The part-time penalty: Evidence from Denmark

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Abstract

We study the part-time penalty. Using Danish register data, the Danish Labor Force Survey, and hospital personnel records, we show that the pay gap between part-time and full-time workers is sizable and increases over the career because the two groups accumulate different levels of human capital over time. Our best estimates of the part-time penalty are for nurses. The penalty is 9-14 percent at the beginning of the career and increases by 0.5 percent each year. This pay gap is closely related to the development of nurses' competence level, highlighting the persistent effects that part-time work has on lifetime earnings.

Introduction

When employees work part-time, their earnings are lower. Is this so-called 'part-time penalty' merely a result of shorter work hours, or do shorter work hours also affect wages? If time spent on the job is unimportant for wages, the part-time penalty will remain constant over employees' careers, as pay is proportional to hours worked. However, if workers learn on the job, full-time workers will accumulate more human capital over time than part-time workers, and their productivity and wages will grow faster (Blank, 1990; Hirsch, 2005; Paul, 2016). Consequently, the part-time penalty will increase with time. Moreover, part-time workers cannot eliminate the part-time penalty by shifting to full-time work, as their productivity and wages are determined by accumulated human capital of which part-time workers have less.

Earlier work from Britain (Manning and Petrongolo, 2008) shows that almost half of women experience part-time work and that part-time women have substantially lower hourly wages than full-time women. The prevalence of part-time employment is lower in the US, but the pay difference between part-time and full-time workers is also significant (Hirsch, 2005). Yet, an unconditional wage differential is not a reasonable measure of the part-time penalty, as Manning and Petrongolo (2008) point out because part-time and full-time workers can have very different characteristics and often work in different occupations.

Attempts to estimate the part-time penalty typically control for worker and job characteristics, and doing so considerably reduces estimates of the pay gap between part-time and full-time workers (Hirsch, 2005; Manning and Petrongolo, 2008). Although these insights are important, estimation of the part-time penalty is still challenged by the fact that many worker and job characteristics (including occupational choice) are outcomes that follow from the decision to work part-time, which implies that, in practice, part-time workers may face an entirely different wage determination process from the one faced by full-time workers. Blank (1990) recognizes this challenge. However, her attempts to overcome the issues econometrically resulted in sharply different conclusions, which led Holden (1990), in her comment on Blank's work, to conclude that our understanding of the part-time work effect is shaky.

In this paper, we strive to estimate the magnitude of the part-time penalty, to determine how it evolves over the career, and to understand the mechanism causing this development. To guide our empirical work, we present a simple theoretical framework, which is based on the job assignment models of Gibbons and Waldman (1999) and Gicheva (2013). This setup is typically used to model the high-end labor market with a focus on the importance of long working hours for wages and promotions among young professionals (Gicheva, 2013; Frederiksen, Kato, and Smith, 2024). We focus on the broader labor market, where standard hours are the norm, part-time work is common, and overtime work is rare. For this reason, we reconfigure the model for this situation and explicitly model the intensive labor supply margin, which gives rise to the notion of part-time, full-time, and overtime workers; and we emphasize the learning mechanism (the accumulation of human capital) as a driver of productivity and wage growth. This setup allows us to determine the wage gap between part-time and full-time workers and to highlight important dynamics linking

hours worked to pay differences between part-time and full-time workers over time.

We use Danish register data and the Danish Labor Force Survey with its detailed information on working hours to produce estimates of the pay gap between workers on part-time and full-time. We subsequently focus our analysis on Danish nurses because this profession is an ideal (almost stylized) setting to study details related to the pay gap.[1] This follows from the fact that part-time is common among nurses and that the workforce in the nursing profession is highly homogeneous. Nurses are predominantly female (96 percent of nurses are women) and the profession is highly regulated with strict entry requirements: Authorization as a nurse requires a formal 3.5-year nurse education in addition to a high-school degree. Furthermore, we know when nurses graduated from nursing school, which provides a clean way to establish how pay progresses over the career as nurse and to produce estimates of how pay would have evolved had the nurse chosen full-time instead of part-time work. In addition to this, we have access to personnel records for nurses from a regional hospital, allowing a deep analysis of what drives pay differences between part-time and full-time nurses.

We estimate the unconditional earnings gap between part-time and full-time workers in Denmark to be 37-53 percent (depending on the hours measure used). For Danish nurses, it is 17-24 percent.[2] Because it is notoriously difficult to determine the time of entry into the labor market in general, we estimate the development over time in the part-time/full-time earnings gap using the nurse sample where we know the graduation date from nursing school. We find that the pay gap at the time of entry into the nursing profession is 9-14 percent and that it increases by 0.5 percent per year thereafter. Because the nursing profession consists of a highly homogeneous workforce in a highly regulated occupation where almost all work in the public sector and because there are limited (if

[1] Earlier research (Hirsch, 2005; Manning and Petrongolo, 2008) show that occupations explain a large part of the unadjusted pay gap between part-time and full-time workers. Hence, any reasonable attempt to estimate the part-time penalty should therefore look for pay differences between similar workers within occupations. Having a focus on nurses, we make such an attempt.

[2] An earlier study for the US by Hirsch and Schumacher (1995) finds no such pay difference for licensed practical nurses and even a small premium for registered nurses. Other studies of particular occupations/professions such as Montgomery and Cosgrove (1995) and Mocan and Tekin (2003) establish pay gaps in child care establishments, but their results are sensitive to empirical specification.

any) constraints on labor supply and a high frequency of employment,[3] this pay gap between part-time and full-time nurses is our best estimate of what may be considered a part-time pay penalty (in the profession of nurses).[4]

In our theoretical model, worker learning on the job (and human capital accumulation) is the key mechanism that causes the pay gap between part-time and full-time workers to increase over time. Using register data, we provide evidence for this mechanism showing that the pay gap indeed increases over the employees' careers. We also show that part-time workers shifting to full-time work have lower earnings than those persistently working full-time, reflecting that part-time work has resulted in relatively low human capital accumulation and productivity. Similarly, we find that full-time workers changing to part-time have higher earnings than those persistently working part-time, reflecting that full-time experience has resulted in a relatively high level of accumulated human capital and productivity.

