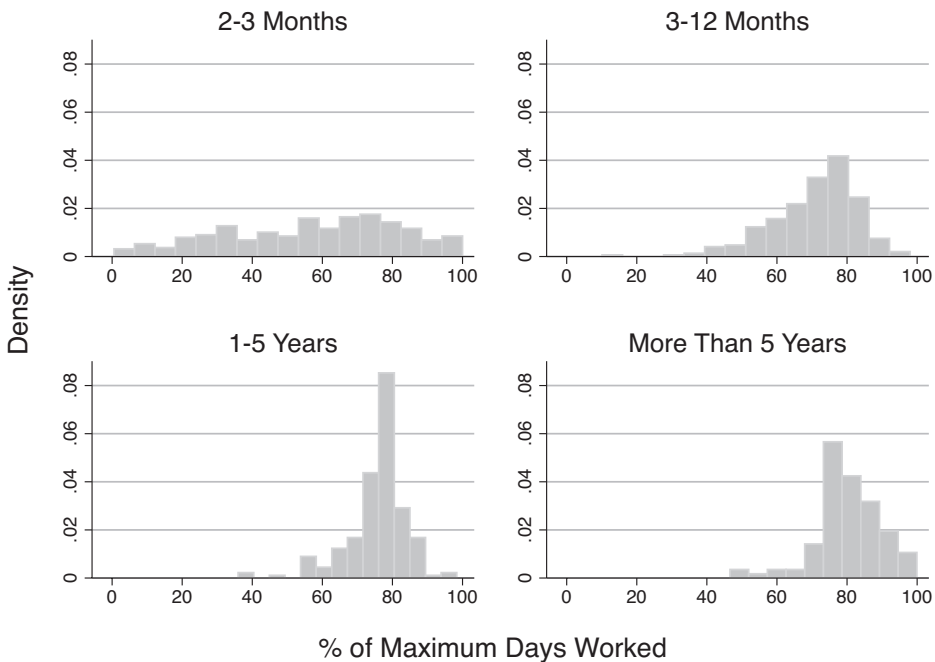


FIGURE 3  
SHARE OF MAXIMUM WORK GIVEN TO LABORERS BY LENGTH  
OF TENURE AT SEPARATION

Source: See text.

contrast, laborers who were present on the site for longer periods, especially those for a year or more, generally worked more intensely, with a convergence to a mode of around 80 percent of the maximum available days. Among the longest-serving laborers, those who stayed more than five years, many worked at the Cathedral on most, if not all, of the possible days during their tenure.

For analytical simplicity, we estimate the effect of prior tenure on work allocation by examining the probability that laborers worked “full time” during a given accounting period. We define full time generously to include anyone working between 85 percent and 100 percent of the maximum number of days any laborer was reported to have worked during an accounting period. In a few cases where the clerk recorded paying wages for more days than existed in the calendar period covered by an accounting period, we capped the maximum number of days at the number of days in the calendar period.

A limitation of our data is that we cannot see which day in an accounting period a laborer began work at the Cathedral. The first time a worker is hired, the number of days they worked may be censored if they started

after the beginning of the accounting period, so we drop the first observation of each worker. Unfortunately, this also means that in this part of the analysis, we lose 157 individuals who only worked at the Cathedral for one accounting period.

The six models in Table 4 estimate the effect of a laborer's prior tenure, in terms of days worked and elapsed time at the Cathedral, on the probability of the laborer working full time during the accounting period. All of the models have year fixed effects to account for time trends and month fixed effects for seasonality, with standard errors clustered at the laborer level.

Columns (1) and (2) give our primary results for tenure percentile in terms of cumulative days worked. The estimates indicate that long-standing workers were significantly more likely to be given full-time work during each accounting period. The marginal effects in Column (2) imply that a one-quartile increase in the percentile rank of a laborer's tenure increases their probability of working full time by 12 percentage points ( $p < 0.001$ ,  $25 * 0.0049 = 0.1225$ ). Figure 4a shows that a worker in the 10th percentile in terms of cumulative days worked has only a 17 percent chance of working full time in a given period, while a worker in the 90th percentile has a 56 percent chance. Column (3) shows that these results are robust to the incorporation of laborer fixed effects, though the effect size is smaller. Columns (4) and (5) explore this further by estimating linear probability models with and without laborer fixed effects, which indicate that the within-laborer effect accounts for about 20 percent of the overall effect but is still strongly significant. Columns (6) and (7) present the results with the laborer's elapsed time percentile rank as the independent variable of interest. The results for the logit model are significant and again slightly smaller, but they are not robust to the inclusion of laborer fixed effects in the conditional logit in Column (8).

