Promotion prospects and within-level wage growth: A decomposition of the part-time penalty for women *

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Abstract

To understand the mechanisms behind hourly wage penalties women face, I study life-cycle patterns of part-time employment and wage growth. Specifically, I break down the part-time wage gap into a i) promotion penalty and a ii) within-career-level penalty. By means of dynamic structural modeling, I document that both mechanisms are essential for wage stagnation. The within-level penalty is three times larger in high-level jobs. The promotion penalty becomes increasingly important the longer the duration of part-time employment. It dominates for part-time spells longer than four years. Counterfactual simulations demonstrate that policies that induce full-time work early in life and stimulate promotions are most successful in increasing lifetime earnings.

Keywords: Wage Growth, Female Labor Supply, Part-Time, Promotions

JEL classification: J21, J22, J24, J31

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1. Introduction

In the developed economies of the 21st century, female labor market participation continues to increase. However, gender wage gaps persist. One important reason for the gender gap in labor earnings is women's high rate of part-time employment. For many female employees, wage stagnation is a dynamic consequence of part-time work (Blundell et al. 2016, Costa Dias et al. 2020). Hourly wage penalties arise because part-time spells are associated with a slowdown in experience accumulation. Thus far, the exact mechanisms through which experience penalties hamper wage growth have not been studied in much detail.

In this paper, I argue that stagnant human capital accumulation in part-time employment can be detrimental for promotions to high career levels, on the one hand, and for wage growth conditional on the career level, on the other hand. Disentangling the two possible reasons why, in the long run, part-time employment leads to lower wages is valuable. Knowledge about the relative importance of the channels and the timing of their occurrence can aid policy to intervene effectively and close the gender wage gap.

Using data from Germany, I break down the long-run part-time experience gap into two distinct components and quantify their relative effect size. I differentiate between a i) *promotion penalty* and a ii) *within-career-level wage penalty*. The analysis employs a dynamic model of labor supply featuring hierarchical wage structures and promotions. It captures long-run effects and allows me to perform a series of counterfactual policy simulations. Bringing the model to the data, I document that part-time employment leads to penalties in experience accumulation and wage stagnation through both channels. In particular, estimations calculate that part-time employment is equivalent to 0.41 full-time units in terms of human capital. The resulting within-level wage penalty is markedly more severe on the high than on the low career level. The threefold difference in the size of the penalty between levels is explained by the fact that returns to experience are substantially higher in high career-level jobs. The penalty in promotions is at least as important. It dominates if individuals reduce their working hours for multiple years or if the worktime reduction is drastic. The counterfactual analysis based on the estimated structural model shows that a policy that induces full-time employment and fosters promotions to the high career level early in the life cycle effectively stimulates wage growth and increases lifetime earnings.

To disentangle and quantify the mechanisms that cause the part-time penalty, I develop and estimate a partial equilibrium life-cycle model of working hours choices. The modeling approach explicitly incorporates career hierarchies and promotions in the dynamic framework of Keane & Wolpin (2010), Blundell et al. (2016) and Adda et al. (2017). The key feature in the model at hand is that the probability of promotion and the speed of within-level wage growth both depend on accumulated human capital. In turn, experience accumulation is a function of the history of working hours choices, where penalties apply: working less than full-time is worth less than a full-time experience equivalent. The model design, thus, stipulates that the experience accumulation penalty within levels and the promotion prospect penalty between levels are two distinct contributors to wage stagnation. Moreover, it enables the quantification of each penalty component separately such that the relative size of the channels can be evaluated. The model assumptions address selection explicitly such that results obtained from estimating the model have a causal interpretation. Observed drivers of selection - interactions between child arrival, child-rearing, and the propensity to work part-time - are captured via a series of preference parameters associated with the presence of children in different age groups. Selection due to unobserved factors is accounted for through unobserved preference types. Another model ingredient that makes the design particularly suitable for analyzing the dynamics of the part-time penalty concerns the choice set in the model. Choices on the intensive margin are continuous, and modeling is such that a small and a large reduction of working hours affect the probability of promotion and the speed of within-level experience accumulation to a different degree. This feature is essential because reduced form evidence from earlier studies suggests that part-time penalties are highly non-linear in the number of hours worked. Estimates of the part-time penalty in experience accumulation are obtained in a method of simulated moments (MSM) procedure and subsequently used to analyze the dynamic effects of policies aimed at mitigating the part-time penalty.

