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Abstract

The calculation of the number of days worked per year is crucial for understanding pre-industrial living standards, and yet has presented considerable obstacles due to data scarcity. We present evidence on days worked and seasonality patterns of work using evidence from a large database of micro-level labor market data for eighteenth century rural Denmark. We estimate that workers worked approximately 5.6 days per week when under full employment. Seasonality of work meant, however, that they were unlikely to find employment during the winter, bringing the estimated number of working days per year to 184. This is lower than often assumed in the literature on real wage calculations, but in line with recent evidence for Malmö and London. We find that days worked increased over the eighteenth century, consistent with the idea of an "industrious revolution". We suggest however that this was probably mostly due to economic necessity rather than a consumer revolution, since unskilled and low skilled workers needed to work over 300 days per year to afford a subsistence basket.

JEL Codes: J22, N33

Keywords: working year, seasonality patterns, real wages, annual workers, casual workers, Denmark, eighteenth century

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1. Introduction

Understanding the length of the working year is crucial if we are to approximate the true standard of living over time. Why might days worked per year have increased prior to the onset of modern economic growth? There are two related reasons for thinking that they might have done so, the first being the idea of an "industrious revolution" (de Vries 1994), a term first coined by the Japanese demographic historian Akira Hayami (de Vries 2008), and the second being the consumer revolution. These suggest that with the arrival of new consumer goods, people chose to work longer in order to have the income necessary to afford them. This process in turn led to increasing per capita incomes and the emergence of sustained economic growth. The present work offers a wealth of new empirical evidence from eighteenth century rural Denmark.

Elsewhere, empirical evidence for an industrious revolution is scarce, leading Clark and van der Werf (1998) to conclude that "the existence of a preindustrial industrious revolution… is at best an open question". Some evidence on the existence of an industrious revolution is available for England, however. Early estimates of the length of the working year, provided by Voth (1998), found increases in industriousness not in the middle of the seventeenth century as de Vries suggested, but at the end of the eighteenth century, based on evidence provided by analyzing witness declarations in historical court records. Allen and Weisdorf (2011) have however succeeded in creating annual estimates of the length of the working year by using existing information on wages in England to calculate the number of days necessary to afford a "respectable" bundle of goods for both farm and urban laborers. Although both are found to have worked more days, for the former this was principally a matter of working more in order to combat low wages and thus to survive, while for the latter, a consumer revolution did indeed take place between 1600 and 1750. More recently, Stephenson (2018) and Gary (2019), focusing mostly on construction workers and urban settings, have claimed that the working year in the past was actually shorter (as low as 180 days per year in London and 150 days in Malmö) than the 250 days which have typically been assumed (e.g. by Allen 2001, 2013). Moreover, a more traditional view sees industrialization and capitalism as bringing both "time thrift" and longer and irregular working hours for employees (Thompson 1967). The disappearance of many holidays, including "Saint Mondays", has also been suggested as a possible reason (Douglas 1976).

We add to this debate, by using an extremely detailed dataset from eighteenth century Denmark. The data were gathered by the Danish Price History Project for a large number of occupations when a number of new products were entering the market, and when important institutional changes were occurring (Andersen 2004, Jensen et al (2019a) , Jensen et al. 2018, Sharp 2018). They provide micro-level information on the number of days worked by various categories of workers, making it possible to investigate the hypothesis of an industrious revolution in Denmark, which was a rather poor, peripheral country in the eighteenth century, and one which only industrialized in the late nineteenth century. These data have not been exploited before for the present purposes, but have otherwise been used recently by Jensen et al (2019a), and Jensen et al. (2018, 2019b).

We find that rural workers under full employment worked an average of 5.6 days per week, but also experienced strong seasonality so that the total number of working days per year was only 184 days due to the fact that it was difficult to find employment during the winter. We also observe that the average number of days paid per data entry for male casual workers increased from around 10 to 30 days and that days paid per individual male casual workers increased from about 26 to 60 days, offering support for the idea of an industrious revolution. We also observe that the length of the working year increased during the eighteenth century, from 80 days in the 1730s year to above 100 in the 1700s, with a peak of 184 in the 1780s. We observe a fall in the 1790s to a little more than 100 days and discuss various interpretations of this. For the sake of comparison with other studies, we also calculate how many days were needed by a casual worker to purchase a subsistence basket, finding that this number also increased to around 300 days at the end of the century and that the number of days needed to equal the income of an annual worker reached 400 days over the same period, meaning that people in the countryside became poorer, and required more days of labor, probably from family members, to earn enough to survive.

The remainder of this paper is organized as follows. The next section discusses the existing literature, and section 3 presents the historical context. Section 4 describes our data and methodology, and section 5 presents our results. Section 6 concludes.

2. Literature on Days Worked and Seasonality

There are relatively few studies which provide historical estimates of days worked in the early modern period, and almost all focus on England. Thus, when using day wages to assess annual incomes it has been necessary to make assumptions about days worked per year, for example 250 (Allen 2001). There has however been an increased focus on finding both direct and indirect estimates of days worked, motivated by theories about what might have motivated workers to increase their labor supply during the centuries before the Industrial Revolution.

Blanchard (1978) studied labor productivity and work psychology in the English mining industry during the period 1400-1600 and found five observations for five years in the fifteenth and sixteenth centuries, demonstrating that workers spent 135 days in agriculture and the remainder, 130 days, in mining.[2] Voth (1998, 2000, 2001) proposed an empirical study to support de Vries' (1994) theory of an industrious revolution, using witness accounts to estimate working time in England for the period 1760-1830. His innovative idea was that the witnesses to a crime had to provide an oath in court in which they had to report their activities of either work, leisure or other at the time when they witnessed the crime. He found evidence of an industrious revolution, with working hours increasing substantially, but this was at the end of the eighteenth century, somewhat later than de Vries had suggested. He also combined his data with calculations

[2] This calculation was made by Allen and Weisdorf (2011)

of labor input provided by Wrigley et al (1997) and Feinstein (1998) to determine changes in total labor supply. A study by Clark and van der Werf (1998) based on estate records and household accounts from across England for the period 1260-1850 used day and piece wages earned by sawyers and threshers to estimate the number of hours worked. They assumed that casual and annual workers earned the same amount and used this assumption to infer the length of the working year, with their results failing to suggest an industrious revolution at any time during this period. In fact, although farm laborers increased their number of days worked per year from 260 to 300 between the sixteenth and eighteenth centuries, they found that it was during the Middle Ages that there was the highest labor supply per person.

Allen and Weisdorf (2011) proposed an innovative method for calculating the number of days per year. They kept Allen's (2001) consumption basket fixed and calculated the number of days per year necessary to afford this basket of goods (the number required to support a household) at Allen's "respectability" level. By using data on household annual consumption expenditures and day wages for two categories of workers, farm laborers and urban workers, they compared their results with the more scattered estimates from the previous literature, Blanchard (1978), Voth (2001) and Clark and van der Werf (1998). Their findings suggested that an industrious revolution was indeed present among farm laborers, but not because of these workers' desire to buy the new goods appearing on the market, but rather from economic hardship. On the other hand, a consumer revolution could be observed for urban workers in the period 1600 to 1750, with their estimates similar to previous work. In a more recent study, Humphries and Weisdorf (2017) collected data on annual wages for England for the period 1260-1850, making it possible to infer the length of the working year based on the assumption that casual and annual workers earned roughly the same (Clark and van der Werf 1998). Thus, the number of working days was calculated by dividing the annual salary by the day rates. The evidence they presented supported de Vries' theory, with a working year that had increased to over 300 days after 1750, and the implication that this was an important factor behind the shift to modern economic growth.

Finally, recent working papers provide new insights. Stephenson (2018) analyzed the building industry in London in the eighteenth century, based on two daybooks of a mason contractor at St Paul's Cathedral. She finds a lower number of days per year than previous estimates, just 180 days, together with a high variation and wide distribution in the number of days worked. Moreover, she also finds that full-time employees worked more than those who were employed on a casual basis. Then, a recent study by Gary (2019), also looking at the construction industry, focuses on the seasonal pattern of paid work in Malmö, a city in the southwestern part of Sweden. She finds that this industry was highly seasonal, and that there were frictions on the labor market, and inefficiencies when it came to worker-employer matching. Like Stephenson, she also finds evidence for a short working year during the Early Modern Period, as low as 150 days.

As regards studies of the seasonality of work in the past, Wrigley and Schofield (1981) were the first to link marriage seasonality to work intensity in their analysis of the English population in the early modern

period. They found that areas producing grains were different from pastoral areas in terms of patterns of marriage seasonality and labor demand. In another study, Kussmaul (1993) also links marriage patterns to labor seasonality in England for the period 1538-1840, by examining historical data on marriages and economic activities for 542 English parishes. He finds that people married when their work permitted, for example, during the spring in the countryside, and that not too many marriages were contracted during the harvest season when workers were kept busy. On the other hand, in the cities or industrial areas, religious holidays dictated a lack of marriage intensity. Finally, Dribe and van de Putte (2012) analyzed marriage seasonality to determine work and leisure patterns in Sweden in the period 1685–1894, finding that marriage seasonality changed over time, consistent with an increase in work intensity. Only the weeks around Christmas were represented as a low season. Finally, as mentioned above, Gary (2019) also considers the seasonality of work.

3. Previous Studies on Days Worked in the Danish Countryside in the Early Modern Period

In the historiographical literature, there is little evidence about the length of the Danish working year. Kjærgaard (1994), however, offers a valuable summary of the work ethic, practices, church involvement, relations between employer and worker, and the scattered evidence from data and anecdotal evidence. For example, he states that during the period 1500-1800 the average working day increased by three or four hours and the working week by one or two days, corresponding to an increase of about 50 percent in working hours (Kjærgaard 1994). At the same time, population doubled. The Danes embraced the Lutheran Protestant Reformation in 1536 (Henriksen 2006) which would later have a visible effect on the number of working days per year. Protestantism has famously been linked to work ethic (Weber 1920), and many initiatives were indeed undertaken to suppress the number of free days per year. Thus, a church ordinance from 1539 abolished various religious festivals, so that from around 50 holidays at the end of the fifteenth century, only 16 were kept plus Sundays (Rørdam 1883). The length of the working week increased to 5.12 days, and this led to protests across Denmark. Bishop Peder Palladius responded strongly to this, stating that the "… day on which you work for your living is one of God's good holy days. Therefore, you should also work on monk's days, which we no longer have to observe, so that you do not become thieves of God's holy days…God has commanded you to work, you day-thief, not to sit down and drink ale!" (Kjærgaard 1994 after Schwarz Lausten 1987 and Palladius 1872). Yet, it has been argued that it was economic necessity which convinced the Danes to adhere to the extensions of their working days (Kjærgaard 1994).

As the above changes took effect, the so-called *skulteuger* were the next target of employers. These referred to a period of two or three weeks around Easter and November in which servants and farmhands were not required to work and were free to change their jobs and cultivate their own patch of land sometimes received as payment in kind from their employer known as *lønnesæd*. In 1770, *skulteuger* were abolished, as the dates when employment could be changed were moved to December 31 and June 30, which were periods

that were unsuitable for working the land. That same year, nine holidays were abolished, leaving a total of just seven, with an associated workweek of 5.9 days and a workday of 10 hours. Even traditions like celebrating the completion of major work were looked at unkindly by priests: “peasants were hardly able to spread dung without a celebration; at mowing time many of them bring their fiddles or drums and celebrate for two or three days running” (Kjærgaard 1994 after Bloch Ravn 1983 pp 10). During this century, to secure cheap labor, and to ensure enough supply of men for the military, serfdom was reintroduced in 1733 (Jensen et al. 2018). Peasants were tied to the area where they were born and would arguably increase the monopsony power of landlords. The rules applied also tightened over the century. In 1733 the age group at which a man could not leave the manor was 14-36 years old, in 1742 the age group was extended to 9-40 years, and in 1764 to 4-40. In 1788 the age group was again 14-36 years and serfdom was finally abolished in 1800. Danes were not unused to serfdom, however, since another type of bondage system, “vornedskab”, had been introduced to part of the country at the end of the fifteenth century, and was only abolished around 1700.