The results in Table 4 strongly support the hypothesis that the Cathedral favored longer-standing laborers when allocating employment. This relationship is robust to alternative measures of allocation, including varying the threshold for "full time" and continuous measures of the share of work given to each laborer (Online Appendices 2.1 and 2.2). It is also robust to the inclusion of controls for external shocks that could have affected hiring at St Paul's, including wars, variation in temperature, mortality, and financial volatility (Online Appendix 2.3).

The relationship grew stronger in periods where the project was at a more critical and potentially risky stage, as with the construction of the Dome, involving flying scaffolds (Campbell 2007, p. 151), when

TABLE 4  
MODELS FOR THE PROBABILITY OF A LABORER WORKING FULL TIME

	Cumulative Days Tenure				Elapsed Time Tenure			
	Logit Coeff. (1)	Logit Margins (2)	Cond. Logit Coeff. (FE) (3)	Linear Prob. (4)	Linear Prob. (FE) (5)	Logit Coeff. (6)	Logit Margins (7)	Cond. Logit Coeff. (FE) (8)
Tenure	0.0267*** (0.0023)	0.0049*** (0.0004)	0.0117* (0.0059)	0.0050*** (0.0004)	0.0010*** (0.0003)	0.0180*** (0.0026)	0.0035*** (0.0005)	0.0092 (0.0068)
Constant	-3.7217*** (0.2213)			-0.1814*** (0.0353)	-0.0681* (0.0343)	-2.8929*** (0.2206)		
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Laborer FE	No	No	Yes	No	Yes	No	No	Yes
N	19861	19861	18921	19861	19861	19861	19861	18921
# Laborers	798			798		798		
(Pseudo) R2	0.172		0.156	0.204	0.136	0.131		0.155

Notes: \* p<0.05, \*\* p<0.01, \*\*\* p<0.001. Robust standard errors in parentheses. Tenure given in percentile rank of all active laborers at the site in an accounting period. The outcome variable is whether the laborer worked 85 percent or more of the maximum days worked in the accounting period.  
Source: See text.

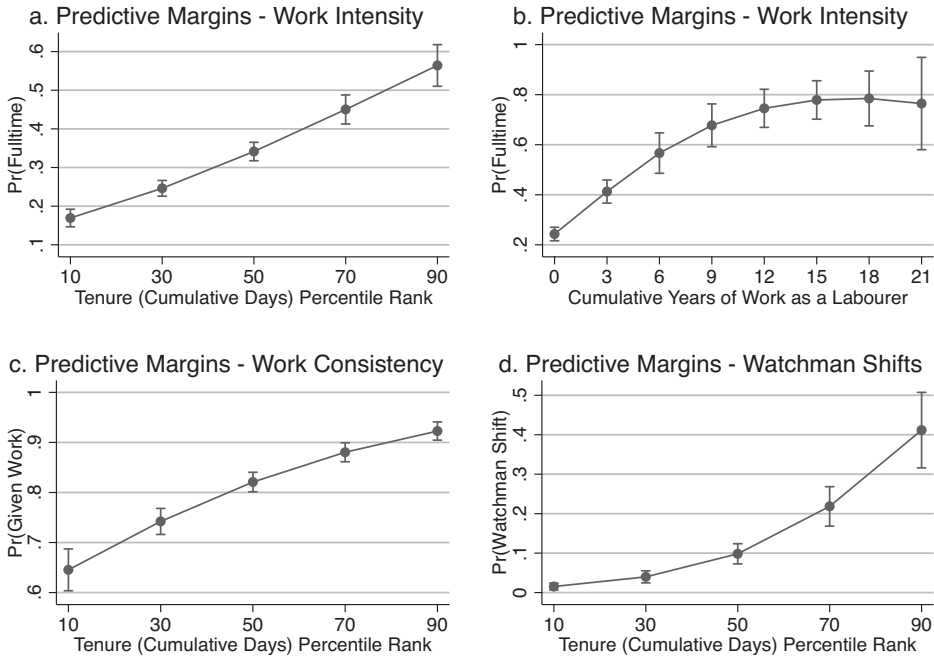


FIGURE 4  
PREDICTIVE MARGINS

Source: See text.

laborers with greater experience and reliability may have been more important to the success of the project (Online Appendix 3). The same pattern of preferential treatment, albeit weaker, persisted in the period from 1714 to 1748 among laborers hired for maintenance work (Online Appendix 4).