I use data from the German Socio Economic Panel Study (SOEP) to motivate and estimate the model. The latest waves of the panel contain key information about the individual job level from the revised occupation classification, KldB 2010. The data allow me to differentiate between two career levels. Low-level occupations have the comparatively low skill and knowledge requirements and pay low wages. High-level occupations carry more responsibilities, require specific knowledge of the profession, and offer higher wage rewards. The SOEP further contains data on monthly earnings, working hours, and past work experience, which is crucial for two reasons. First, wage growth and part-time penalties can be analyzed based on hourly wages. Second, human capital accumulation can be measured as a function of the precise number of hours worked. Finally, the data also features detailed information on children, which allows for the explicit modeling of the effects of child arrival, putting the part-time penalty into the context of motherhood.The descriptive analysis of the data yields several key insights which motivate the design of the life-cycle model used for empirical analysis. First, high-level occupations exhibit a visibly higher wage trajectory than low-level occupations. Second, wage growth on both levels appears to slow down around the childbearing years, when part-time work is most common. Finally, there is evidence that the probability of promotion depends positively on the number of hours worked. Consequently, modeling wage increases upon promotion and within-level wage growth simultaneously is critical for understanding how part-time work hinders wage growth.

Bringing the model to the data yields two sets of findings. First, the model estimation quantifies the relative size of the within-level experience accumulation and promotion penalty. Second, the counterfactual policy analysis compares the effectiveness of childcare cost reductions and promotion opportunity policies in mitigating wage stagnation due to part-time work.

The first set of results suggests that the high career level is associated with a higher baseline wage and steeper returns to experience. In comparison, experience hardly generates wage growth on the low career level. Part-time spells trigger both within-level wage penalties, as well as promotion penalties. According to the estimation, a year of working 20 hours per week is worth 0.41 full-time equivalents. The median individual experiences a penalty of one Euro per hour following two years of part-time work at ages 31 and 32. Due to the difference in the speed of human capital accumulation on both levels, the within-level penalty on the high level is approximately three times higher than on the low level. The yearly gross part-time penalty in earnings after four years of part-time employment amounts to 2,370 Euros. The part-time spell length of 4 years marks the point at which the forgone chances of promotion and the wage losses within-level contribute to the penalty to an equal degree. For more extended periods of part-time work, the higher share of the long-run part-time penalty accrues to foregone opportunities to be promoted. Missing the jump to the wage trajectory of the high career level becomes the dominant force when part-time employment persists.

Based on the above findings, I analyze how policy can act to close the part-time gap and, by extension, the gender wage gap. To this end, I consider two policy regime changes and study their effect in a set of counterfactual simulations. The first policy I analyze is a decrease in childcare costs by 10%. In the new regime, working hours increase by 1.75 hours of work per week, or 5.8%, on average. The expansion in worktime translates into a 6% increase in lifetime earnings from employment. However, the increase in hourly wages is markedly lower. In the mean, these increase by 9 Cents per hour, corresponding to 0.41% of the average wage. The increase in lifetime earnings is, thus, driven mainly by the mechanical effects of the working hours increase rather than by a mitigation of the part-time penalty. Part-time penalties are mitigated only to a small degree. The generated increase in working hours is insufficient to increase promotions significantly, nor to compensate much of the within-career-level penalty.

The second policy I evaluate is a promotion stimulus policy directly targeted at the promotion prospects channel. Specifically, I simulate a counterfactual scenario in which the probability of promotion increases by 2%. The upturn in promotion chances proxies the effect of measures such as coaching, mentoring, and equality of opportunity programs. The effects of the promotion stimulus policy are very different from those of the childcare cost reform analyzed previously. The increase in promotion probabilities results in a 1.16% decrease in the hours of work on average. The higher rate of promotions has positive implications for the average hourly wage. Mean gross hourly wages increase by 33 Euro Cents and accumulate to a rise in labor earnings by 1.8%. As working hours do not increase but rather fall, there are no mechanical increases in earnings. All gains are attributed to more individuals reaching the high career level where they receive higher wages. In sum, the policy analysis indicates that an increase in full-time employment early in the life cycle would deliver high gains in terms of wages, earnings, and promotions among females. Policies that expand the intensive margin of labor supply among young women would be most successful in mitigating gaps in pay and gender composition at the high levels of the career ladder.