We also establish direct evidence on this learning mechanism using hospital data. Theoretically, we argue for a mechanism that transforms hours into productivity. Personnel files from the hospital allow us to establish *how* this is done in practice because they contain information on the structure of wages, including wage supplements. Such supplements are given for non-standard work hours and competencies. We use this information to show that full-time nurses receive competency supplements faster than part-time nurses and that these supplements are larger for full-time nurses. This points directly to the learning mechanism and is an illustrative example of learning at work: longer hours lead to faster competency development. Consequently, part-time workers cannot eliminate the part-time penalty simply by shifting to full-time work as they do not possess the competences associated with the higher pay.

These findings are of broader interest because of the evidence that on-the-job learning connects hours worked to productivity and pay. This implies that decisions made early

[3]In the study of US workers by Blank (1990) there is a focus on total compensation due to unequal access to pension plans and health care for part-time and full-time workers. Nurses in Denmark have equal access to such fringe benefits irrespective of work hours.

[4]Our more detailed analysis below addresses measurement error. Our results show that measurement error has a moderate effect on our estimate of the part-time pay penalty, especially if we focus on results based on the fairly stable measure of "usual hours of work".

in life, such as working part-time while having small children, have persistent effects on earnings, and recent research shows that women may not be sufficiently informed about such consequences (Costa-Ramón et al., 2024). Furthermore, a lower average labor supply of women in combination with persistent wage effects make it clear that working hours should play an important role in any discussion of the gender wage gap (Blau and Kahn, 2017; Goldin, 2014; Manning and Robinson, 2004).

The paper proceeds as follows. In the next section, we develop a theoretical model that allows us to derive and study the pay differential between part-time and full-time workers. In Section 3 we present data and descriptive statistics, and we show results in Section 4. In Section 5 we evaluate the model's key assumption that learning is causing the changes in the part-time penalty over the career. Section 6 concludes the paper.

Theory

In this section, we derive the part-time penalty from a simple model of hours and earnings in a career perspective. This work builds on the job assignment model of Gibbons and Waldman (1999), which we augment with an explicit labor supply decision as in Gicheva (2013). In this framework, we can show that the pay gap between part-time and full-time workers is the compound effect of hours worked and differences in wages, and we can establish how it develops over time.

The model

We consider a two-period model. Workers are employed in jobs with formal competency requirements: $T_k, k = 1, 2, 3$. A worker with competences exceeding T_k but not T_{k+1}can be employed at job level $j \leq k$. New workers enter the labor market with a competency level $\eta_1 = 1$ and accumulate human capital according to $\eta_{t+1} = (1 + \theta_i h_t)$, where h_t is the hours worked at time t and $\theta_i \sim f$ is the speed of learning of a given individual. We assume $T_1 \leq \eta_1 \leq T_2$, such that all workers start their employment at job level 1.

Productivity in the first period is $Y_1 = h_1$. In period two, productivity is a function of accumulated human capital $(1 + \theta_i h_1)$, hours worked (h_2), and job level (j): $Y_{j2} = c_j(1 + \theta_i h_1)h_2$ with $1 = c_1 < c_2 < c_3$, which implies that human capital becomes more

effective at higher job levels. Due to complete information and perfect competition, employers assign workers to jobs that match their level of competences and pay a wage equal to productivity.

Workers have disutility from work and heterogeneous preferences for leisure as in Gicheva (2013). The cost of effort functions are $C(h_t) = \frac{1}{2}h_t^2$, and the worker's preference for leisure is denoted $b_i \sim g$. Thus, workers choose work hours to maximize utility across j:

$$U_{ij} = h_1 - \frac{1}{2}h_1^2 + c_j(1 + \theta_i h_1)h_2 - \frac{1}{2}h_2^2 - b_i.$$

Consequently they end up at job level j^* in period two and they have labor supply of:

$$h_1^{j*} = h_2^{j*} = 1/(1 - c_{j*}\theta_i),$$

which implies that the labor supply for a given individual is constant over time.[5] Furthermore, hours worked, speed of learning, and job level feed into the production function and, in turn, determine the worker's productivity and pay.

In general, the labor supply will be higher for workers with a higher learning capacity (θ_i) who also end up at higher job levels. That is, we can show that for some (low) values of θ_i workers will have short hours and remain at job level 1; yet there exist cut-off values for θ_i such that individuals with intermediate values of θ_i will work longer and end up at job level 2 in the second period, and those with the highest values of θ_i will have the longest hours and move to job level 3. Furthermore, for a given θ_i it is possible to show that leisure preferences can be so strong (b_i large) that such individuals prefer to work short hours and stay at job level 1, whereas other workers with the same θ_i, but more moderate b_i, will have longer hours and move to a higher job level. Hence, individuals will choose different levels of labor supply, but the same level of labor supply over time. This gives rise to the notion of part-time, full-time, and over-time workers.

If we compare part-time workers to other individuals (full-time and over-time workers), they have lower earnings. Toward the beginning of the career, the earnings difference simply reflects that part-timers work shorter hours. However, part-time workers also accumulate less human capital, and they move slower in the competency hierarchy than full-time workers, and for this reason, their productivity and pay growth are slower.

[5]Earlier work by Blank (1998) and Manning and Robinson (2004), and our own results below show that work hours are indeed highly persistent over time.