The intensity of the work of employees in agriculture, unlike in the construction industry, became greater during the eighteenth century as herds and milk yields increased considerably. A dramatic transformation of agriculture underpinned by a whole package of reforms entailed extra work which was not as seasonal as had previously been the case, such as digging ditches to drain water from the land, removing stones from fields and building fences between them.[3] As noted by Esther Boserup (1965), these types of activities, associated with growth in agriculture, led to a rise in the need for labor and a decreasing yield of labor hours, which are both factors that would lead to an increase in the working week.

The literature presents some scattered information regarding the length of the working day from the middle of the eighteenth century. In 1771, the villeinage ordinance stated that villeins were compelled to follow the following program: from November to February they needed to start working at 8am, have an hour’s break at noon and leave at 4pm; for March, April, September, and October they should work from 7am to 6pm, with two hours of rest; and for May to August they had to work from 6am until 7pm, again with a two hour break. In the 1790s these hours were lengthened even more. On some manors, for example at Gerdrup-Lyngbygård Manor on the island of Zealand, Glomstrup Manor on the island of Mors, and Boddum Bisgård in Jutland, the agreement was that during the winter, villeins had to work from sunrise until sunset while in the summer, from 5am to 6 or 7pm. Moreover, from September to April, they were not permitted breaks during the day. Thus, during the summer the working day was between 12 and 14 hours while during the winter the working day lasted throughout the daylight hours, which are a little over seven hours on the shortest day of the year (Archives of Gerdrudp-Lyngbygård, Glomstrup, and Boddum Bisgård manors, in Kjærgaard 1994). This development was aptly summarized by a Swiss preacher after a visit to Denmark at the end of the eighteenth century: “Everybody works in the fields and on the roads. You will see no maid or

[3] Stated in Kjærgaard (1994) based on the archives of Gjorslev Manor. See also Lampe and Sharp (2018).

farmer's wife who is not knitting. Even when carrying something on their heads they continue to work as they talk" (Bobe 1898, p.16 and Kjærgard 1994). A similar opinion was stated by two Danish officials who visited Jutland in 1799: "One finds the immigrants, especially the Germans, at their work by 3 o'clock in the morning and continuing until past 10 o'clock at night, without devoting time to sleep or rest" (Windfeld Lund 1975, p.59 and Kjærgaard 1994). Of course, such observations should be taken with a pinch of salt, but with our data we can provide more solid statistical evidence on this.

4. Data and Methodology

As discussed above, a lack of economic data on days worked per year has been a barrier to assessing important questions from economic history, such as the idea of an industrious revolution. Occasionally, however, a new source of data turns up which allows for direct assessments on the length of the working year or seasonality patterns. This paper utilizes one such resource which is unique to Denmark, discussed and standardized by Jensen et al (2019a) and based on data collected by the Danish Price History Project.[4] It consists of 331,614 workdays and 21,557 observations on wages for 17 different manors and two households in the Kingdom of Denmark for the eighteenth century. The wage rates are available for various occupations for employees paid every year or every six months, and for those who worked by the day. The number of days worked, the year in which the workers were paid as well as information about whether payment was made in kind are listed. The name of the workers and their residence are also recorded for some of the manors, and it is also possible to observe the season during which the work was completed.

From the perspective of this study, one of the most useful and valuable details is that for some of the records - besides the number of days worked - the length of employment was mentioned with the month and day in which they started and finished working. This was available for 436 of our records and allows us to calculate how many days per week the individual worked. These datapoints are from 13 of the manors, spread across the three regions of Denmark and cover most of the century for a range of occupations in the unskilled, low skilled and medium skilled HISCLASS[5] categories such as farm workers, craftsmen and laborers,

[4] In 1929, the historian Peter Munch established the Danish Institute of Political and Economic Research with the aim of focusing on the economic and social development in Denmark before the nineteenth century. Over time, many historians and social scientists joined the research work, and in 1939 a more detailed study on the Danish wages and prices was commenced, covering the period 1660-1800. Unlike the other price history projects, which had records from long-lived organisations such as hospitals and charitable institutions, the data for Denmark were collected from material from the Danish government, the royal court and its property, the army, firms, churches, and from local and private archives. The data we use comes from manorial accounts.

[5] HISCLASS refers to historical international social class scheme. The HISCO system was developed by Van Leeuwen et al (2002) to facilitate research comparisons between historical occupations activities. Then HISCLASS was developed by van Leeuwen and Maas (2011) to further frame them into fewer categories. The Dictionary of Occupational Titles (DOT) system was used to assess each occupation and to put it into one of the following four levels of skills: unskilled, lower-skilled, medium-skilled and higher-skilled according to the competencies required for an average worker

and domestic servants. While most of these records are for men, some also give evidence for women and children. Thus, although the total number is reduced compared to the whole data set, the fact that this subset is so diverse should provide a representative estimate of how much people worked while under employment.

Another crucial aspect offered by the data is the workers' first and last names, which can be used to calculate how long a person worked at a manor on average. Thus, we consider that two records belong to the same employee if the same names appeared in the same manor and were performing similar jobs. From the whole dataset, including both full time and casual workers, the average number of years a person could be tracked was 1.8 and the average total number of days worked was 133. For the rest of the workers that could be tracked over a long period, the time between the first and last entry varied between 10 and 30 years. Grouping the observations in this particular way may give rise to concerns about the division not being restrictive enough, but this is the best method we currently have in the sense that the observations are traced in intervals short enough that we can be pretty sure they are the same individuals. These include both day laborers but also craftsmen such as carpenters and roofers. The longest length between the first and last record of a full-time worker was 35 years for a gamekeeper working on the Løvenborg manor.

Women and children are also represented in the data set, with more than 2,000 and 1,400 observations respectively along with the number of days they worked, but unfortunately, the length of their employment is only available for 15 observations in the case of women and none for children. Nevertheless, based on the number of days worked, some conclusions can be drawn.

Since we have observations on both annual and casual workers, we can apply the methodology first suggested by Humphries and Weisdorf (2017) to calculate the number of working days per year. That is, we can assume that the casual and annual workers worked roughly the same amount of time. Based on this, it is possible to calculate the number of days necessary for a day worker to obtain the salary received by an annual employee (work days = annual wage / day wage). To circumvent the issue that the annual worker could have enjoyed food and lodging from the manor, we follow Humphries and Weisdorf by adding Allen's (2009) subsistence basket to their earnings. The subsistence basket represents the value of goods necessary to support two adults and two children at a subsistence level.

We thus proceed as follows. First, we divide the data into those who were employed on an annual basis and casual workers and show how the number of days worked per entry (i.e. when it this is specified for the individual) varied over the eighteenth century for casual workers, divided into HISCLASS categories, and for men, women and children (Section 5.1). Second, in order to provide more information on days worked than specified in the data, we link individuals, again dividing by those who are employed on an annual and on a casual basis. This allows us to investigate the evolution of days worked per individual casual worker (5.2). Third, we use the length of employment and number of days worked per year to investigate the length of the working week (5.3). Fourth, we investigate seasonality by calculating the number of days worked per month for the casual workers, dividing by sector. We furthermore compare the number of days worked per week to the month in which the work was performed (5.4). Fifth, using the data on seasonality and data on

days worked per week under full employment we estimate the number of days worked per year for casual workers. We also check whether there is a relationship between the number of days worked per month and the wages paid (5.5). In a final step, we also use the methods proposed by Allen and Weisdorf (2011) and Humphries and Weisdorf (2017) to assess the length of the working year (5.6).

5. Results

5.1 Days worked per employment entry

We begin by analyzing the number of days worked by casual workers. As mentioned above, our dataset has observations on the period of employment, the number of days worked, wages, prices along with other relevant information from seventeen different manors and two households, collected by the Danish Price History Project (for a more detailed classification, Table A1 in the appendix shows the percentage of days worked by each manor for every year). To get an idea of how the length of the working time varied over the century, the average number of days worked per entry for each year in the dataset is plotted by HISCLASS category in Figure 1. Each entry in the dataset is associated with a number of days worked, the length of employment, names of the workers and so on (examples of entries are offered in Table A2 in the appendix). Individual casual workers can have several entries and by using this as our measure, we avoid making assumptions on how to link individuals. Below, we consider how the analysis changes when we use days worked per unique individual and find that our basic conclusions are similar.

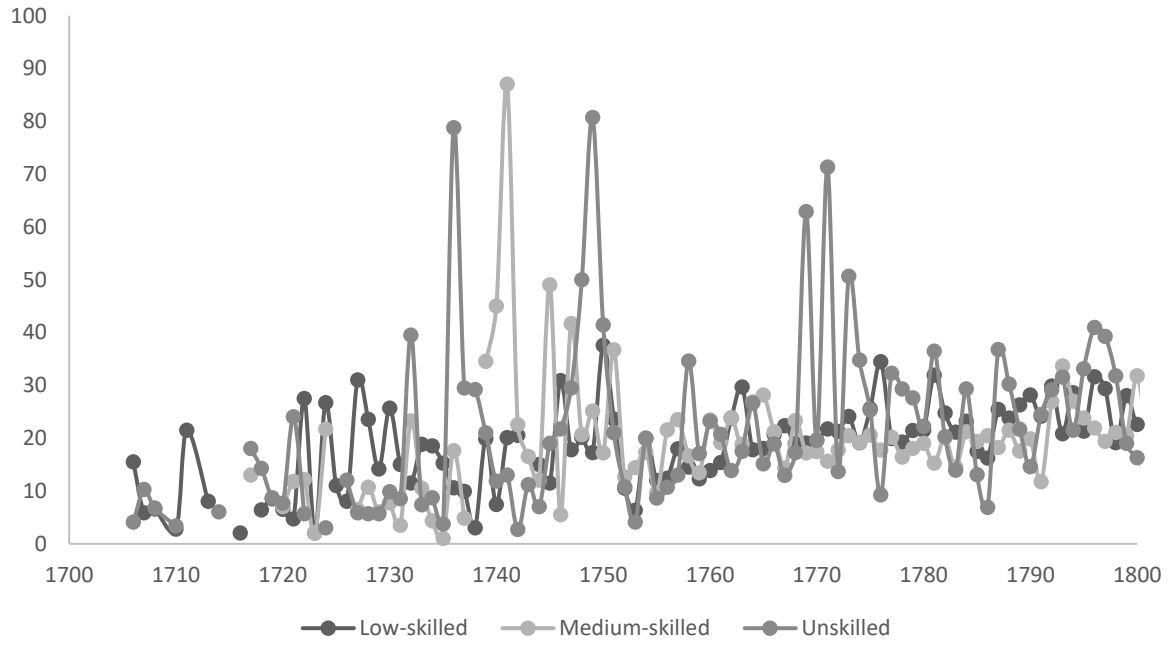

Figure 1. Average number of days worked per entry by HISCLASS category

It should be noted that the high skilled category is missing from Figure 1 because not many observations of high skilled workers were available on a casual basis, since this type of worker tended to be employed on an annual basis. From the graph, it is quite clear that there were no significant differences in the number of days worked per observation on employment length by skill level. Additionally, a constant increase in the average number of days worked is observed, from values approaching 10 days per employment period to values close to 30 days at the end of the century, suggesting that all types of workers tended to work more in 1800 than before. We obtain similar figures when we consider male workers alone.

It is also interesting to consider the information we have on women and children, see Figure 2. We observe an increasing trend in the length of employment that was also visible for men. Additionally, although the earlier observations show that women and children worked less from the middle of the century, women and children worked on average the same number of days as men. It should also be noted that we have more observations in the later period, which seems to imply that men, women and children were working approximatively the same number of days per entry.