### *Marginal Returns to Tenure over Time*

The results in Table 4 suggest that St Paul's favored long-standing workers when allocating days of work each accounting period. There is a strong and significant relationship between tenure and the number of days of work a laborer was allocated in a month, even when individual productivity is accounted for, albeit imperfectly, with laborer fixed effects. How does this relationship change as a laborer's tenure increases?

We expect the marginal returns to tenure to diminish if the employment patterns we observe at St Paul's are explained by two of the standard models in labor economics: worker's on-the-job learning (Lazear 2009), or the employer's discovery of a worker's true productivity, as in the Jovanovic (1979) model. If on-the-job learning is driving our results,

the marginal effect of tenure should diminish to zero after a short period of learning. Because laboring at St Paul's was relatively unskilled, we would expect this learning to take a year or less. Likewise, it would not take more than a year for employers to recognize which workers are most productive and adjust their hiring accordingly, especially as no explicit contracts were involved. If the returns to tenure do not diminish shortly after a laborer is hired, this suggests that tenure was incentivized and rewarded for other reasons.

We capture whether the relationship between tenure and whether a laborer worked full time diminished after one year by interacting the laborer's tenure percentile rank measured in cumulative days with an indicator for whether their cumulative years of tenure was greater than one year. The results for the logit specification are given in Table 5, Column (1). For robustness, we also estimate this model as a conditional logit with laborer fixed effects in Column (2), and as a linear probability model with and without fixed effects in Columns (3) and (4). We also examine different thresholds for learning/discovery with an indicator for whether tenure was greater than six months, two years, or three years in Columns (5), (6), and (7), respectively.

In all seven models in Table 5, the interaction of the tenure rank percentile with the indicator for cumulative years of tenure greater than  $k$  is insignificant. The marginal effects of tenure on the probability of a laborer working full time are similar for laborers who were just beginning their careers at St Paul's and for laborers who had been associated with the Cathedral for longer. This suggests that on-the-job learning and employer learning do not drive the relationship between tenure and the number of days worked.

Table 5 indicates that the marginal effects of tenure did not diminish early in the employment relationship. Is there any change in the importance of tenure over a laborer's career? We can estimate how long it takes for the marginal returns to tenure to diminish by allowing the relationship of tenure to the probability of working full time to vary non-linearly. We estimate a logit model with tenure and tenure squared, where we measure tenure using raw cumulative years worked at St Paul's. Using this logit model, Figure 4b shows that the probability of working full time only begins diminishing after a laborer's 18th year of work at St Paul's.<sup>31</sup>

The employment patterns we observe at St Paul's were not apparently driven primarily by on-the-job learning or by the clerk learning laborers' true productivity in the first months or years of a laborer's employment.

<sup>31</sup> The full estimation results are given in Online Appendix 7, Table 7.3.

TABLE 5  
MARGINAL RETURNS TO TENURE AS TENURE INCREASES: LEARNING MODELS

	1 Year Indicator, <i>k</i> = 1			6 Month Indicator, <i>k</i> = 0.5			2 Year Indicator, <i>k</i> = 2			3 Year Indicator, <i>k</i> = 3		
	Logit (1)	Cond. Logit (2)	Linear Prob. (FE) (3)	Linear Prob. (FE) (4)	Logit (5)	Logit (6)	Logit (7)	Logit (8)	Logit (9)	Logit (10)	Logit (11)	
Tenure percentile rank	0.0272*** (0.0029)	0.0144** (0.0049)	0.0048*** (0.0005)	0.0014*** (0.0003)	0.0369*** (0.0038)	0.0232*** (0.0024)	0.0246*** (0.0022)					
Indicator for <i>k</i> tenure years	-0.5856* (0.2600)	0.0099 (0.3357)	-0.1223** (0.0419)	0.0130 (0.0210)	-0.4374 (0.2315)	-0.5981 (0.3689)	-0.3758 (0.5927)					
Tenure * Indicator for <i>k</i> tenure years	0.0056 (0.0042)	-0.0030 (0.0062)	0.0015 (0.0008)	-0.0006 (0.0004)	-0.0052 (0.0047)	0.0100 (0.0053)	0.0065 (0.0078)					
Constant	-3.7571*** (0.2402)		-0.1728*** (0.0365)	-0.0975* (0.0380)	-4.0713*** (0.2489)	-3.4779*** (0.2331)	-3.5771*** (0.2258)					
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes					
Month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes					
Laborer FE	No	Yes	No	Yes	No	No	No					
<i>Avg. Marginal Effects</i>												
Tenure years indicator												
<i>k</i> = 0	0.0051***		0.0048***	0.0014***	0.0067***	0.0042***	0.0045***					
<i>k</i> = 1	0.0056***		0.0062***	0.0008***	0.0055***	0.0057***	0.0055***					
N	19861	18921	19861	19861	19861	19861	19861					
# Laborers	798		798		798		798					
(Pseudo) R2	0.173	0.156	0.206	0.136	0.176	0.173	0.172					

Notes: \* p<0.05, \*\* p<0.01, \*\*\* p<0.001. Robust standard errors in parentheses. Tenure in cumulative days given in percentile rank of all active laborers at the site in an accounting period. The outcome variable is whether the laborer worked 85 percent or more of the maximum days worked in the accounting period.