Hence, later in the career, the difference in earnings between part-time workers and other workers becomes the compound effect of shorter hours *and* lower pay (and productivity) per hour. This implies that the pay differences between part-time and full-time workers, which we refer to as the part-time penalty, begin small and then increase as the career progresses.

We further note that the worker's hour choice is a choice of a particular earnings trajectory. Consequently, workers cannot jump between trajectories simply by changing working hours. For example, it is not possible for part-time workers to jump to the earnings trajectory of full-time workers because they do not possess the level of human capital associated with that trajectory.

Data and Descriptive Statistics

We estimate the part-time penalty using register-based employer-employee data and the Danish Labor Force Survey (DLFS). Our sample period is 1994 to 2022. In this period, the register data comprises 4.9 million unique working individuals and 65 million person-year observations. The register data contains detailed information on earnings, gender, age, experience, education, graduation time, and a broad set of covariates, including occupation, but lack detailed information on work hours. We obtain reliable information on work hours from the DLFS, which is a comprehensive survey of a representative sample of Danes conducted every year.[6] When merging this sample with the register data, we obtain a regression sample with 882,437 observations.

We will provide two sets of estimates of the pay gap between part-time and full-time workers. The first set is based on the representative sample of Danes. The second set focuses on Danish nurses and will provide a more narrow but also more precise estimate of the part-time/full-time pay gap (for a relevant group of workers in the labor market). The key advantages of the nurse sample is that we know when nurses entered the nursing profession (graduation date from nursing school), that the nursing profession is populated by a highly homogeneous group of individuals in terms of gender and educational background (96 percent are women and they all have a 3.5-year nursing education on top of a

[6]The DLFS is very similar to the CPS in the US. For more detail see, for instance, Frederiksen, Kato and Smith (2024).

high school degree), and that the nursing profession experiences labor shortage, implying that working hours are unconstrained. Our sample of nurses has 22,574 observations (2.6 percent of the original sample).

Table 1 shows descriptive statistics. Column 1 contains statistics for the representative sample and column 2 presents statistics for nurses. The average earnings in the large sample is DKK 320,198 (sd = 233,306) (7.5 DKK = 1 EUR). For nurses, the earnings are 355,920 (sd = 129,865). The average individual is 41.62 years old, while the average nurse is 45.61 years old. Furthermore, the data confirm that nursing is a predominantly female profession, with 96.08 percent of nurses being women. The corresponding proportion in the larger sample is 49.25 percent.

Table 1: Descriptive statistics

	Representative sample	Nurse sample
Earnings	320,198	355,920
	(233,306)	(129,865)
Woman	0.4925	0.9608
Age	41.62	45.61
	(13.53)	(10.63)
Experience	17.50	20.92
	(12.34)	(10.90)
Experience at graduation		5.70
		(4.00)
Experience as nurse:		
Years since graduation		17.71
		(10.44)
Experience since graduation		15.22
		(9.60)
# Observations	882,437	22,574

The labor market experience in the large sample is 17.50 years and for nurses it is somewhat higher (20.92 years). Because we know when a nurse graduated, we can split their

overall experience into experience before and after graduation. This reveals that nurses have 5.70 years of experience before graduating and 15.22 years of experience after graduation. Comparing experience as a nurse to the average time since graduation (17.71 years), we find that nurses have an employment frequency close to 86 percent.

From the Labor Force Survey, we obtain information on both actual and usual weekly working hours. Conceptually, human capital accumulation should be more closely linked to usual working hours than working hours in a particular week, yet, it has been noted in the literature that usual hours are more subject to measurement error (such as recall bias) than actual hours (Barrett and Hamermesh, 2019; Baum-Snow and Neal, 2009). For this reason, we apply both measures in our analysis.

Table 2: Working Hours

	All	Men	Women	Nurse
Actual hours				
h	33.68	36.11	31.17	33.58
sd(h)	12.32	12.46	11.64	9.80
Part time ($h < 37$)	0.3829	0.2619	0.5076	0.5308
Full time ($h = 37$)	0.3424	0.3853	0.2982	0.2067
Over time ($h > 37$)	0.2747	0.3528	0.1942	0.2625
Usual Hours				
h	33.66	35.80	31.45	33.72
sd(h)	11.37	11.31	11.00	7.52
Part time ($h < 37$)	0.3310	0.1988	0.4672	0.5096
Full time ($h = 37$)	0.5049	0.5748	0.4329	0.3897
Over time ($h > 37$)	0.1641	0.2264	0.0998	0.1007
Observations	882,437	447,857	434,580	22,574

The descriptive statistics for hours are presented in Table 2. The standard work time in Denmark is 37 hours per week. In the representative sample, average usual labor supply is 33.66 hours per week and actual labor supply is 33.68 hours per week. Working hours are higher for men than for women on average; and nurses have a labor supply that is

very close to the average for the population. That the work week is generally short in Denmark compared to other countries has recently been documented in Frederiksen, Kato and Smith (2024).

A striking observation from Table 2 is that more than one third of Danes work part-time ($h < 37$). For women this number is closer to half, and for nurses, it is between 51 and 53 percent. Further analysis shows that working hours are highly persistent (Table 3).[7] Comparing usual work hours that are one year apart for a given individual[8], 79 percent of those working full time ($h = 37$) in year t also worked full time in year *t-1*. For part-timers ($h < 37$) and over-timers ($h > 37$) the proportions are 77 and 54 percent, respectively. For nurses, the persistence in part-time work is even higher: 86 percent of nurses who work part-time in t also worked part-time in *t-1*. The high persistence in work hours (and, in particular, in part-time work among nurses) will prove particularly useful in our endeavors to estimate the part-time penalty.