The remainder of this paper is organized as follows. The next section links the paper at hand to previous research. Section 3 describes the data used to derive empirical conclusions from the model. Section 4 presents the model in details. Section 5 explains the estimation methods used. Sections 6 and 7 present estimation results, the key findings on the part-time penalty decomposition, and insights for policy design from the counterfactual simulations. Section 8 concludes.

2. Literature

A vast economic literature looks at the different types of gender gaps heatedly debated among scholars and policymakers. The various strands of the literature are closely related as the distinct gaps often co-occur. Broadly, this paper speaks to the female labor supply topics of the part-time penalty, the motherhood penalty, and the penalty in occupational attainment at the top of the career ladder. Since all of these contribute to explaining the gender pay gap, the paper at hand also speaks to the copious literature on wage gaps.

In the context of Germany, part-time employment is a widespread phenomenon (OECD 2017). Therefore, part-time penalties are likely a principal factor determining the gender pay gap. Conclusions on the relationship between part-time work and wage growth yet vary. For example, Manning & Petrongolo (2008) argue that the substantial part-time penalty they observe in British data almost wholly disappears after controlling for observable characteristics and, most importantly, occupations. At the same time, research using data from Germany generally documents significant penalties for very low working hours and lower or no penalties for modestly reduced hours. Wolf (2002) finds a robust non-linear relationship between work hours and wages, with a penalty for working 20 hours or less and a premium for overtime. Similarly, Paul (2016) highlights that it is mainly the part-time work of 15 hours and less that is strongly associated with a penalty. In light of this evidence, it is imperative that a rigorous causal analysis of part-time penalties controls for key observable characteristics and considers different degrees of reduction of working hours. The estimation in this paper takes education, the presence and age of children, and the career level of individuals into consideration. It also includes the continuum of working hours between 0 and 48 as possible labor supply choices.

In a more recent study for Great Britain, Costa Dias et al. (2020) find that full-time work has a strong positive impact on wage growth which increases with education, while part-time work has little or no impact on wage evolution. A related finding is reported in Blundell et al. (2016), where authors estimate a fully-fledged life-cycle labor supply model. Parameter estimates suggest that depending on the level of education, an additional year of part-time work adds no more than one-fifth of a full-time equivalent to the human capital stock. Thus, part-time employment barely counteracts depreciation and does not generate significant wage growth. Using different econometric techniques, both Blundell et al. (2016) and Costa Dias et al. (2020) take the dynamic effects of part-time employment on human capital accumulation into account. Contrasting their results with the findings on the static effects of part-time work on wages implies that the wage penalty associated with part-time employment is dynamic. The modeling approach in the paper at hand is similar to the framework in Blundell et al. (2016) in that it analyzes dynamic life-cycle effects explicitly. My findings agree that the one-period-ahead penalty is rather small, but the penalty for working part-time for extended periods is substantial. In particular, I argue that, to a large extent, the wedge between part-time and full-time wages opens up because promotion opportunities are foregone when working part-time.

Part-time spells and career interruptions of females are strongly correlated with young children's presence in the household. Looking at childbirth in an event study framework, Kleven et al. (2019) show that motherhood gives rise to "a long-run gender gap in earnings" caused by, among other things, a reduction in the hours worked. The Danish data show that mothers have a lower probability of becoming a manager while being more likely to select into a public sector job. In an experimental study, Correll et al. (2007) find that employers perceive mothers to be less competent and less committed. As a result, they are judged by higher standards regarding expected test scores and receive a lower recommended salary. In the study, the proportion recommended for hire, promotion, and management position is lower among mothers than non-mothers. In their dynamic life-cycle analysis of the motherhood penalty in Germany, Adda et al. (2017) find those career penalties even precede the arrival of children, as forward-looking agents sort into disadvantageous trajectories in anticipation of fertility. In sum, previous literature provides evidence that the presence of children is simultaneously associated with employment interruptions, part-time employment episodes, the lower probability of being promoted, and the opening of a persistent earnings gap. In this paper, I consider the effect of children - particularly children below six years of age - on individual choices on the intensive margin of labor supply. Employment interruptions and part-time spells following a child's birth are modeled so that they can be structurally related to both wage growth within each level on the career ladder and the probability of being promoted to a higher career level. Thus, the motherhood penalty can be decomposed into a pure wage penalty and a career progression penalty.