Source: See text.

This is further evidence that long-standing laborers were rewarded for their tenure and seniority at St Paul's.

### *Persistence of Employment*

As well as deciding how many days of work to give to laborers in each week, the clerk also chose who would be hired again the next week. As the estimates of churn in Table 1 indicate, the Cathedral saw high levels of hiring and separation from month to month. This offers us a second, critical test of the structure of employment: were long-standing laborers more likely to be retained month-by-month at St Paul's? If the clerk saw laborers as undifferentiated (differentiated), then the amount of time they had spent on the site should be uncorrelated (correlated) with the probability they would be hired in the future.

The consistency of employment would have been a pressing concern for laborers. The peaks and troughs of labor demand on the site (Figure 1) left few untouched. Breaks in employment at the Cathedral were commonplace; we can identify 840 periods of temporary separation in our panel, when a laborer was absent for one or more accounting periods before reappearing in a later period. Because we do not observe separations of less than a month, this is likely to be an underestimate. Almost all absences (89 percent) were for less than a year, and the median absence was two months (62 days). Long-serving workers did not escape periods without work—four-fifths of laborers employed for more than a year had at least one break in employment.

Given the frequency of breaks in employment, we model how prior tenure affected whether laborers were hired in each accounting period. In each time period, as above, we focus on the supply of possible laborers from among those individuals who were existing active workers at the Cathedral—those who had worked one shift at the Cathedral previously and who had not yet made their final appearance in the records. However, in this part of the analysis, we can also include the 157 workers dropped from the analysis in the previous sections who appeared in the accounts only once. These estimates do not speak to the choice of whom to hire from outside the pool of active laborers, and we cannot examine the determinants of a laborer's final exit from the site. In effect, this analysis can be interpreted as how tenure affected the chance that workers had periods in which they were not hired from among the general pool of laborers.

In the three models in Table 6, the dependent variable is a binary indicator equal to 1 if the worker was given work in an accounting period,

TABLE 6  
MODELS FOR THE PROBABILITY OF A LABORER BEING GIVEN WORK

	Cumulative Days Tenure				Elapsed Time Tenure			
	Logit Coeff. (1)	Logit Margins (2)	Cond. Logit Coeff. (FE) (3)	Linear Prob. (4)	Linear Prob. (FE) (5)	Logit Coeff. (6)	Logit Margins (7)	Cond. Logit Coeff. (FE) (8)
Tenure	0.0260*** (0.0025)	0.0035*** (0.0003)	0.0275*** (0.0084)	0.0035*** (0.0003)	0.0036*** (0.0002)	0.0184*** (0.0027)	0.0026*** (0.0004)	0.0440*** (0.0084)
Constant	-1.0639*** (0.2196)			0.4073*** (0.0357)	0.4220*** (0.0268)	-0.3757 (0.2043)		
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Laborer FE	No	No	Yes	No	Yes	No	No	Yes
N	20780	20780	17839	20780	20780	20780	20780	17839
# Laborers	955			955		955		
(Pseudo) R2	0.154		0.151	0.148	0.105	0.119		0.185

Notes: \* p<0.05, \*\* p<0.01, \*\*\* p<0.001. Robust standard errors in parentheses. Tenure given in percentile rank of all active laborers at the site in an accounting period. The outcome variable is whether an active laborer was given work during the accounting period.

Source: See text.



and 0 otherwise. Our independent variable of interest is the worker's prior tenure relative to all active workers in that period, again given as a percentile rank of cumulative days worked or elapsed time at the Cathedral. As above, all of the models have year and month fixed effects with clustered standard errors.