Table 3: Persistence in working hours

	Actual Hours			**Usual Hours**		
	Part-time	Full-time	Overtime	Part-time	Full-time	Overtime
(t-1)			**All**			
Part time	0.6774	0.1907	0.1319	0.7686	0.1704	0.0610
Full-time	0.1803	0.6108	0.2088	0.0879	0.7887	0.1234
Overtime	0.1605	0.2670	0.5726	0.1010	0.3598	0.5392
			Nurses			
Part time	0.7361	0.1114	0.1525	0.8587	0.0972	0.0440
Full-time	0.2746	0.4610	0.2644	0.1191	0.7687	0.1122
Overtime	0.3501	0.2157	0.4342	0.2824	0.3618	0.3559

Note: In the construction of the table we use individuals with hours information available in consecutive years. This is the case for 245,257 individuals in the large sample (*All*) and for 6,649 nurses. The numbers show the proportion of individuals in a given state in year time t-1 who move to a given state in year t. The rows sum to one for each hours measure.

[7]High persistence in work hours was also noted in Blank (1998) and Manning and Robinson (2004), where the latter states that there are so few transitions between full-time and part-time for women that one can treat them as approximately separate groups.

[8]For a subset of individuals we have repeated observations, see Frederiksen, Kato and Smith (2024), who use the same data, for a detailed discussion.

Results

In this section, we estimate the pay gap between part-time and full-time workers. We present results using the representative sample of Danish workers and the sample of nurses. We also estimate how the pay gap evolves over time. Our best estimate of the part-time penalty is based on the nurse sample, where we find a part-time/full-time pay gap of 9-14 percent at the time of entry into the nurse profession and that this gap increases by 0.5 percent each year thereafter.

Estimation of the part-time penalty

We present estimates of part-time/full-time pay differences in Table 4. In column 1 we show results from a regression of ln(earnings) on dummies for part-time, full-time (reference group), and overtime. When using actual hours to identify work-hour groups, we establish a "raw" pay gap between part-time and full-time workers of 58.77 percent; and a gap between full-time and overtime workers of 28.00 percent. In column 2 we control for a quadratic in age and year (23), industry (14), and sector (2) fixed-effects, and obtain a part-time/full-time pay gap of 37.05 percent. Using usual work hours, the gap is 52.76 percent. Similar regressions based on the nurse sample (column 3) lead to a gap of 17.07 to 23.75 percent.

In column 4 we estimate how the pay gaps develop over time for nurses.[9] This development is established in the regression from column 3 augmented with a variable for "Time since graduation" and its interactions with work-hour categories. We find that earnings growth is around one percent per year for full-time nurses and half a percent lower for part-time nurses, implying a widening pay gap of half a percent per year from the time of graduation.

[9]We focus the analysis on nurses because we know the date of graduation and actual experience for this sample. Earlier attempts to estimate the development in the part-time penalty, such as Hirsch (2005), rely on potential experience (or age).

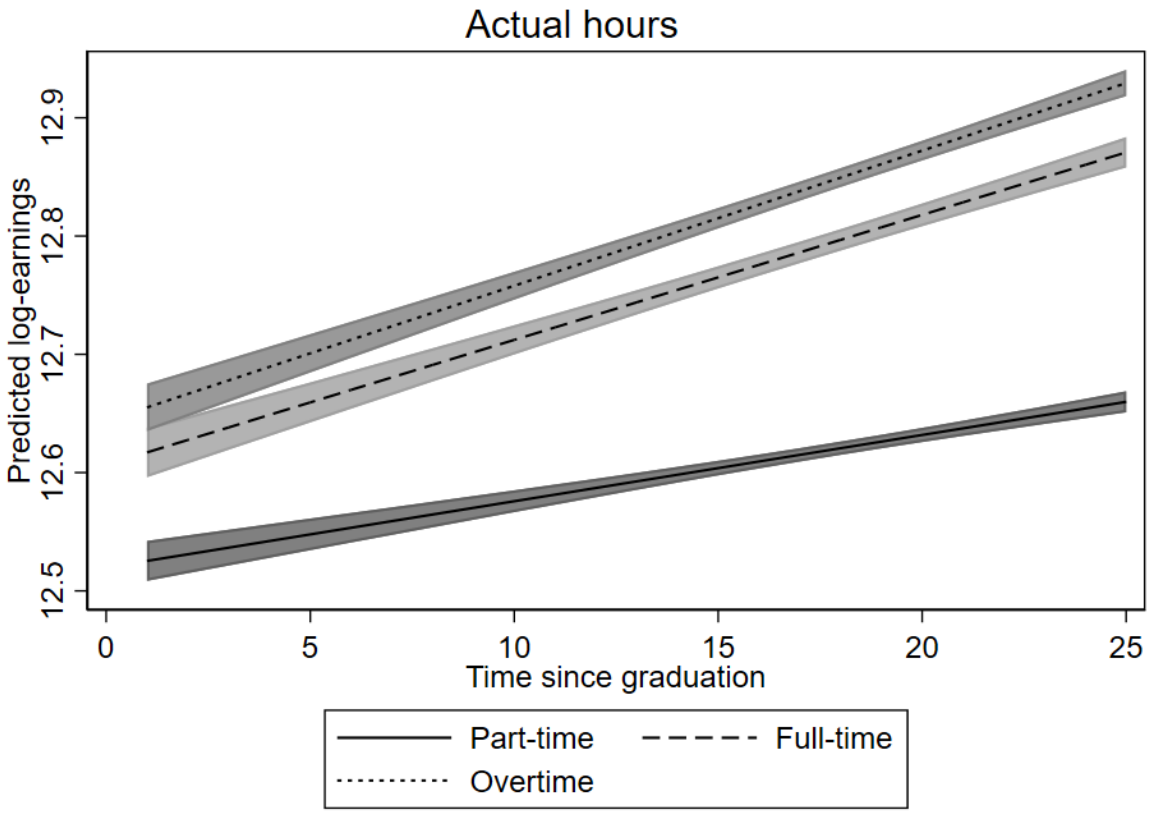
Table 4: The part-time penalty (log-earnings regressions)