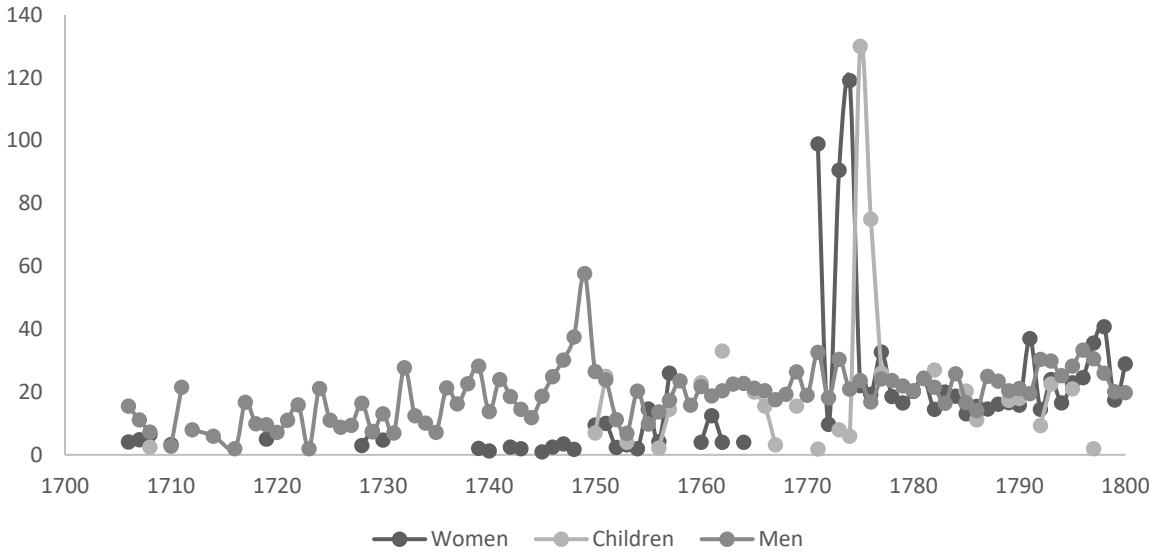

Figure 2. Average number of days worked per entry for women, children and men

Note: an outlier from 1769 for women was removed from the graph since the value for that year was very high (231.9).

It is also important to consider the total number of days worked on the manors, as well as the average and median period of employment against the wage levels, as presented in Figure 3. Thus, for each wage grouped in intervals 0-4, 4-8, 8-12 and so on, we can see the total numbers of days worked on the manors. For example, for the wage rates in the interval 8-12 the total number of days were more than 60,000. We can also observe that by far the most common occupation was paying around 16 *skilling* per day (one *skilling* was 1/96 of a *rigsdaler*, the currency of the time (Andersen and Pedersen 2004)). This is not surprising since

it is a rate frequently observed for day laborers and assistants, which are some of the most common categories in our dataset, being present in both the agricultural and construction sectors. The right axis represents the average days worked per entry which shows whether individuals were paid more or less if they worked more or less time. The average employment period was around 20 days. We note that the graph does not show any clear tendency of longer employment periods for more highly paid employees, most likely because the best paid employees were usually employed on a full-time basis.

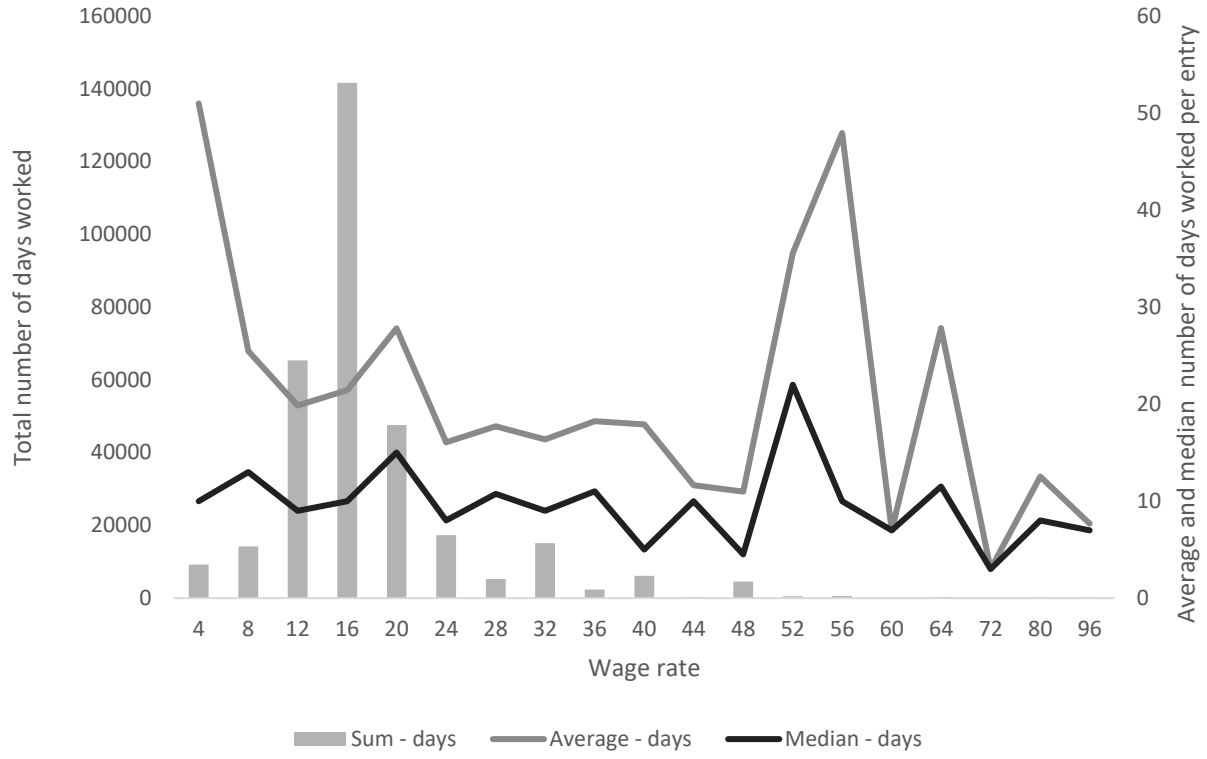

Figure 3. Total number of days worked on the manors, average and median days worked per entry against the wage rate

5.2 Days worked per unique individual

In order to provide more information on days worked, we next link individuals between separate entries as described above. Thus, observations were grouped as belonging to the same individual if they were from the same manor and had the same job title and name. Based on this assumption, Figure 4 plots how many unique individuals were observed each year split by annual workers and casual workers

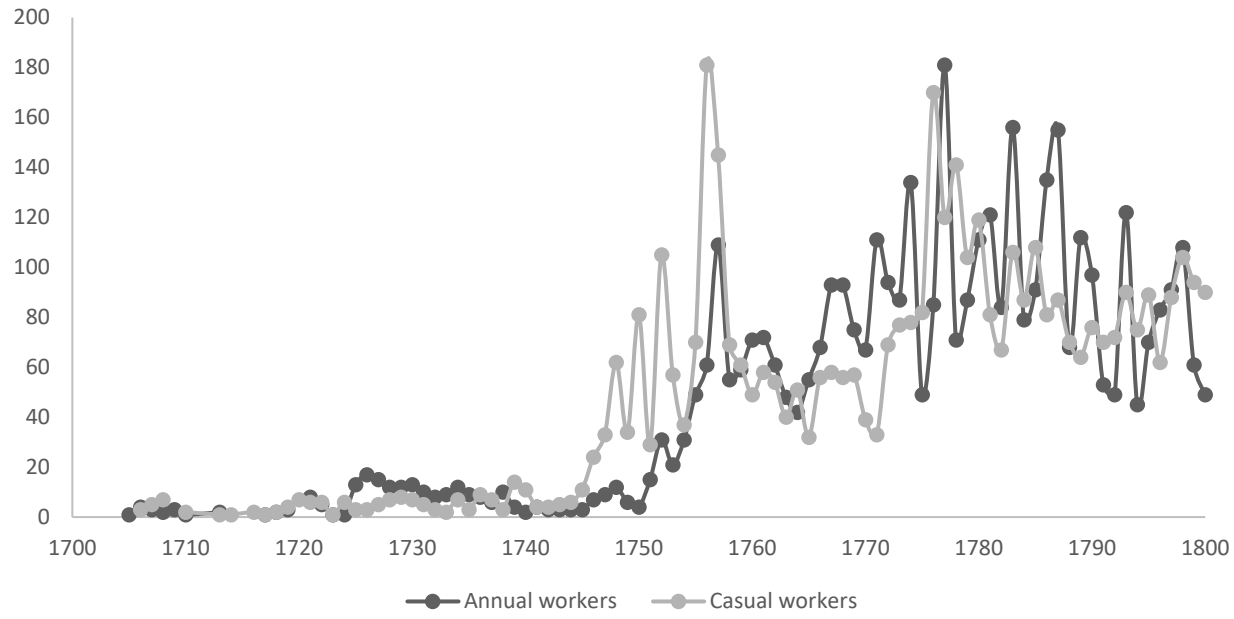

Figure 4. The number of unique individuals observed for each year for casual workers (workers paid by the day) and annual workers (workers who were paid by the year or every six months)

This shows that, although the total number of individuals observed changes throughout the century, the number of full-time workers is approximatively equal to that of casual workers. However, the average casual worker worked around 20 days per observation of employment length while full time workers were on the job for the whole year (only receiving pay twice a year - in spring and autumn). This implies that, besides serfs, most of the labor used by manors was coming from full time (or annual) workers. Our study focuses however on the casual workers because our data source only mentions the number of days worked for these, while for the annual employees it gives only how many months they were employed.

In the appendix, we have computed the number of working days per unique individual per year. This measure is noisier, but largely shows similar patterns to Figures 1 to 3 with days worked per unique individual tending to increase over time, see Figures A1 to A3. To further illustrate the results, we estimated the time trends for male casual workers using both the per entry and per individual measures. Both are positive and strongly significant. Moreover, the two measures are positively correlated with a correlation coefficient of about 0.78, which is also statistically significant. Work days per individual were 25-26 days on average in the beginning of the eighteenth century and had reached 63 by the end. When interpreting the levels of the work days per entry or individual, we note that we use all available observations including those with only one paid work day. We therefore stress that one should consider the changes and not interpret the level as all days worked by the individuals included.

Further, to find out how long a person worked per year at a manor, we use the names of the employees to figure out how long each person worked. We calculated for each person how much he/she

worked every year, for example, if that person worked five years we have five different observations. In figure A4 in the appendix we construct a histogram of the number of days worked per year with an interval size of 20 days per year.

5.3 Average number of days worked per week

To estimate how much a person typically worked per week, we take a new approach: for some of our observations, both the duration of employment as well as the number of days worked by the person are provided. More specifically, one measure shows the difference between the starting and the end dates of the employment (the day and month a person started to be employed, and the day and the month the employment finished) and the other is a measure of how many days the person actually worked during this period of employment. This enables us to get an idea about the number of days worked per week by a person while employed. In some cases, the number of days worked exceeded the length of the period mentioned. This was usually when two or more people worked on the same task and were paid together, and these observations are therefore excluded (115 observations excluded out of 436 observations). The remaining 321 observations are plotted in Figure 5, where the number of paid days worked by an employee is presented against the length of the period in which the work was conducted.