Our main results in Columns (1) and (2) demonstrate that long-standing workers were more likely to be given work in each accounting period. Column (1) gives the coefficient estimates from a logit model. The marginal effects in Column (2) indicate that a one-quartile increase in a laborer's tenure percentile rank increases their probability of being given employment by 9 percentage points ( $p < 0.001$ ,  $25 * 0.0035 = 0.0875$ ). As Figure 4c indicates, these estimates indicate that a worker in the 90th percentile of cumulative days worked prior to a given accounting period had a 92 percent chance of being hired, while a worker in the 10th percentile had only a 65 percent chance. This effect is robust to the inclusion of laborer fixed effects in a conditional logit model in Column (3), and the effect size is similar between a linear probability model with and without laborer fixed effects in Columns (4) and (5).

Columns (6) and (7) give the coefficients and marginal effects of a logit model using our alternative measure of tenure percentile based on elapsed time. The effect size is significant but slightly smaller: a one-quartile increase in the laborer's elapsed time percentile rank increases the probability of being hired by 7 percentage points ( $p < 0.001$ ,  $25 * 0.0026 = 0.065$ ). Column (8) indicates that these results are also robust to the inclusion of laborer fixed effects.

The models in Table 6 indicate that long-standing workers were given more consistent employment at St Paul's. Of all active laborers, it was those with the least tenure who were most likely to face periods in which they were not hired. Longer-standing laborers, in contrast, were the last to be stood down. Moreover, as Online Appendix 5 shows, the seasonality of building work strongly suggests that laborers were not absenting themselves for better offers on other sites. Less-tenured workers were laid off in periods when low demand was widespread across the sector, making a seamless transition to another site unlikely.

### *Additional Income Earning Opportunities*

Finally, how did the clerk distribute the chance to earn additional income at the Cathedral? One lucrative perk in his gift was shifts as night watchmen, given to laborers in addition to their regular labor days. A night's watch paid 8d. until 1700 and 12d. thereafter, equivalent to half

to two-thirds of the daily wage.<sup>32</sup> The maximum number of watch shifts any laborer was allotted was two per week or ten per month, limiting the monthly income premium to about 15 percent. Our test is the same as that in the previous sections: were long-standing laborers more likely to be given watchman shifts at St Paul's?

Overall, just 8 percent of all laborers served as watchmen.<sup>33</sup> Watch shifts were associated with longer tenure—the median tenure at the Cathedral for workers given watch shifts was nine years, whereas the median tenure for workers who were not given watch shifts was only six months. Two-thirds of watchmen had been active as laborers for more than a year before their first night shift. However, even among long-standing laborers, the majority were not hired as watchmen—only 32 percent of laborers who were employed as laborers for longer than two years in the construction period were given watch shifts.

In general, being hired as a watchman seems to have been a valuable privilege that possibly reflected information about trustworthiness: shifts were given to a small and relatively stable group among the laborers.<sup>34</sup> This trustworthiness mostly appears to have arisen from a worker's tenure at the Cathedral, but relationships and kinship may also have had an effect. Four laborers (Charles Lepton, Thomas Tillison, Thomas Bugby, and Richard Hart) were given a watchman's shift in their first period working at the site, and at least two of them may have had relatives who already worked at the site.<sup>35</sup> Watch shifts thus appear to be a lucrative reward for laborers who were considered trustworthy enough to manage the site overnight.

We estimate the extent to which long-standing laborers at the Cathedral were more likely to be allocated shifts as watchmen. In the four models in Table 7, the dependent variable is whether or not a laborer was also

<sup>32</sup> Since not all long-standing laborers were offered shifts as watchmen, we infer watch work was a desirable opportunity, not an obligation accepted as the price for an additional day. Lang (1956, p. 87) describes men who serviced the watch as being furnished with "warm cloaks" for their comfort. The watch was a privileged position of trust at other city and crown institutions (see Sainty and Buckholz 1998; Murphy 2023, pp. 35–37, 182–3). We have not been able to establish why the rate of pay per shift increased in 1700 in the minutes of the commission or otherwise.

<sup>33</sup> The exception was the quiet years of the 1690s; in these slump years, just under half of laborers took work as watchmen. In years when construction peaked, this fell to as low as 7 percent of laborers.

<sup>34</sup> Over 90 percent of those with watch shifts in one period were given shifts in the next period, and the majority (60 percent) of those serving as watchmen would do so for every month of a year in which they were active.

<sup>35</sup> Charles Lepton, who became a watchman in his first account (March 1703), may have been related to Christopher Lepton, who had worked between October 1697 and September 1698, and who himself reappeared in November 1703 (with a watch shift at his reappearance). Thomas Tillison was possibly related to John Tillison, who had worked for a year from March 1676 to June 1677.