	All	All	Nurses	Nurses
Actual hours				
Part-time (PT)	-0.5877***	-0.3705***	-0.1707***	-0.0868***
	(0.0026)	(0.0019)	(0.0067)	(0.0119)
Full-time (FT)	-	-	-	
Overtime (OT)	0.2800***	0.1977***	0.0585***	0.0372***
	(0.0018)	(0.0016)	(0.0058)	(0.0110)
Time since graduation	-	-	-	0.0106***
				(0.0009)
Time since graduation x PT	-	-	-	-0.0050***
				(0.0006)
Time since graduation x OT	-	-	-	0.0009
				(0.0006)
Usual hours				
Part-time (PT)	-0.8364***	-0.5276***	-0.2375***	-0.1437***
	(0.0028)	(0.0021)	(0.0066)	(0.0116)
Full-time (FT)	-	-	-	
Overtime (OT)	0.1091***	0.1590***	0.0541***	0.0091
	(0.0023)	(0.0020)	(0.0095)	(0.0161)
Time since graduation	-	-	-	0.0108***
				(0.0008)
Time since graduation x PT	-	-	-	-0.0054***
				(0.0006)
Time since graduation x OT	-	-	-	0.0023**
				(0.0009)
Covars	No	Yes	Yes	Yes
# Observations	882,437	882,437	22,574	22,574

Note: Regressions control for: quadratics in age and year (22), industry (13), and sector fixed-effects. Standard errors are clustered. Significance levels: 0.1* 0.05**, and 0.01***.

We illustrate the differential earnings growth by work-hour categories in Figure 1 using the results for nurses from Table 4 column 4 (*Actual hours*). Newly educated nurses on part-time have ln(earnings) of 12.53 whereas full-time nurses earn 12.62 and overtime nurses earn 12.66. This implies an early career earnings gap between part-time and full-time nurses of ca. 9 percent and between part-time and over-time nurses of 13 percent.

Figure 1: Part-time penalty over time (Nurses)



After 25 years, ln-earnings for part-time nurses have increased to 12.66 and the earnings gap between part-time and full-time nurses to 21 percent.[10] Therefore, the earnings gap has increased by a little over 0.5 percent per year. These results comparing pay for nurses from different work hour categories with the same number of years since graduation are our best estimates of a part-time penalty (for the profession of nurses).[11]

Robustness

In Table 5 we evaluate the robustness of our results. In column 1 we replicate the baseline nurse results from column 3 in Table 4 for convenience. In column 2 we show results for nurses employed in the public sector. Denmark has public health care, and consequently

[10]The higher pay growth of full-time workers relative to part-time workers has also been established in Manning and Robinson (2004) and Hirsch (2005). Most recently, Paul (2016) concluded that workers in Germany lost between 1.3 and 3.7 percent for each year they worked part-time.

[11]We address the issue of measurement error below and find that their influence on the results are modest, especially when it comes to results based on "usual hours" worked.

most health care services are provided in the public sector. However, there are private clinics and hospitals; and some nurses work in employment agencies and are called in on an ad hoc basis to assist public healthcare providers when needed. In our data, 16.7 percent of nurses work in the private sector, and excluding those from analysis leads to results that are very similar to baseline results. In column 3 we narrow the sample further by focusing on public sector nurses who are registered to work in the health care sector (78,3 percent of our original sample). This restriction is also inconsequential for the results.

An additional analysis of this type excludes nurses with foreign income (column 4). The reason we conduct this analysis is that it is well known (a recurring theme in public media) that Danish nurses have strong financial incentives to work in Norway, and supposedly many Danish nurses make use of that option. The register-data that we use contain information about Danes, including Danes with foreign income, but not Danes working abroad with no Danish income or tax liability to Denmark. In our sample, we observe that only 0.8 percent of nurses have foreign income, yet, for such nurses, foreign income constitutes 21 percent of total income on average. Omitting this small proportion of nurses from the analysis has little consequence for the results.

We can also control for grades in high school and nursing school. This would be important if such variables reflect differences in innate ability or performance. However, data on grades are only available for a subset of nurses, and they have been more frequent in recent years. Analysis is further complicated by the shift in the grade-point scale from a "13-point scale" to a "7-point scale" in 2006. We deal with this by augmenting our baseline model with dummies for each combination of grade and scale. For these reasons, the results using grade information (presented in columns 5 and 6) should only be considered a sensitivity check; nevertheless, the results from these regressions are similar to earlier results.

Now, let us turn to a more subtle point. Theoretically, individual labor supply is constant across time, which gave rise to the notion of part-time and full-time workers and led to the result that earnings trajectories are markedly different for part-time and full-time workers. Up to this point, we have referred to part-time and full-time workers and relied on the fact that hours of work are highly persistent, as documented in Table 3 where we showed that 73 to 86 percent of part-time nurses choose to work part-time in consecutive

years (see also Blank (1998) and Manning and Robinson (2004) for evidence on the high persistence in work hours). Despite that it is common for part-time nurses to continue in part-time work, we do see empirically that some nurses shift work-hour category. One way to interpret this is that we have some sort of measurement error in the work-hour category dummies. To be precise, some of the nurses we classify as part-time nurses may have had full-time experiences (at some point), which could lead to an upward bias in our estimate of the part-time/full-time pay gap. That is, the estimated pay gap being too small. For those we classify as full-time nurses, the situation may have been the opposite (i.e., a part-time experience), which would also lead to the estimated pay gap being too small.