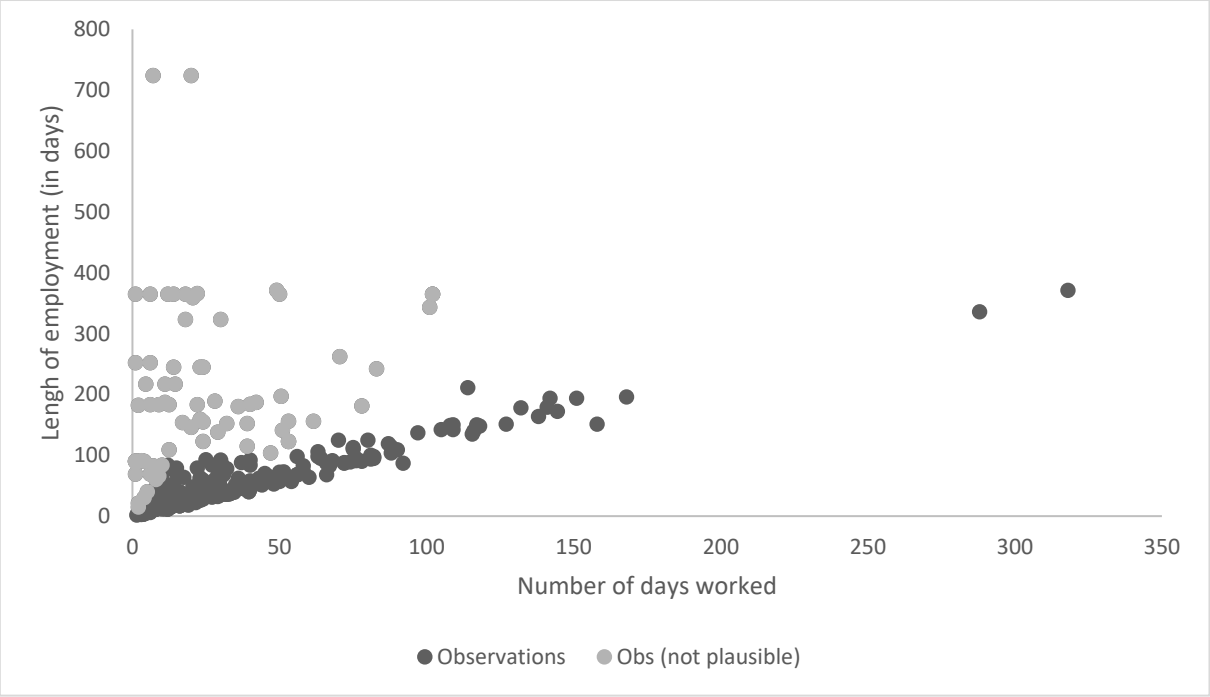

Figure 5. Number of days that workers actually worked against the length of their employment

Generally, a positive relationship can be observed, with a few exceptions. Many of these exceptions are cases when the length of the employment period is significantly longer than the number of days actually

worked (in most cases less than 20 days worked over 1 or 2 years), and they were therefore excluded from the next steps in this study leaving us with 250 observations.

The average number of days worked per week for each of the observations is then calculated by dividing the number of days worked by the length of the employment period and multiplying by seven. In Figure 6 we show the total number of observations by four categories, based on the total number of days paid, and the number of days worked per week.

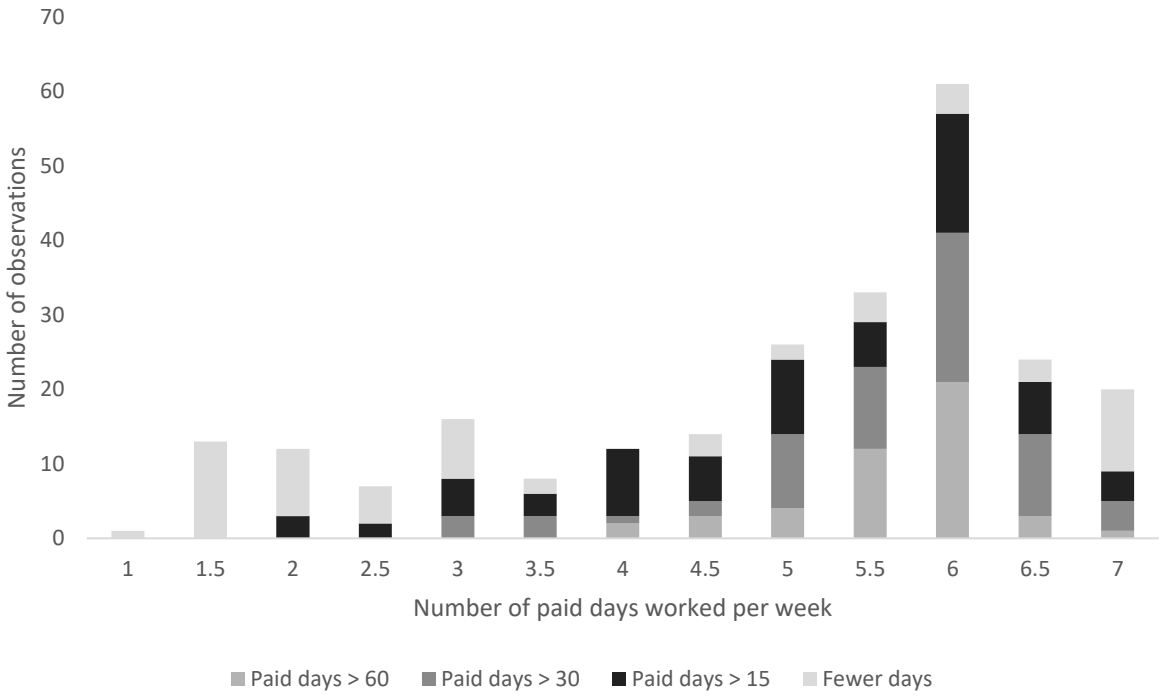

Figure 6. Number of paid days worked per week

Those who worked less than 15 days did not work a regular number of days per week. However, for the employees who worked more than 15 days, it is apparent that most worked around 5-6 days per week. To get a better picture, we plot the median and the average number of days worked per week in Figure 7 for each category.

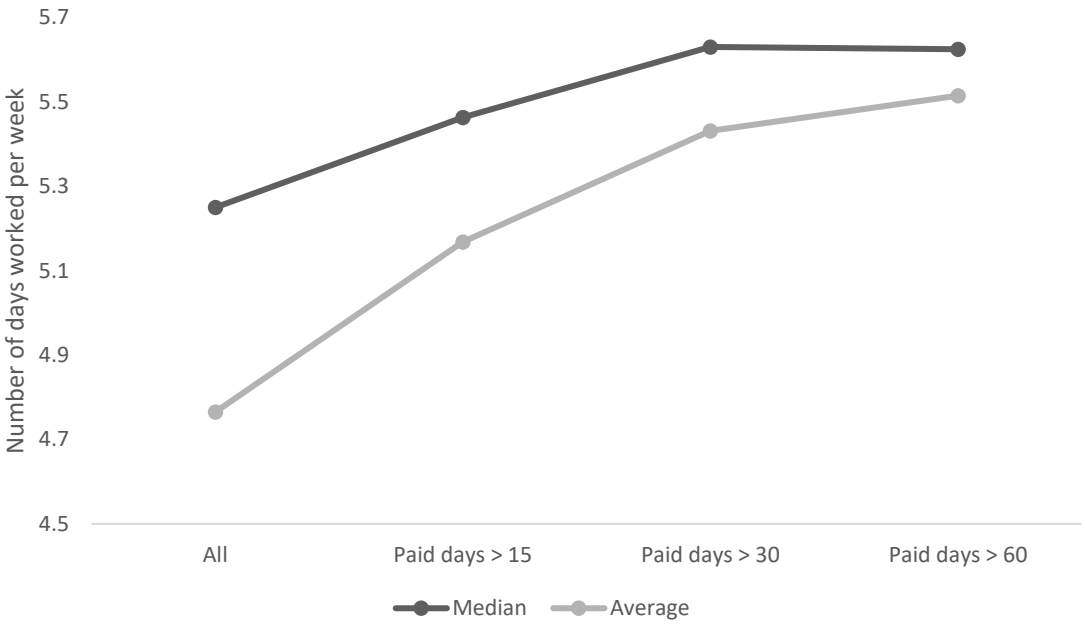

Figure 7. The median and the average number of days worked per week

The median and the average number of days worked per week converge towards a value of 5.6 days per week, which is close to the value of 5.9 days per week which has been suggested in previous work (Kjærgaard 1994) as the number of days that a villein had to work. We can thus conclude that a person under full employment worked close to 5.6 days per week.

We can also investigate how the picture looks for different industries and to show the number of days worked per week per sector (Figure A5 in the appendix). A distribution of the number of days worked per week by skill level can also be constructed (Figure A6). Finally, the number of days worked per week against the wage rates is also plotted (Figure A7).

5.4 Seasonality patterns and the length of the working year

Figure 8 shows the total number of days paid in each month by sector, revealing strong seasonality of employment on the manors.

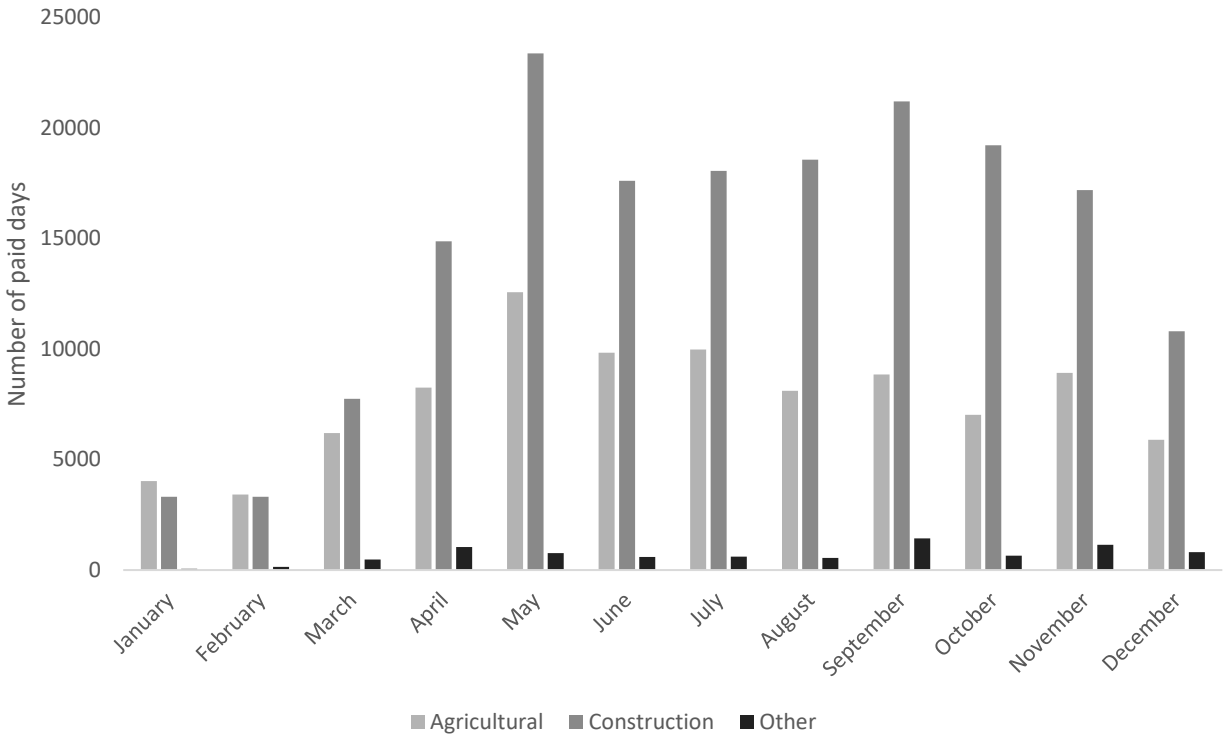

Figure 8. Number of paid days by month and by sectors: agriculture, construction and other sectors

We note that the most strongly represented sectors in our data, by number of days worked, are construction and agriculture. Both sectors show that most of the casual workers employed by the manors worked during summer and early fall. The difference is striking, as for example, in the construction sector in February there were 5-6 times fewer people employed than in May. The differences are not as large for the agricultural sector but still compelling. Finally, the "other" category, which covers all other occupations, such as, for example, administration, housekeeping and cooking, also displays some seasonality, probably because, with fewer people working on the manor, there was less need for these activities. To check whether the seasonality pattern presented in Figure 8 is valid, in Figure A8 in the appendix we plot the number of paid days for each month in a five year span for two manors, Frederiksgave and Tåsinge. It is again noticeable that most of the work done by casual workers was during the summer, with significantly fewer days worked registered in the winter months, although there is some heterogeneity between manors.