TABLE 7  
MODELS FOR THE PROBABILITY OF A LABORER HAVING A WATCHMAN SHIFT IN AN ACCOUNTING PERIOD

	Cumulative Days Tenure			Elapsed Time Tenure		
	Logit Coeff. (1)	Logit Margins (2)	Linear Prob. (FE) (3)	Linear Prob. (FE) (4)	Logit Coeff. (5)	Logit Margins (6)
Tenure	0.0497*** (0.0054)	0.0053*** (0.0006)	0.0050*** (0.0007)	0.0046*** (0.0002)	0.0431*** (0.0055)	0.0048*** (0.0007)
Constant	-5.6099*** (0.5309)		-0.1838*** (0.0506)	-0.0046 (0.0233)	-4.7720*** (0.5134)	
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Laborer FE	No	No	No	Yes	No	No
N	16903	16903	16903	16903	16903	16903
# Laborers	746		746		746	
(Pseudo) R2	0.228		0.178	0.110	0.188	

Notes: \* p<0.05, \*\* p<0.01, \*\*\* p<0.001. Robust standard errors in parentheses. Tenure given in percentile rank of all active laborers at the site in an accounting period. The outcome variable is whether the laborer was given a watchman shift in an accounting period.

Source: See text.

hired as a watchman during an accounting period. Tenure is measured as before. The final years of the construction phase (1708–1711) are excluded because watchman shifts are not recorded in these years.

Our main results in Columns (1) and (2) show that more tenured laborers were more likely to be hired as watchmen. The marginal effects in Column (2) indicate that a one-quartile increase in the percentile rank of a laborer's tenure increases the probability that they were hired as a watchman by 13 percentage points ( $25 \times 0.0053 = 0.1325$ ). Figure 4d plots how the probability of being awarded a watchman shift changes with a laborer's tenure percentile. New laborers in the 10th percentile in terms of tenure had only a 15 percent chance of being given a watchman shift, while those in the 90th percentile had a 41 percent chance. Columns (3) and (4) give linear probability models with and without laborer fixed effects, demonstrating that the within-laborer effect of tenure on getting a watchman shift is very large and significant. Columns (5) and (6) in Table 7 show that this effect is robust to our alternative measure of tenure and is of a similar magnitude. Watch shifts were thus largely given to laborers with longer tenure and added an important additional reward for laboring at the Cathedral.

### *Implications for Laborer Income*

Long-term laborers were advantaged in the number of days of work they were allocated each month and the persistence of their work over the seasons. The impact of this on annual employment and income was substantial.<sup>36</sup> The median number of days worked per year on this site for all laborers in any year was just 145, but for those who were active at the Cathedral for more than two years, the median was 200 days.<sup>37</sup> With longer tenure, laborers could achieve something like full-time work from a single employer, avoiding the costs of searching for other work. Because wages were nominally rigid, this differential in hiring determined the level of income that laborers could achieve through work at the Cathedral.

The dispersion in laborers' income from St Paul's is apparent in Table 8, which summarizes the average income of laborers according to their tenure for each half decade of the construction period, 1675–1709, and

<sup>36</sup> We acknowledge that we can only calculate income from the Cathedral here, with income from other external sources unknown. That income will depend on the day or task rate paid for such work, the amount of external work, and the cost of time and effort spent searching for it. There is unfortunately not enough information about other sites to calculate laborers incomes more comprehensively.

<sup>37</sup> Calculations for the construction phase, excluding watch shifts.

TABLE 8  
AVERAGE ANNUAL INCOME (£) FOR LABORING AND WATCH AT ST PAUL'S,  
BY TENURE

	Tenure Percentile			
	1st–24th	25th–49th	50th–74th	75th–99th
Construction				
1675–9	£3.61	£7.73	£11.16	£10.31
1680–4	£6.31	£9.79	£13.38	£13.53
1685–9	£4.11	£9.63	£11.33	£14.84
1690–4	£4.95	£11.32	£14.08	£17.98
1695–9	£8.72	£15.47	£15.86	£20.56
1700–4	£11.56	£16.21	£19.79	£22.85
1705–9	£9.78	£16.42	£18.71	£22.34
Maintenance 1711–1748	£15.75	£19.09	£18.57	£19.25

*Notes:* Tenure percentile rank is calculated each year relative to all laborers who worked in that year based on the elapsed time since the laborer began working at St Paul's. These calculations only include income from the Cathedral, laboring or watch shifts, with any other income from other external sources unknown.