To address this issue, we reapply the data comprising nurses with work-hour observations in consecutive years that we used to construct Table 3. We simply select the smaller sample of nurses who have been employed in the same work-hour category in consecutive years (and omit nurses with only one observation on hours worked or a shift in the work-hour category). The results based on this sample are shown in column 7 of Table 5 and confirm the expectation that the point estimates on the part-time dummies are somewhat lower than the baseline results. Using actual hours, the pay gap increases from 17 percent to 21.6 percent. Using usual hours, the increase is just over one percent (25.0 percent vs. 23.8 percent).

Furthermore, when we apply an instrumental variable approach to this regression to purge the estimate of any remaining measurement error (column 8)[12], we produce point estimates that are indistinguishable from previous results. In fact, the IV results for usual hours (the more stable of the two measures of hours) is 29 percent which, given the increase in standard error, implies that the estimated pay gap of 25 percent established in the sample of workers with no change in their hours and the 24 percent established as the baseline are contained in its confidence interval. Hence, our results, especially results based on usual hours, are robust and are judged to be only moderately affected by measurement errors.

[12]We use the conventional instruments for part-time from the literature, i.e., children and partner (Blank, 1990)

Table 5: Robustness analysis (Nurses)

	Baseline	Public sector	Public health care	No foreign income^{+}	Grades from high school	Grades from nursing school^{++}	No change in hours	No change in hours IV
Actual hours								
Part-time	-0.1707***	-0.1527***	-0.1425***	-0.1686***	-0.1446***	-0.1152***	-0.2159***	-0.3848***
	(0.0067)	(0.0063)	(0.0056)	(0.0073)	(0.0085)	(0.0160)	(0.0118)	(0.0978)
Full-time	-	-	-	-	-	-	-	-
Overtime	0.0585***	0.0501***	0.0492***	0.0544***	0.0578***	0.0618***	0.1177***	-0.0150
	(0.0058)	(0.0057)	(0.0055)	(0.0064)	(0.0076)	(0.0143)	(0.0125)	(0.0778)
Usual hours								
Part-time	-0.2375***	-0.2157***	-0.2010***	-0.2533***	-0.2224***	-0.2171***	-0.2495***	-0.2894***
	(0.0066)	(0.0062)	(0.0054)	(0.0075)	(0.0083)	(0.0151)	(0.0090)	(0.0451)
Full-time	-	-	-	-	-	-	-	-
Overtime	0.0541***	0.0489***	0.0497***	0.0792***	0.0553***	0.0960***	0.1007***	0.0749**
	(0.0095)	(0.0093)	(0.0085)	(0.0125)	(0.0129)	(0.0325)	(0.0214)	(0.0342)
# Observations	22,574	18,799	17,679	18,953	13,645	4,182	$^{+++}$	$^{+++}$

Note: All regressions control for: quadratics in age and year (22), industry (13), and sector fixed-effects. Standard errors are clustered. Significance levels: 0.1* 0.05**, and 0.01***. $^{+}$Register data on foreign income (and tax) is available from 2002 onward. $^{++}$ Register data on nursing school grades started in 2004 and is only available for a subset of nurses. $^{+++}$ The number of observations for actual hours are 3,975 and 5,135 for usual hours.

The learning mechanism

In our theoretical model, a learning mechanism drives productivity and pay dynamics. When workers choose to work part-time or full-time, the learning mechanism determines how much human capital is accumulated and, as a consequence, how productivity and pay develop over time. Evidence for this learning mechanism was established above, where we showed that part-time workers had slower pay growth than full-time workers. In the following, we provide additional evidence for this mechanism.

Human capital accumulation

Theoretically, we can show that when learning is important, part-time workers will have lower productivity and pay than full-time workers, and part-time workers cannot eliminate the part-time penalty simply by switching to full-time employment. When part-timers do shift to full-time employment, their earnings will naturally be higher, yet they cannot jump to the earnings trajectory of full-time workers because their level of accumulated human capital is too low. Instead, they will find themselves earning more than before, but at a level which corresponds to the pay level of a full-time worker with fewer years of experience.

We test this assertion in Table 6, where we present results from a fixed-effects model. These results show that across all workers, part-time work reduces earnings by 5 to 11 percent compared to full-time workers, and for nurses, the reduction is between 1.3 and 4.5 percent. These estimates identified of individuals moving between part-time and full-time show that the pay changes associated with a switch in hours are modest compared to the pay differences observed between full-time and part-time workers in general (Table 4). Hence, in line with the learning mechanism, a worker's accumulated human capital constitutes a persistent component in worker pay and mute pay responses to shifts in hours.

Table 6: The part-time penalty (Fixed-effects estimation)

	All	Nurses
Actual hours		
Part-time (PT)	-0.0551***	-0.0129***
	(0.0009)	(0.0034)
Full-time (FT)	-	-
Overtime (OT)	0.0057***	0.0080**
	(0.0009)	(0.0034)
Usual hours		
Part-time (PT)	-0.1096***	-0.0448***
	(0.0012)	(0.0041)
Full-time (FT)	-	-
Overtime (OT)	-0.0026**	-0.0024
	(0.0011)	(0.0045)
# Observations	882,437	22,574

Note: Regressions control for: quadratics in age and year (22), industry (13), and sector fixed-effects. Significance levels: 0.1* 0.05**, and 0.01***.

Competency development

Furthermore, the theoretical model contains an explicit process: The learning mechanism transforms hours worked into human capital and, in turn, the level of accumulated human capital determines productivity and pay. However, from this structure, it is not clear *how* hours are transformed into human capital and pay in practice. To shed light on this "black box" process, we use data from a regional hospital located in the western part of Denmark. Unlike the previously used register data, hospital data contain detailed information on the structure of nurse pay. Most importantly, the data contain detailed information on supplements paid for competences and nonstandard work hours (evening, night, Saturday, and Sunday). This information allows us to investigate the relationship between hours worked and competency development (which the hospital is willing to pay for), providing a concrete example of how hours are transformed into pay. In addition, it shows that there is a close link between competency development and the accumulation

Figure 2a: Proportion of nurses with a competency supplement.