Several recent studies relate the consequences of extended periods of leave and part-time employment to promotion prospects. Based on 1994-2002 data from Belgium, Deschacht (2017) documents that the yearly promotion probability for women is less than half that of men, with statistics being even more skewed for promotions to managerial positions. The paper shows that higher contract hours and a higher propensity for overtime and late work are associated with higher promotion rates. In the internal labor market of a Chinese firm, Zhang (2019) finds a gender gap in the promotion probability, years to promotion, and the wage increase upon promotion. In this data, the selection into occupations explains as good as the entire gap in promotion premiums, almost two-thirds of the gap in promotion speed, and half of the gap in the probability of promotion. The remaining probability gap is associated with human capital. Hospido et al. (2022) also look at one institution alone - the European Central Bank - and employ data that allows the authors to disentangle applications for promotion from promotions upon application. The results suggest that conditional on applying for a promotion, there is no gender difference in receiving a promotion. However, women are less likely to apply, which correlates with part-time work and children. The data I use for empirical analysis does not allow for the differentiation between the propensity to apply for a promotion and the probability to be promoted conditional on applying. Promotions are observed as an equilibrium outcome of the application process. This aggregation is a disadvantage that is hard to overcome in a country-wide analysis since data on job applications are generally unavailable on such a large scale. The data I employ has the advantage that it is a random sample of the entire German population. Consequently, results from the estimation I perform are better suited for policy analysis, as they do not reflect the status quo of one firm or industry alone but offer an economy-wide view instead.

A second key finding in Hospido et al. (2022) is that promotions are essential for wage growth. The authors find that a large portion of the wage gap is between levels and conclude: "[...] promotions are a major contributor to the gender wage gap.", (p.988). In another paper, Bayer & Kuhn (2018) decompose life-cycle wage growth in several components and state that "it is promotions along the hierarchy dimension that are key to explaining average wage growth", (p.14)[1]. These findings motivate the inclusion of two distinct career levels in the model I develop in Section 4. The exact mechanism explaining why wages increase with promotions, in turn, is motivated by the micro-theoretical model literature, which I turn to comment on next.

The seminal paper of Lazear & Rosen (1990) proposes a tournament model and argues that empirical facts can be rationalized by a lower probability of being promoted for women. Booth et al. (2003) offer a model of sticky floors focusing on explaining differential increases in pay upon promotion, which includes heterogeneity in outside opportunities and productivity. The framework is extended to multiple hierarchy levels in Zucco & Bächmann (2020). In turn, Gicheva (2013) proposes a two-period career ladder model where labor supply choices depend on the heterogeneous preferences of workers, while wage functions on the distinct career levels reward human capital differently. I transfer the notion of a career level and promotion from Gicheva (2013) to the dynamic discrete choice framework in the style of Keane & Wolpin (1997, 2010), Blundell et al. (2016) and Adda et al. (2017). The model I propose enables me to decompose the life-cycle part-time wage gap into a gap in promotions and a gap in wages conditional on the career level. The model can disentangle the two components of wage stagnation and capture their

[1] The comment refers to the sample of male employees the authors analyze. They note that the lack of wage growth over the life cycle they observe for women is due to the slower progression of women up the career ladder, (p. 15).

dynamic effects while controlling for selection on both observable and unobservable characteristics. The results obtained using the model have a causal interpretation and are thus well suited to guide policy targeted at closing the part-time wage gap and, by extension, the gender wage gap. In this way, the paper contributes to the broad literature on gender pay gaps (Goldin 2006, 2014, Blau & Kahn 2017, Granados et al. 2020). Specifically, I find that promotions are highly relevant for wage growth as they propel individuals to a significantly higher persistent wage trajectory. Consequently, policies that increase full-time employment early in the life cycle and, thus, induce more promotions effectively reduce wage gaps.