Furthermore, the number of days worked per week is plotted against the month in which the work was conducted in Figure 9. It is again noticeable that most employment length observations took place during the summer months, but there is no apparent variation in the length of the working week based on the month.

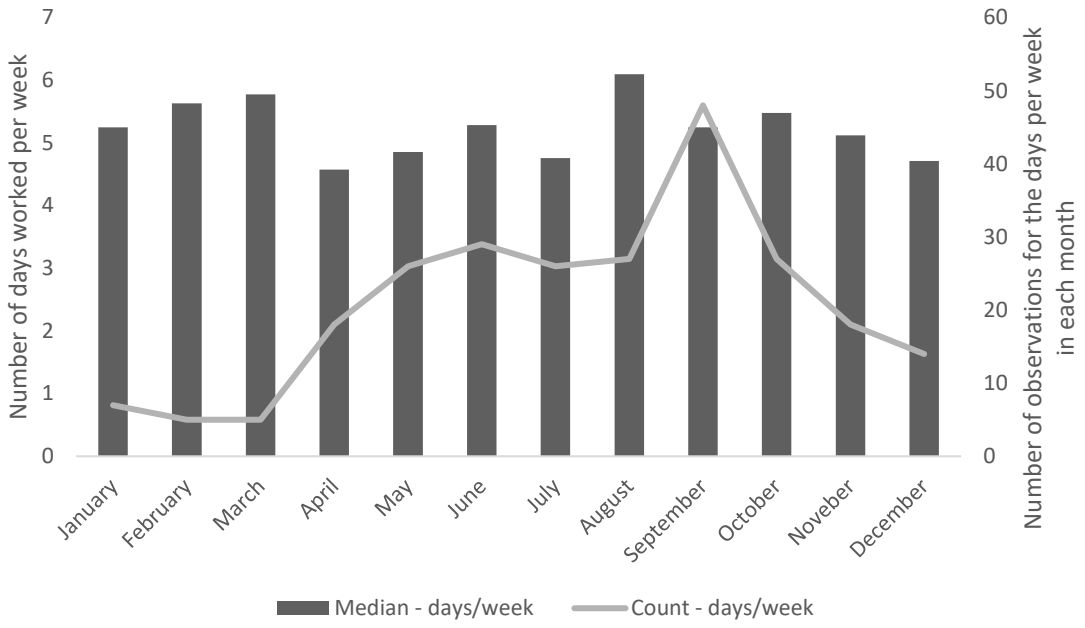

Figure 9. The number of days worked per week against the month in which the work was conducted

In light of the seasonality pattern shown above, we show in Figure A9 in the appendix how much casual workers earned during summer and winter, and the pattern is similar for both unskilled and medium skilled workers. It appears that unskilled casual workers earned slightly lower wages in the winter than in the summer, while the difference between summer and winter wages for medium skilled workers was slightly larger. This implies that the length of the working day did have a small effect on the daily wage rate. On the other hand, the difference in the numbers of days worked in summer and winter would have had a much more significant effect on a family's income.

5.5 Working days per year

Bringing all the above together, we can estimate how long a casual worker worked during a year. With a working week of 5.6 days, if a casual worker would be employed for a full year, he would work 292 days per year. However, the strong seasonality of the available jobs meant that he or she was unlikely to find work during the winter months. We therefore assume that the number of working days a casual employee was likely to work during each month is proportional to the number of days worked paid by the manors (Figure 2), and that for the month of May, which has the peak values, the worker enjoyed full employment. This means that a worker was likely to have 5.6 days per week in May and 1.02 working days per week in February. Figure 10 presents how many days per month a person would work, if the pattern of employment would follow the seasonality pattern. Summing this, we get a value of 184,02 working days per year for casual employees.

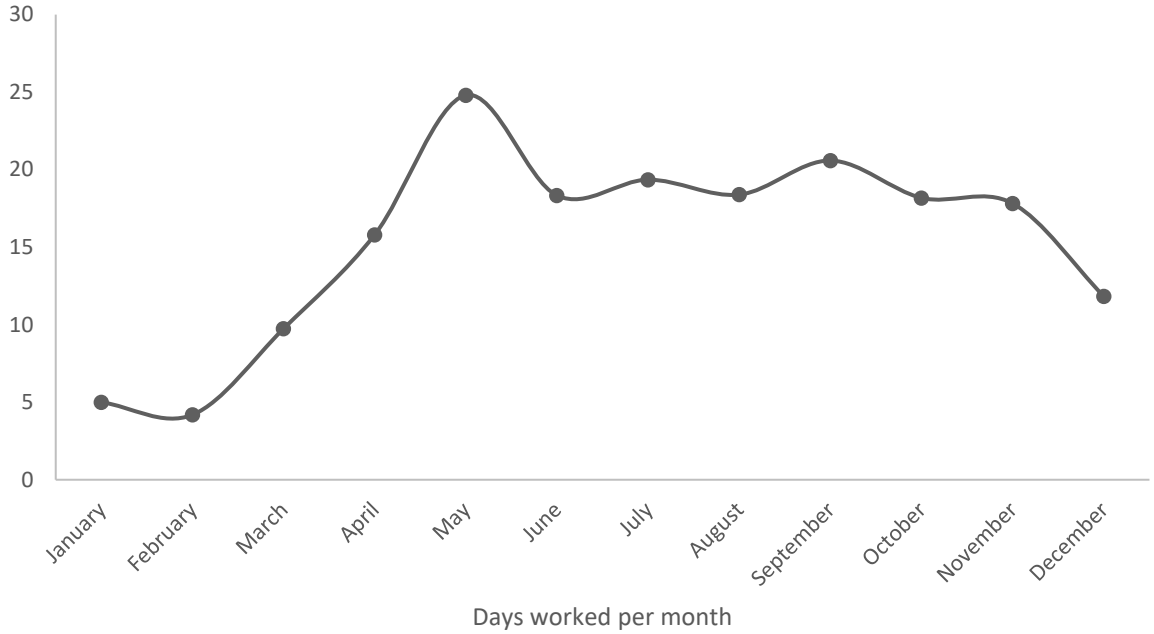

Figure 10. The expected number of days per month worked by a person

The final and most important result in this study is the estimate of how many days people worked per year by decade to get an idea of how this number changes over time. Using the same methodology as above, we calculate the days worked per week under full employment and the number of days worked per month by decade, starting with 1730 (the first decade were the data on working days is available). Then the data is used to compile the number of days worked per decade which is presented in Figure 11.

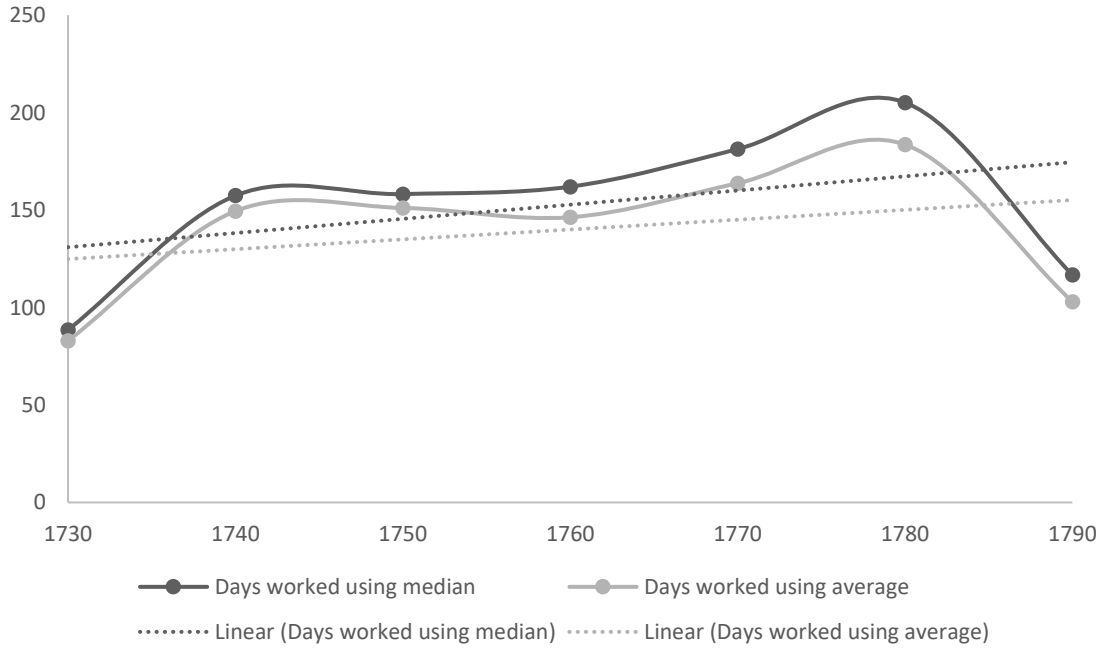

Figure 11. The evolution of the working days per decade

The graph paints a picture of an increasing trend in the working days through the period, although a decrease is seen for 1790. The number of observations at the beginning and at the end of the period are the fewest, especially for the days worked per week, thus being one of the explanations for the lower values for the 1730s and 1790s which therefore should be taken with a grain of salt. It can also be added that the 1790s were a period that saw the French Revolutionary Wars so there might be reasons to suspect that economic conditions were unfavorable. The gradual abolition of serfdom might also have induced a reduction in the amount of free labor available to the manors. This could have incentivized them to use less labor, by for example, delaying maintenance or construction projects. Another fact that can be noted is that the working year also reaches a first peak in the 1740s, at the height of the agricultural crisis, when problems such as the cattle plague and sand dunes required increased labor, and manors were trapped between high nominal wages and low grain prices on the export market. It is just after this point that serfdom was introduced in Denmark, providing manors with a supply of free labor (Jensen et al 2018). All in all, the trend is increasing, but the actual number of days worked suggests that the working days in the past were fewer than what it is assumed in the standard 250 days wage calculation. The result is also in line with what has been found for London (180 days per year) and Malmö (150 days).

5.6 Indirect estimates of the length of the working year

Finally, we can compare our results to those obtained using the well-known methodologies of Allen and Weisdorf (2011) and Humphries and Weisdorf (2017). In the former, the number of days a casual worker needed to work in order to earn a subsistence basket are computed as follows: days worked per year = annual price of the basket / day wage. Table A3 illustrates Allen's subsistence basket of products, without the new or the more luxurious items such as for example clocks, tea, coffee and so on. These quantities are consumed per year by an adult male and are multiplied by 3.25 in the analysis, with the assumption being that a household consisted of two adults and 2.5 children, who consumed half that of the adults.

The results are illustrated in Figure 12, and are similar to the picture presented for rural laborers in England during the eighteenth century (Allen and Weisdorf 2011). Over the course of the century, the number of days a low-skilled or unskilled worker had to work to earn a subsistence basket increased from around 200 days per year to around 300 days. A similar development is visible for medium skilled workers who required under 100 days of work to earn a subsistence basket at the beginning of the century and over 200 days by the end.

Following Allen and Weisdorf (2011), we might take this as an indication of an "industrious" revolution, but it is most likely that this happened out of necessity and not because of a consumer revolution in which they would have decided to work more to buy the more varied goods available on the market. Since we have demonstrated above that the labor market was extremely seasonal and thus that it was unlikely that a worker could find employment all year, unless he was an annual worker, this implies that the other

members of the family (women and children) also had to work to support the family. This result is also in line with the conclusion made by Kjærgaard (1994), who stressed economic necessity in his interpretation of the scattered existing evidence for Denmark.