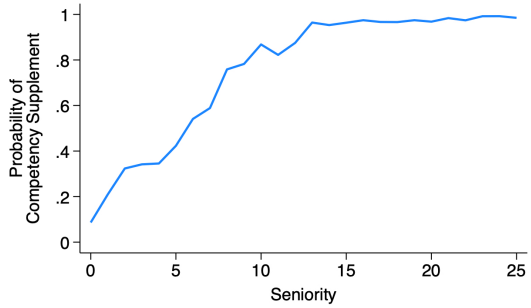
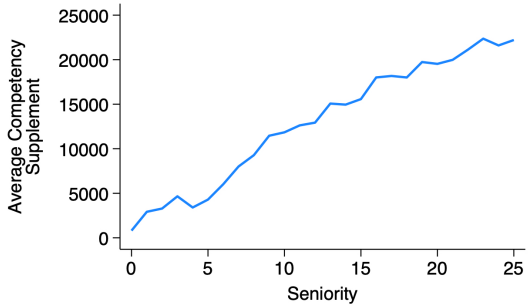


Figure 2b: Average competency supplement.



Note: In both figures, the 3 percent with highest seniority are not shown.

of human capital.

The sample period is 2017 to 2021, and during this period, the hospital employed 817 nurses on average.[13] Nurses often receive supplements. In a given year, 90.1 percent of nurses receive at least one supplement for non-standard work, and 79.3 percent receive competency supplements. For the average nurse, the work-hour supplement adds 9.9 percent to pay and the competency supplement contributes an additional 3.9 percent.

The importance of learning shows in two ways: First, the proportion of nurses who receive a competency supplement is low at the beginning of the career (10-20 percent) and increases with seniority, so that almost all nurses receive a competency supplement after 10 years of service (Figure 2a). Second, competency supplements are small in magnitude early in the career and grow steadily with seniority (Figure 2b).

[13]The hospital covers a population of 287,000 people. The hospital data that we use for analysis contain information on 1,049 unique nurses and 4,085 nurse-year observations for the period 2017 to 2021. Hospital nurses are fairly similar to the population of nurses. However, hospital nurses are slightly younger (44.58 vs 45.37 years in the register data), even more female (98.41 percent vs. 96.02 percent in register data), and their earnings are somewhat higher 397,075 (SD=123,078) compared to 341,507 (SD=114,122) in the register data.

Table 7: Competency supplements

	Likelihood	Likelihood	Likelihood	Magnitude	Magnitude	Magnitude
Actual annual hours/1000 (AH)		0.0656***	0.1328***		5,898***	-298.3
		(0.0134)	(0.0244)		(486.9)	(882.1)
Seniority (S)	0.0591***	0.0582***	0.0750***	1,141***	1,063***	106.5
	(0.0024)	(0.0024)	(0.0054)	(87.89)	(86.60)	(194.7)
Seniority square/100 (S^2)	-0.1175***	-0.1156***	-0.1610***	-2,101***	-1,932***	-408.9
	(0.0065)	(0.0065)	(0.0162)	(241.8)	(238.0)	(585.4)
S x AH			-0.0132***			800.0***
			(0.0038)			(136.8)
S^2 x AH			0.0352***			-1,336***
			(0.0112)			(403.2)
Scheduled annual hours/1000 (SH)		0.0301***	0.0285		4,427***	-1,122*
		(0.0100)	(0.0176)		(361.8)	(629.3)
Seniority (S)	0.0591***	0.0585***	0.0697***	1,141***	1,058***	131.8
	(0.0024)	(0.0024)	(0.0048)	(87.89)	(86.80)	(171.0)
Seniority square/100 (S^2)	-0.1175***	-0.1167***	-0.1657***	-2,101***	-1,985***	-701.8
	(0.0065)	(0.0065)	(0.0142)	(241.8)	(237.7)	(508.2)
S x SH			-0.0063**			696.0***
			(0.0027)			(97.56)
S^2 x SH			0.0283***			-1,086***
			(0.0079)			(282.1)
# Observations	4,085	4,085	4,085	4,085	4,085	4,085

Note: All regressions control for: quadratics in age, and year (5) fixed-effects. Standard errors are clustered. Significance levels: 0.1* 0.05**, and 0.01***.

We investigate these findings in more detail in Table 7. In column 1 we regress a dummy for receiving a competency supplement on seniority and controls, and the results confirm that the likelihood of receiving a competency supplement increases in seniority. In column 2 (upper part), we augment the model with actual annual hours worked and show that both hours and seniority increase the likelihood of receiving a supplement.[14] Column 3 is the most comprehensive model that includes hours, seniority, their interaction, and controls. In this model, the result that the likelihood of receiving a competency supplement increases in hours and seniority is preserved. Using scheduled annual hours (lower part) results in similar findings (see the predicted profile in Appendix A, Figure A1). In columns 4-6 of Table 7, we estimate similar models using the magnitude of the competency supplement as the dependent variable, and we confirm that the competency supplements increase in hours and seniority (see the predicted profile in Appendix A, Figure A2).

These results vividly show that time on the job is important for pay. Theoretically, this connection is established by the process transforming hours into human capital, and subsequently pay. Our empirical analysis provides a concrete example of this, where accumulated hours link to workers' competency development, which the hospital is willing to pay for.

Conclusion

In this paper, we study the part-time penalty. To understand how pay progresses for part-time and full-time workers, we develop a theoretical framework that connects hours worked to pay. Through that lens and a series of empirical tests, we conclude that there is a significant pay gap between part-time and full-time workers. This pay gap increases over the course of the career because the two groups accumulate different levels of human capital over time.