3. Data

3.1 Data source

The empirical analysis in this paper leverages the German Socio Economic Panel Survey (SOEP). The data has two distinct advantages, making the SOEP most suitable for studying the interactions between working hours choices, wage growth, and promotions. First, the dataset features detailed information on individual biographies, labor market situation, and family composition. Among other key pieces of information, the data include measures of contractual and overtime working hours. The analysis at hand can, thus, target hourly wages and track wage growth and promotions as a function of the choice of working hours[2]. Second, the data feature a classification of the occupation of each individual. Notably, in 2010, this classification of occupations (KldB) was revised and extended to facilitate not just a horizontal but also a vertical differentiation of the occupations. Since 2013, the yearly panel survey records comprise an indicator of the level of expertise and the associated level of responsibility of each occupational position. The availability of this indicator allows me to infer the career level each individual is at and motivates the construction of the estimation sample, which is described next.

3.2 Estimation sample

The estimation sample is an unbalanced panel of females present in the SOEP between 2013 - the survey in that a variable indicating the seniority level was introduced - and 2020 - the latest year currently available for scientific use. Furthermore, the sample is constrained to individuals with a high education level. Specifically, the sample includes women who have obtained a higher vocational degree, a university degree, or an even higher degree. I choose to focus on the group of highly educated women because they are those who have the best career prospects, on the one hand, and whose wage growth is shown to suffer the most as a result of part-time spells, on the other hand, see e.g., Blundell et al. (2016), Costa Dias et al. (2020).

[2] In contrast, administrative labor market data in Germany does not include a measure of working hours and tracks daily earnings instead, see Antoni et al. (2019). The lack of working hours and hourly wage measures renders the analysis of the effect of working hours choices on human capital accumulation impossible.

The sample includes all women who are part of the labor force and are aged 26 to 55. In Germany, for the cohorts represented in the data, the average age at which students complete their education and enter the labor market ranges from 26.5 years in 2013 to around 23.5 years in 2020[3]. The last years of employment before retirement appear irrelevant as far as a chance to be promoted to the high career level is concerned, as promotions of individuals above the age of 55 are very rare in the data[4]. Therefore, I abstract away from modeling individuals approaching retirement and focus on the earlier stages of the life cycle. It is working hours choices in childbearing ages that are strongly associated with the part-time penalty in experience accumulation. Ultimately, this penalty fuels both within-level wage stagnation and the reduced rate of promotions. To conclude the description of the data analyzed in the following, I note that the sample excludes civil servants, self-employed, pensioners, and persons in education, training, military, and community service. It also leaves out disabled individuals and apprentices.

The final sample has information on 3,443 females and consists of 12,342 person-year observations. Table 1 presents summary statistics of the key variables in the data set.

Table 1: Descriptive Statistics

	Mean/Share	Median	S.D.	Min	Max
Age	39.17	38.00	8.53	25.00	55.00
Motherhood	0.56	1.00	0.50	0.00	1.00
Number of Children in Household	0.71	0.00	0.94	0.00	7.00
Age at first Child	29.79	30.00	5.03	16.00	44.00
Contractual Working Hours	33.55	38.00	8.39	2.00	70.00
Overtime Hours	2.11	1.00	2.97	0.00	23.00
Gross Hourly Wage	23.07	21.70	8.80	8.36	59.21
Employment Status					
Non-Working (%)	0.18				
Part-Time (%)	0.31				
Full-Time (%)	0.51				
Promotion	0.11				
Individuals	3443				

Notes: Estimation sample. SOEP 2013-2020. Unbalanced panel of women with high education (N=12,342). Ages 26 to 55. Motherhood indicates the fraction of women who become mothers at some point in their life. Hourly wages are calculated based on the contractual working hours and gross monthly earnings. Adjusted to 2020 Euro equivalents. Employment status as per categorical self-reported classification. Promotion indicates the fraction of individuals observed at least at two points in time who have experienced a promotion.

The average age in the sample is 39.17 years. Fifty-six percent of the individuals have had a child at some point in their life. In the mean, there are 0.71 kids per household. The average age at first birth is ca. 30. The SOEP data contains several measures of earnings from employment and

[3] *Statistisches Bundesamt. (3. September, 2021). Durchschnittsalter von Hochschulabsolventen* in Deutschland in den Prüfungsjahren von 2003 bis 2020 (in Jahren) [Graph].In Statista* (n.d.), accessed 2022-05-25.