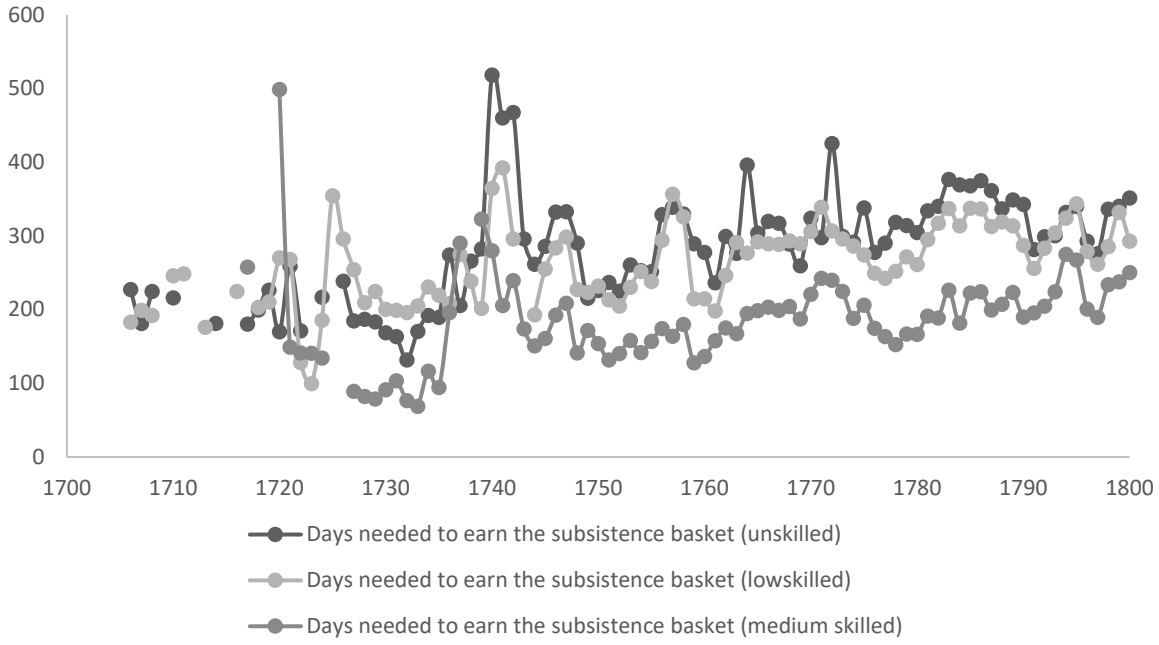

Figure 12. Number of days a casual worker needed to work in order to earn a subsistence basket

As another indirect way of estimating the number of working days, we follow Humphries and Weisdorf (2017) and make use of the wages received by annual workers and calculate the number of days a casual worker needed to work in order to earn the wage received by an annual worker, see Figure 13. To account for board and lodging that might have been received by the annual workers, we added Allen's substance basket to their nominal wages (again following Humphries and Weisdorf, 2017). We have also divided by HISCLASS, and took out the highest paid category, since there were fewer observations. Here, the upward trend is again visible, with the number of days required to earn a full-time employee's wage increasing from around 200-300 to 400 at the end of the century. This implies that a casual worker could not reach the same level of income as an annual employee, making this type of work very sought after. This also meant that the only way for a casual employee's family to reach the same level of income as a full-time worker's family would be if the women and children also worked. On the other hand, women and children in an annual worker's family likely also had to work in exchange for the room and board provided to them, which would make the difference between the two types of workers smaller than presented here.

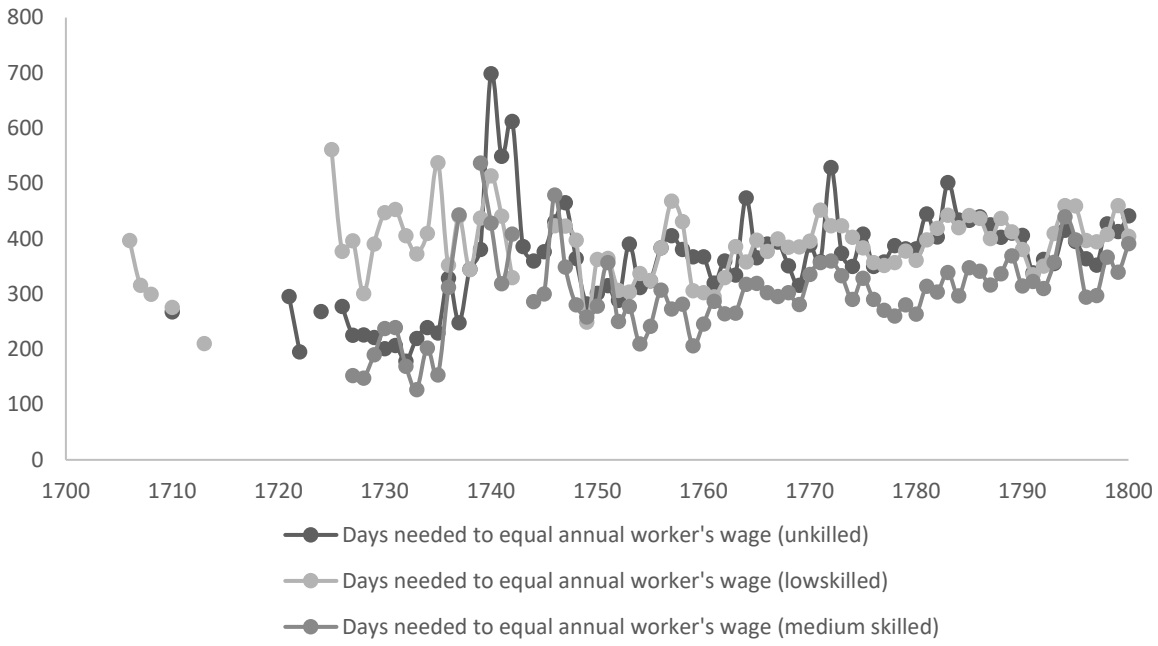

Figure 13. Number of days a casual worker needed work to earn the wage received by an annual worker

6. Conclusions

Using a rich micro level dataset, we have provided new estimates of the working week and year for casual workers for eighteenth century Denmark. These estimates are in line with the work of Kjærgaard (1994) who found close to 6 days for villeins for the 1770s. If employed for a full year, a casual worker would work 292 days per year. However, strong seasonality of the available work results in us calculating an average value of 184,02 working days per year, which is lower than the 250 days often assumed. We find that days worked per entry and per unique individual increased over the century. Moreover, the results based on observations of the length of the working year suggest that there was a modest increase in the days worked per year over the course of the eighteenth century. Finally, using Allen and Weisdorf's (2011) indirect approach, we find that lower skilled workers would have needed to increase their working days if they were to be able to afford a subsistence level of consumption. These findings are consistent with an industrious revolution driven by economic necessity rather than a consumer revolution.

Still, it should be kept in mind that the increase in working days could have taken place over centuries rather than within a century as we observe. We have cited various sources that suggest that the number of working days in a year increased as a consequence of the protestant reformation and that the working week also increased. Finally, it should also be kept in mind that we consider the rural economy and that this development may have been different in the more urban parts of Denmark. Thus, more work is needed to gain a fuller understanding of the long run evolution of the length of working year.

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Appendix

Table A1: Days worked per manor

Manor name	Year	Days worked	%
Bregentved	1748	80	0,7%
	1749	66	0,6%
	1750	6	0,1%
	1754	103	0,9%
	1755	13	0,1%
	1758	456	4,0%
	1760	318	2,8%
	1770	20	0,2%
	1780	12,5	0,1%
	1781	38,5	0,3%
	1782	113,5	1,0%
	Total	**1226,5**	**10,9%**
ErholmSondergade	1742	25	0,2%
	1743	41	0,4%
	1744	18	0,2%
	1745	62	0,6%
	1752	4	0,0%
	1753	12	0,1%
	1754	31	0,3%
	1755	148,5	1,3%
	1756	17,5	0,2%
	1758	11	0,1%
	1760	7	0,1%
	1764	83	0,7%
	1765	40	0,4%
	1766	45	0,4%
	1775	9	0,1%
	1776	96	0,9%
	1794	153	1,4%
	Total	**803**	**7,1%**
Frederiksgave	1780	66	0,6%
	1793	5	0,0%
	1794	86	0,8%
	1795	5	0,0%
	Total	**162**	**1,4%**
Frijsenborg	1778	31	0,3%
	1779	22	0,2%
	1780	27	0,2%
	1785	18	0,2%
	1786	14	0,1%
	Total	**112**	**1,0%**

Gauno	1771	105,43	0,9%
	1772	42,5	0,4%
	1773	38	0,3%
	1774	306,5	2,7%
	1782	119	1,1%
	1792	70,5	0,6%
	1793	80	0,7%
	1794	44	0,4%
	Total	**805,93**	**7,2%**
Giesegaard	1734	26	0,2%
	1736	53	0,5%
	1746	190	1,7%
	1747	736,5	6,5%
	1748	139	1,2%
	1761	64	0,6%
	1764	8,01	0,1%
	1773	182	1,6%
	1774	146	1,3%
	1775	49	0,4%
	1779	31	0,3%
	1780	34,5	0,3%
	1781	21,5	0,2%
	Total	**1680,51**	**14,9%**
Gisselfeld	1739	6	0,1%
	1740	5	0,0%
	Total	**11**	**0,1%**
Holsteinborg	1765	120	1,1%
	1768	132	1,2%
	1770	187	1,7%
	1772	50	0,4%
	1777	109	1,0%
	1787	11	0,1%
	1795	151	1,3%
	1796	55	0,5%
	1797	440	3,9%
	1798	90	0,8%
	1799	12	0,1%
	1801	61,5	0,5%
	Total	**1418,5**	**12,6%**
Lindenborg	1725	2	0,0%
	1762	226	2,0%
	1763	18	0,2%
	1764	8	0,1%
	1773	159	1,4%
	1774	109	1,0%
	1785	118	1,0%

	Total	**640**	**5,7%**
Lovenborg	1760	99	0,9%
	1761	201	1,8%
	1786	93	0,8%
	1787	61	0,5%
	Total	**454**	**4,0%**
SoroAkademi	1753	17	0,2%
	Total	**17**	**0,2%**
Stovringgard	1739	66	0,6%
	1772	27	0,2%
	1775	141	1,3%
	1776	23	0,2%
	1779	27,5	0,2%
	1780	20	0,2%
	1781	15	0,1%
	Total	**319,5**	**2,8%**
Taasinge	1747	112	1,0%
	1748	143	1,3%
	1749	141	1,3%
	1750	485,5	4,3%
	1751	363	3,2%
	1752	337	3,0%
	1756	26,5	0,2%
	1760	25,5	0,2%
	1761	85,5	0,8%
	1762	62	0,6%
	1766	13	0,1%
	1777	28	0,2%
	1780	32	0,3%
	1782	262	2,3%
	1784	250	2,2%
	1785	468,5	4,2%
	1786	138	1,2%
	1787	368,5	3,3%
	1788	50	0,4%
	1792	71	0,6%
	1793	125	1,1%
	1795	19	0,2%
	1799	15	0,1%
	Total	**3621**	**32,1%**
Total		**11270,94**	**100,0%**