[14]There are two measures of hours available in the hospital data: Planned and actual working hours. In contrast to our work on the labor force survey data, where we used weekly hours worked either usually or actually, we used yearly hours when working on hospital data. One reason for doing this is that it is difficult to translate the measured hours in the hospital data to weekly hours given the way they are registered. Variation in days per month, timing of vacation, distribution of holidays, etc. impose undesirable variation when we attempt to construct measures of weekly hours in the hospital data. This challenge has been recognized in earlier research, as reflected in the discussion in Holden (1990).

We provide estimates of the part-time/full-time pay gap based on register data for a random sample of the population. However, our most convincing estimates of the part-time penalty are established using a sub-sample of nurses. The nursing profession is highly homogeneous in terms of gender and educational background, and from the data we know the nurses' graduation date. This allows for comparison of earnings of part-time and full-time nurses at various stages of their career and production of reasonably convincing estimates of the so-called part-time penalty.

Complementing our analysis of register data with personnel data on nurses from a regional hospital, we also shed light on the human capital accumulation process that causes the part-time pay penalty to increase over the career. Most importantly, we are able to link human capital accumulation directly to competency development. This link is important because human capital plays an important role in many economic models. In some cases, we have a clear understanding of what human capital is. One such example is the link between human capital and formal education. In other cases, human capital is more elusive. This is often the case when we study human capital development in the context of the workplace. Naturally, formal training programs in firms link directly to the concept of human capital, whereas the concrete materialization of "specific human capital" and "informal on-the-job training" are harder to pin down. We hope that our analysis and the identified link between human capital accumulation and competency development will be seen as a genuine attempt to advance our understanding of *how* human capital building unfolds in the workplace.

Our analysis also makes the case that working hours are important for lifetime earnings. This insight resonates well with earlier research by Manning and Robinson (2004) who link part-time work to the gender pay gap and to arguments in Goldin (2014) connecting hours worked, their flexibility, and how they are remunerated to the gender gap. Our contribution to this discussion is to point out that part-time work has ramifications for earnings early in the career and that such ramifications increase over time, amplifying the consequences of women's lower average labor supply over time. Adding to this is contemporary research showing that women may not be sufficiently aware of how their decisions, such as working part-time early in life when they have small children, influence future earnings and retirement savings (Costa-Ramón et al., 2024). Clearly, much more should be done to understand the complexity surrounding part-time work and its consequences

for workers.

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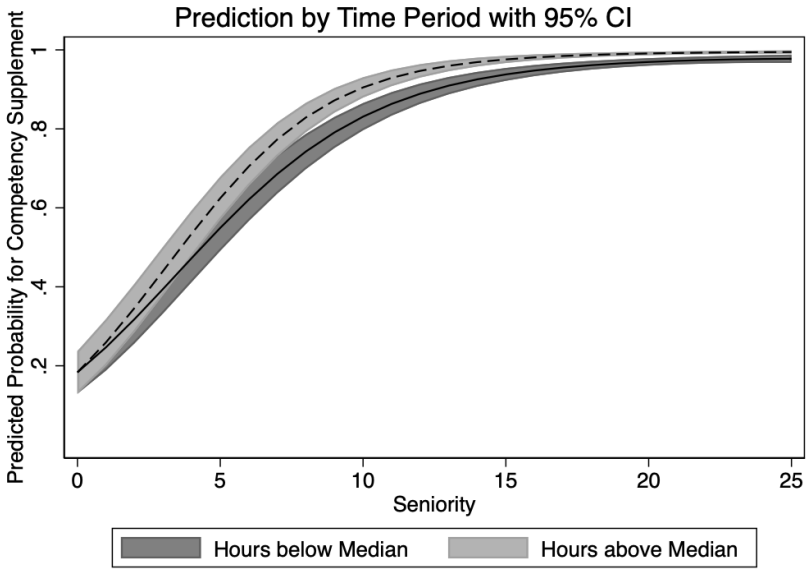
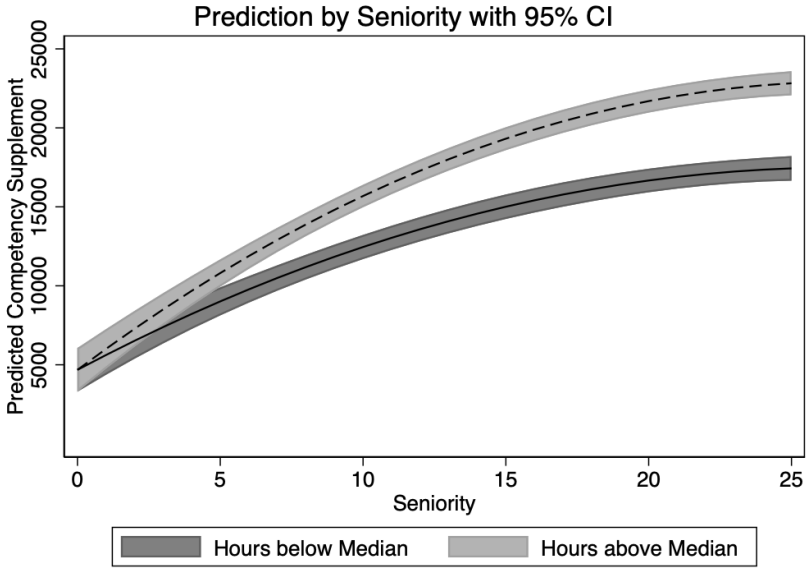
Appendix A

Figure A1: Predicted probability of a competency supplement.



Note: Predictions are based on a logit model with covariates similar to model 3 in Table 7.

Figure A2: Predicted competency supplement.



Note: Predictions are based on model 6 in Table 7.