*Source:* See text.

for the maintenance period, 1711–1748. These calculations include pay for days worked as a laborer and any additional income from watch shifts. In each period, laborers who had worked at the Cathedral the longest had higher annual incomes from the Cathedral than those who were relatively new to the project. Their access to more days of work, more consistent working patterns, and watchman shifts gave them substantially higher average annual incomes than those in the bottom half of the tenure distribution.

During the early years of construction, even the most tenured workers earned less than £20 per year in nominal terms.<sup>38</sup> If they were to earn enough to support themselves and a family, these workers would have needed to find work on multiple sites or in a variety of by-employments each year, although the seasonality of construction work will have made this difficult. In later years, with the stabilization in hiring at the Cathedral, laborers' incomes from employment there grew markedly. By 1700–1709, the majority of laborers were employed for enough days each year on this site to earn over £18. As work moved towards maintenance after 1711, and the laboring workforce dwindled to a few men in each month, the average laborer at the Cathedral was employed for over 300 days a year, and even laborers in the lowest quartile of tenure

<sup>38</sup> For comparison, the standard estimates of annual income for this period are generally based on day rates of 20d to 24d for a standard 250 days a year (Allen 2009; Broadberry et al. 2015). This implies that an average laborer earns £20–£25 per annum.

were earning £16 or more. In real terms, this would have fluctuated considerably, as this was a period of highly volatile price inflation and deflation.<sup>39</sup>

## DISCUSSION

To summarize, despite enormous volatility in labor demand during the construction of St Paul's, the hiring of general laborers gradually stabilized, turnover fell, and average tenure increased. Employment became highly polarized, even though all the general laborers were doing similar work requiring a similar skill level. A core set of workers achieved relative job stability and access to additional work, and a periphery of temporary workers experienced short tenure. This core of long-lasting workers supplied a large share of the project's needs.

The day wage rate was almost identical for all workers in both groups and did not change over eight decades. However, as we have shown, longer-standing laborers received preferential treatment in four ways that increased their earnings. First, they were given more days of work in each period in which they were present. Second, they were more likely to be retained. Third, they were more likely to be rehired after being laid off. Finally, they were given access to lucrative watchman shifts. That this was a deliberate strategy developed by the Cathedral is apparent from the accounts. Core workers were hired first by the site each month, with peripheral workers added later as needed. Evidently, workers had to choose to return and were rewarded for doing so, but their chance of selection rested on the clerk's view of their place in his system.

An intuitive explanation for the clerk's hiring decisions is that they simply reflected productivity differences between laborers: it was those workers who were the most productive, or expected to be the most productive, who were being hired first and for the most days. In a competitive market, we would usually expect productivity differences to be reflected in wages.<sup>40</sup> With wages nominally fixed, offering extra work could have been a form of additional incentive. Perhaps the clerk was able to learn about which workers were innately more suitable or productive, as in Javonovic (1979)'s screening model, or workers were building up firm-specific human capital through on-the-job learning (Lazear 2009).<sup>41</sup> The

<sup>39</sup> See price series in the Bank of England's "A millennium of macroeconomic data," Thomas and Dimsdale (2017).

<sup>40</sup> That wage differentials are expected for workers with heterogeneous expected marginal products is a typical feature of neoclassical labor market models.

<sup>41</sup> Note that Javonovic (1979) implies wage differentials, which are not found at St Paul's.

greater returns to tenure during the construction of the Dome (Online Appendix 6) offer some support for this interpretation.<sup>42</sup> The absence of declining marginal returns to tenure, however, indicates that neither on-the-job learning nor employer learning can fully explain how hiring operated at the Cathedral.

A second explanation is that the early modern labor market in construction in London had more frictions than previously assumed. St Paul's may have pursued strategies in order to address principal-agent problems (Shapiro and Stiglitz 1984), minimize turnover costs (Stiglitz 1974), or overcome information asymmetries with adverse selection (Weiss 1980). The efficacy of these strategies varies with workers' tenure, possibly explaining the different experiences of tenured and non-tenured workers at the Cathedral.

Among explanations focusing on frictions, our results are most obviously consistent with a model in which St Paul's faced high costs of hiring and training workers, and so "tenure mattered."<sup>43</sup> If turnover costs were significant, there would be an incentive for the clerk to create long-term bonds, such as implicit contracts, that could provide this form of job security (Okun 1982). To reduce the costs of turnover while posting fixed wages, some workers were given access to additional income through more consistent work and a higher probability of being rehired after seasonal breaks. This ensured enough worker retention to minimize these costs. The clerk's adherence to seniority in hiring across the duration of employment at the site fits well with this. The risk that weather, finance, or project factors might stop work at any time, however, precluded longer-term contracts.