Table A2: Examples of entries from the dataset

Manor name	Region	Year1	Gender	Type	Occupation in Danish	Occupation in English	HISCO code	Month	Wage rate	Number of days worked	Names	Start Day	Start Month	End Day	End Month
Giesegaard	Zealand	1734	male	temporary	plovdage	agricultural labourer	62105	5	8	26	Hans Mortensen	21	4	27	5
Erholm-Søndergaarde	Funen	1742	male	temporary	murer	bricklayer	95120	8	16	25	Rasmus Nielsen	1	5	2	8
Stovringgard	Jutland	1739	male	temporary	kalkslager	painter	93120	8	16	18	Lars Christensen	9	8	30	8
ErholmSondergade	Funen	1753	female	temporary	daglejer	day labourer	99920	4	4	4	Johanne Bødkers	9	4	18	4
ErholmSondergade	Funen	1755	female	temporary	daglejer/vask m.m.	day labourer	99920	9	4	10	Johanne Bødkers	17	8	22	9

Table A3: The contents of a subsistence basket as in Allen (2009)

	Subsistence
Bread	155 kg
Beans/peas	20 kg
Meat	5 kg
Butter	3 kg
Cheese	-
Eggs	-
Beer	-
Soap	1.3 kg
Cotton	3 m
Candles	1.3 kg
Lamp oil	1.3 l
Fuel	2 mbtu
Rent	5% of total

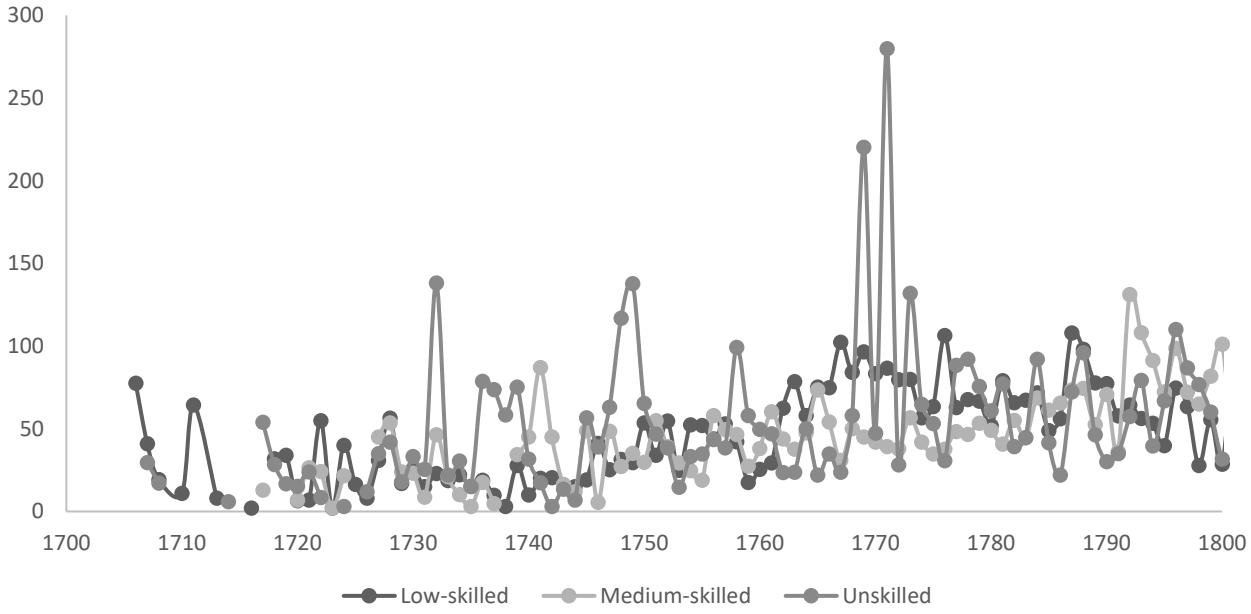

Figure A1. Average number of days worked per individual by HISCLASS category

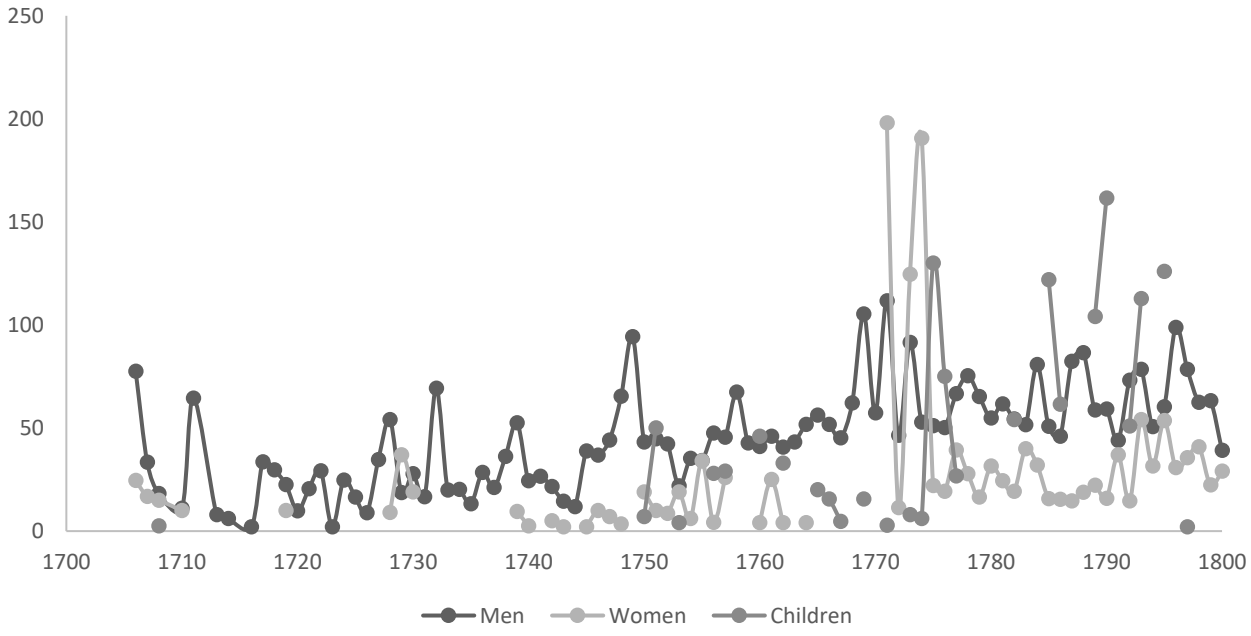

Figure A2. Average number of days worked per individual for women, children and men

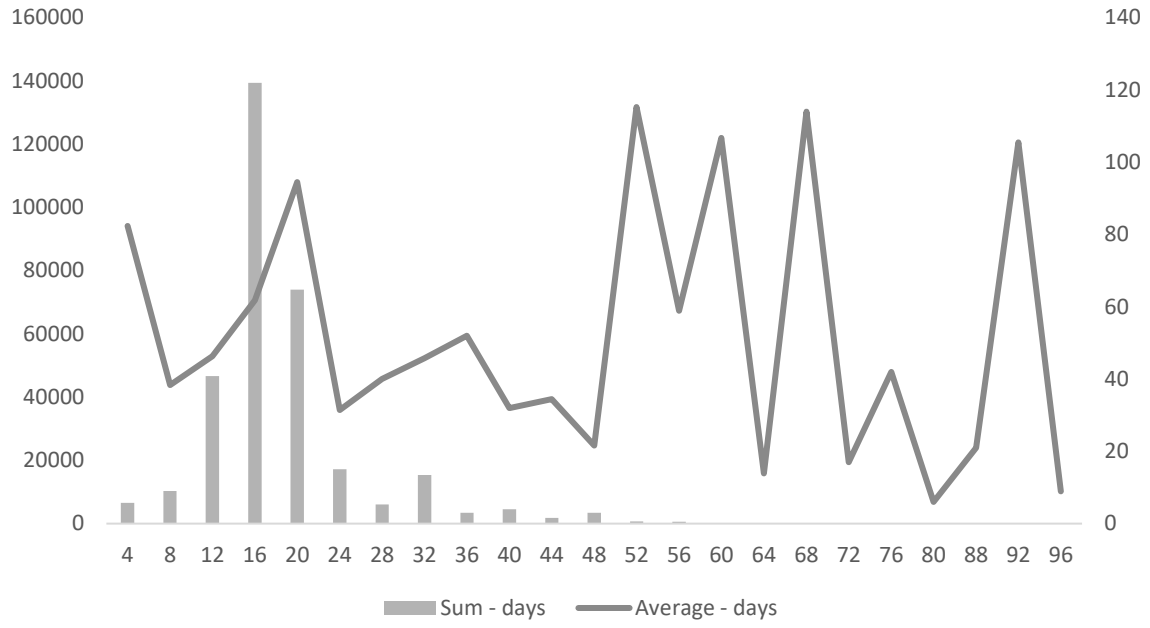

Figure A3. Total number of days worked on the manors, average days worked per individual against the wage rate

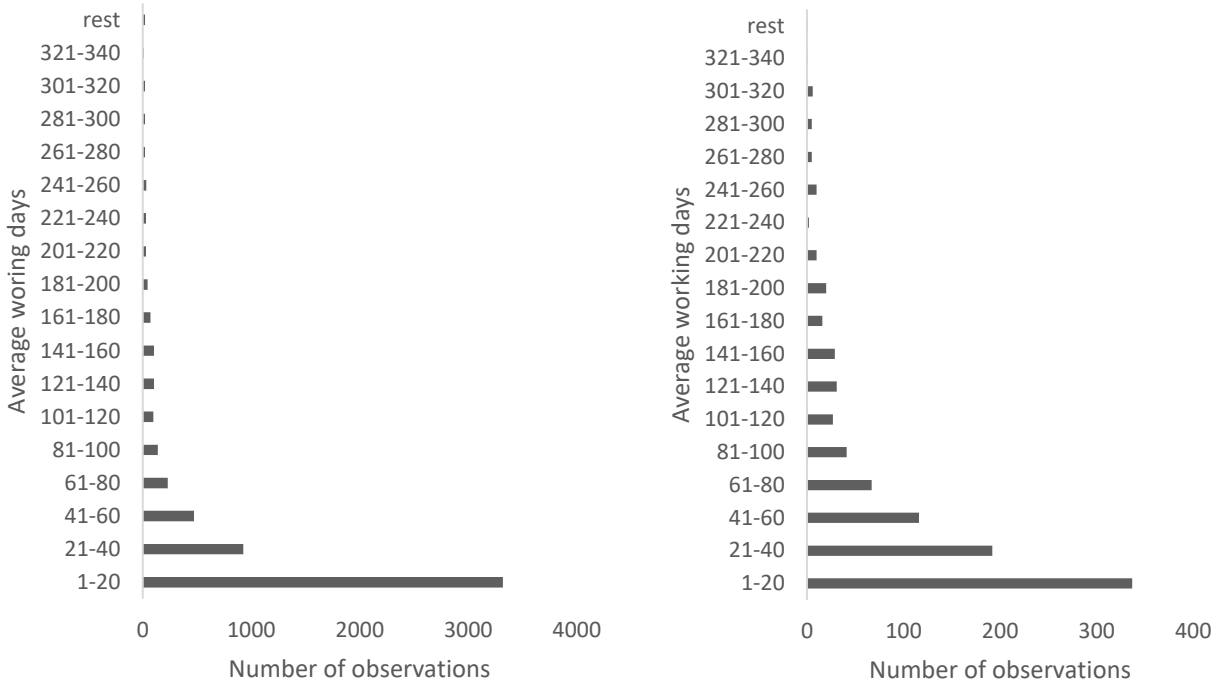

Figure A4. Average working days (left panel) and the number of days worked by persons who show up in at least two years, and at least twice a year in the records (right panel)

Note: Figure A4 constructs a histogram of the number of days worked per year with an interval size of 20 days per year. The result is plotted in the left panel of Figure A4. The graphs can be read as follows: the bottom line shows that we have over 3000 observations of people that worked between 1 and 20 days per year, the second to bottom line shows that we have close to 1000 observations of people that worked between 20 and 40 days per year, and so on. The distribution is strongly skewed to the right with most people working on average 20 or fewer days per year at the manor, making it difficult to extract meaningful information about the length of the working year. Thus, to obtain more information, we plotted the number of days worked by individuals who show up in at least two years, and at least twice a year in the records. The result is presented in the right panel of Figure A4. Again, the bottom line shows that we have over 300 observations of people working 20-40 days per year, the second to bottom line shows that we have close to 200 observations of people who worked between 20 and 40 days per year, and so on. This distribution is also strongly skewed to the right with most people working on average 20 or fewer days per year at the manor, motivating alternative approaches.