Our results reveal how employers could use the organization of work rather than wages to manage supply and demand in pre-industrial unskilled labor markets. The Cathedral optimized the structure of its pool of general laborers by rewarding and incentivizing tenure, reducing turnover costs in the face of substantial shifts in supply and demand for labor.

Given the difference between our findings and earlier assumptions, the question arises of how much we can surmise about the market for and employment of unskilled labor more generally from St Paul's. The very existence of the records we study and the argument we pursue suggest employment patterns may have been different at this site because its scale and duration offered the opportunity for longer-term working

<sup>42</sup> In a sense, by hiring the most experienced or safest workers on the Dome, the clerk was avoiding "mistake costs," where the employer's strategy was designed to avoid moral hazard in scaffolding safely.

<sup>43</sup> As per Manning (2003, p. 3) jobs have rents.

relationships than other projects. However, recent results from a similar eighteenth-century project in Madrid imply returns to tenure for skilled and unskilled workers elsewhere.<sup>44</sup>

The Cathedral was certainly an unusually large project. Although it was publicly funded in a possibly bureaucratic manner, the operations of its hiring and contracting were broadly representative of the market. Other aspects of building work on the Cathedral operated in the same way as on other large sites in the city (Stephenson 2020a, pp. 35–64, 79–106). The wharving of the Fleet Ditch in the early 1670s reputedly used hundreds of laborers contracted by Thomas Fitch during the two to three years that the project took; unfortunately, no named records survive (Skempton, Cross-Rudkin, and Chrimes 2002, p. 228). General laborers were also hired at Westminster Abbey, 1712–1713, and Greenwich, 1696–1706, two of the largest contemporaneous sites, although in smaller numbers.<sup>45</sup> Similarly, Woodward (1995, pp. 100–6) offers evidence of some laborers' long-term association with sites. Other places, such as the dockyards, may have developed similar systems of hiring to St Paul's, but it is impossible to test whether the same trends in tenure and hiring occurred. However, the records of the contractors who operated such sites also tentatively indicate a positive relationship between tenure and the annual number of days worked (Stephenson 2020b, p. 424). Those contractors worked on private and publicly funded projects.

The relationship we document between a worker's length of tenure with an employer and the number of days for which they were hired has obvious implications for living standards. Wage laborers' income has conventionally been estimated by multiplying day rates by a standard number of days worked.<sup>46</sup> Changes in the number of days worked have been linked to general shifts in industriousness and immiseration. If the days of work available to laborers were not randomly distributed, as this case strongly suggests they were not, then flat nominal day wage rates may conceal considerable inequality between workers.

## CONCLUSION

Workers on London's largest building site in the late seventeenth century faced high levels of uncertainty about whether or not they would be given work in the next week or month. The needs of the project varied

<sup>44</sup> García-Zúñiga and López-Losa (2021).

<sup>45</sup> Westminster Abbey Muniments cat. no.34513; The National Archives, Greenwich Hospital ADM 68/4.

<sup>46</sup> Clark (2005, 2007) and Allen (2001). But see Allen and Weisdorf (2011) and Humphries and Weisdorf (2019) for a consumption-led variation on this.



dramatically, and with them came the chance of being hired. However, work was not allocated in a pure spot market. Instead, the Cathedral developed and prioritized a core group of long-term workers, who were put at the head of the queue in hiring, offered additional work as watchmen, and were allotted a larger share of the available work than their less-experienced peers, who received short and insecure periods of work. Tenure—as we might generously term what remained a tenuous and intermittent relationship—was rewarded by the Cathedral with access to larger amounts of work, and so a higher and more reliable income. Building laborers' incomes were thus more varied than their day rates imply.

These patterns are explicable if St Paul's was using its hiring strategy to deal with the volatility of labor markets. Wages did not adjust to shifts in demand in the short or long term; rather, nominal rates persisted despite eight decades of urban expansion, persistent GDP growth, and structural change. Laborers were incentivized to return by the prospect of more work, not more money per day: higher incomes, not higher wages. This strategy may have reduced turnover costs for the Cathedral, contributing to the stabilization of their workforce, which we have observed.

To be clear: no direct record of the management strategy of the Cathedral exists, even if one was ever articulated explicitly by those involved. But the Cathedral's hiring choices indicate an employer deliberately favoring their long-term workers. St Paul's thus presents a phenomenon that is, in the context of the existing literature, unexpected for a pre-industrial unskilled labor market. This distinctive mechanism used to reward and retain workers seems to have emerged endogenously as a response to the standard challenge of supplying large numbers of workers of a suitable quality in a volatile labor market.

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