Figure A5: The number of days worked per week in the building, agriculture and other sectors

Note: Although the building sector has frequently been the subject of real wage studies, the agricultural sector is arguably the most relevant and important for this period of time. Hence, Figure A5 plots the number of days worked per week in the building, agriculture and other sectors. Most observations belong to the construction sector (e.g. carpenters, bricklayers, painters, joiners, glaziers, thatchers, stone splitters, laborers) and employees there worked most frequently six days per week. For those working in the agricultural sector (agricultural laborer, gardener, day laborer) the number of days worked per week varies considerably. This is however not surprising since those living from agriculture usually also had a small plot of land of their own to tend and thus did not need to work full time for the manor in order to support themselves. Finally, those working in other sectors, such as domestic servants, coopers, saddlers, and washerwomen, were at the high end of the number of days worked per week, but not enough observations are available to draw a clear conclusion.

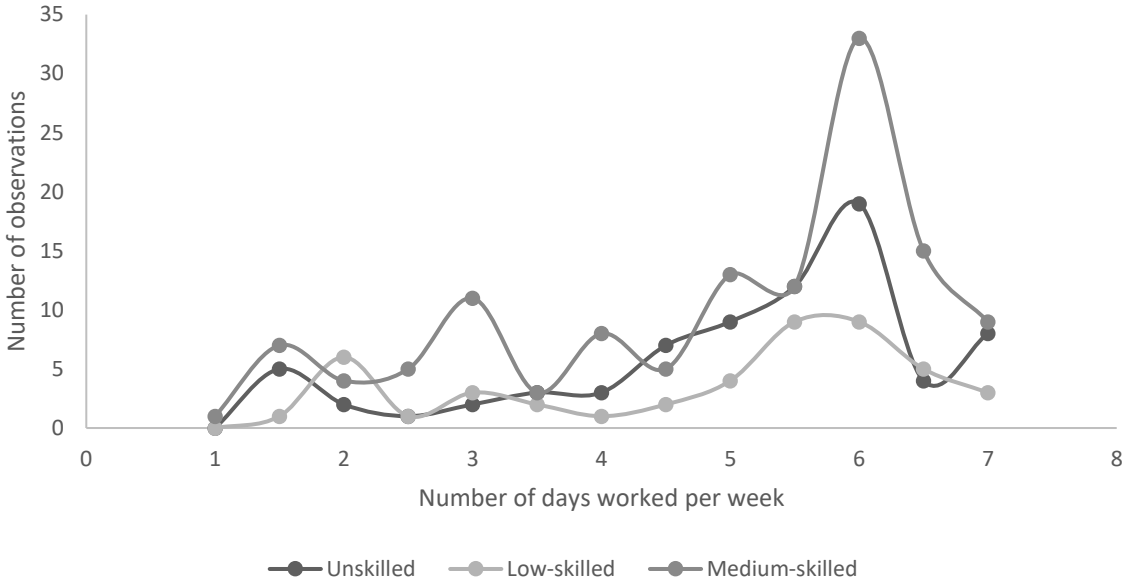

Figure A6. Number of days worked per week by skill level

Note: A distribution of the number of days worked per week by skill level can also be constructed in Figure A6. Medium skilled workers (like craftsmen) tended to be the best represented in our data set. The majority of people worked around six days a week according to Figure A6. Otherwise, low skilled workers are not as well represented, and while most worked around 5-6 days per week, a significant proportion had fewer days per week (probably again because this category includes agricultural workers with their own land to tend to).

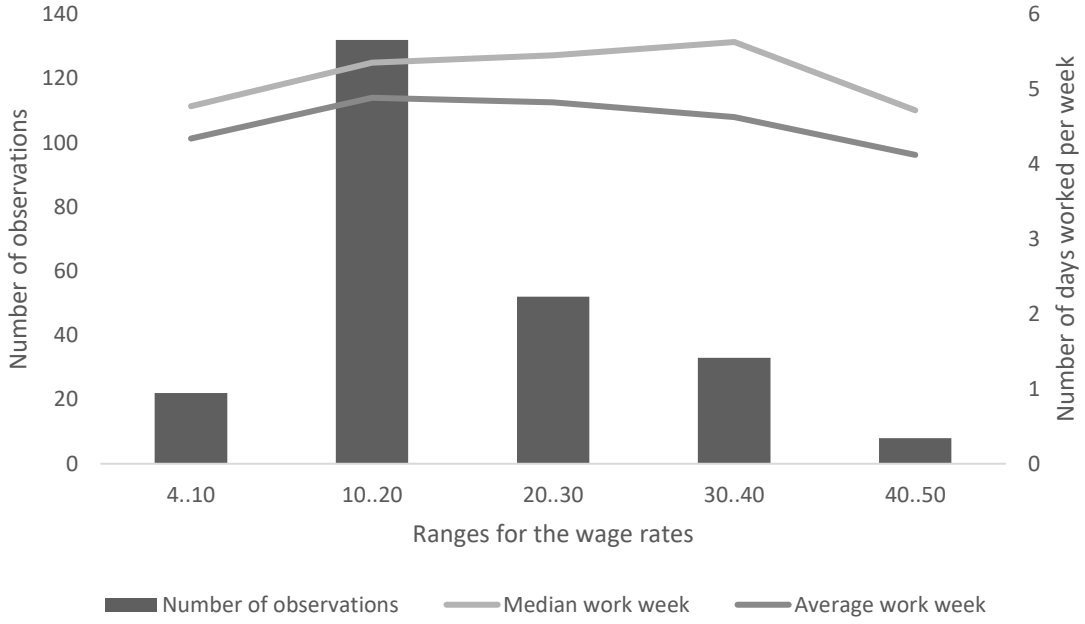

Figure A7: Median work week, average work week, and representative wage rates

Note: The number of days worked per week is plotted next, in Figure A7, against the wage rates. The left axis represents the number of observations while the horizontal axis represents the wage rate ranges. We decided to split the ranges as the following: 4-10; 10-20; 20-30; 30-40 and 40-50 (measured in *skillings*). As can be noted from the figure, most observations lie in the range of 10 - 20 *skilling* per day, which is in line with the fact that most employees earned around 16 *skilling* per day. The axis in the right represents the number of days worked per week, and as in the case of the larger dataset, there seems to be no clear relationship between salary and length of the working week (as suggested by the median and average work week)

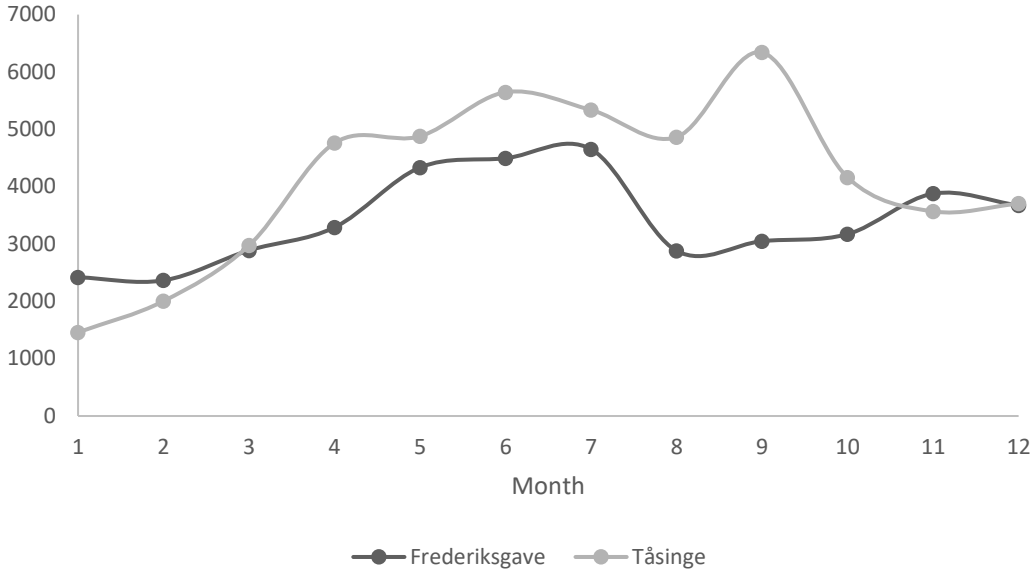

Figure A8: Number of work days by month for the manors Frederiksgave and Tåsinge

Note: Even if all the manors in our dataset have this information available, they were chosen because they offered the most complete five-year datasets with observations for nearly every month.

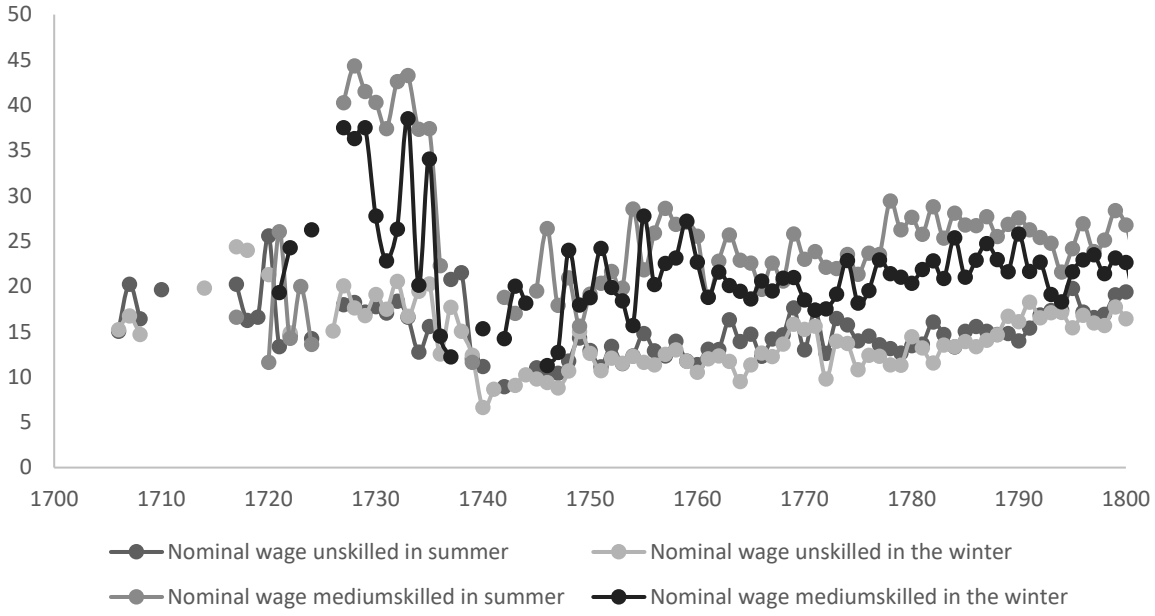

Figure A9: Nominal wage rate in winter and summer by unskilled and medium-skilled workers

Note: We perform OLS regressions to get a representative value for the wage rate in each year, for the unskilled and medium skilled workers, leaving low skilled and high skilled out from the HISCLASS classification. We choose to show the nominal wages instead of the real wages, since the latter would imply calculating the consumer price during both the summer and winter seasons. Although it would be possible to calculate such indices, new assumptions about the price of heating or food and other winter or summer specific characteristics would be required. Thus, we apply the regressions by controlling for occupations, the number of days worked, year, period of time in which they worked, gender, adult/children, and regions. The series are shown in Figure A9.

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