[4] In addition, health shocks and informal care for one's spouse and parents start to be increasingly important for time allocation choices. Accounting for such events would significantly increase the requirements on the data without adding much value to the analysis of the career development channel.

hours worked that can be used to calculate each individual's hourly wage. The analysis at hand is performed using the person's gross monthly income from employment and their agreed-upon working hours. Wages are transformed to their 2020 equivalents. The average gross hourly wage in the sample is 23.07 Euros. In the mean, working contracts specify 33.61 hours of work per week. In addition to the agreed-upon working hours, employed individuals report 2.11 hours of overtime. 51% of the person-year observations correspond to years of full-time work, 31% accrue to years of part-time employment. In the remaining 18% of cases, individuals state that they do not work. Finally, 11 percent of individuals are observed to have been promoted from the low to the high career level during the analysis period.

The definition of promotions and the measurement of occupation levels in the data are discussed in detail in the following subsection.

3.3 Occupation levels

For each person-year observation in the estimation sample, the level on the career ladder - low or high - is assigned based on the Classification of Occupations 2010 (KldB, 2010).[5] In 2010, the German Federal Agency of Employment revised the classification of occupations to modernize it and improve its comparability to the International Standard Classification of Occupations 2008, ISCO-2008. Jobs of SOEP respondents are classified according to the KldB 2010 from 2013 onward.

The job of each interviewee in the analyzed SOEP sample is assigned a five-digit code from the KldB 2010. The first four digits of the code facilitate the horizontal differentiation of 700 distinct occupations. The fifth digit of the code distinguishes between up to four horizontal levels within each occupation. The horizontal levels represent groups of jobs with increasing skill and knowledge requirements within the same occupation. The lowest level corresponds to simple, routine-task jobs with low complexity that require low or no specific knowledge. Level 2 corresponds to relatively more complex jobs that require some level of specific knowledge of the profession. Levels 3 and 4 indicate jobs of even higher and highest complexity and specific professional knowledge requirements.

To give a clear idea of the types of occupations and jobs the classification distinguishes, Table 2 lists the occupations and examples of associated jobs that are most frequently observed in each of the four levels. *Level 1* typical careers include jobs in cleaning, storage, geriatric care, cooking, and gastronomy services such as a *geriatric care nurse, kitchen assistant, and waitress.* Examples of common *Level 2* jobs in the data include an *information desk assistant, a cashier in a bank, and a nurse*. Jobs on career *Level 3* and *Level 4* are predominantly jobs typical for larger organizations, such as an *assistant accountant, a management assistant, a social media manager, or a scrum*

[5] Information on the methods and codes of the classification is publicly available, see *Klassifikation der Berufe 2010 – berarbeitete Fassung 2020 Band 1: Systematischer und alphabetischer Teil mit Erläuterungen* (2021).

Table 2: Examples of frequently observed jobs in each occupation level

	Occup. Nr.	Occup. Title	Job Example
Level 1			
	54101	Jobs in Cleaning	Cleaning Assistant
	51311	Jobs in Warehousing	Bottler
	82101	Jobs in Geriatric Care	Geriatric Care Assistant
	29301	Kitchen Staff	Kitchen Assistant
	63301	Jobs in Gastronomy	Service
Level 2			
	83112	Jobs in Childcare and Education	Caretaker
	71402	Office Management	Counter Information Assistant
	71302	Jobs in Commerce and Technical Consulting	Assistant in Commerce
	72112	Bank Clerk	Cashier (Bank)
	81302	Jobs in Medicine and Nursing	Nurse
Level 3			
	72213	Jobs in Accounting	Assistant / Professional Accountant
	92113	Jobs in Advertising and Marketing	Social-Media-Manager
	71393	Executive Business Organisation	Agile Coach / Scrum Master
	71403	Office Management	Management Assistant
	73283	Jobs in Administration	Professional Administration
Level 4			
	83124	Jobs in Childcare and Education	Career Advisor
	84124	Teachers in Secondary Schools	Teacher
	81404	Medical Doctors	Pediatrician
	84304	Jobs in Higher Education and Research	University Professor
	84114	Teachers in Primary School	Teacher

Notes: Examples of occupations and jobs in each respective occupation from KldB 2010, *VII Systematisches Verzeichnis der Berufsbenennung, pp. 126 - 212*. Examples were chosen as the five most frequent occupations for each occupation level present in the estimation sample of the SOEP as described in the main text. The leftmost column contains the occupation code, the last digit in the code stands for the occupation level (1-4). The middle column contains the name of the occupation category. The rightmost column contains one example of a job in the category. Text columns translated from the document's original language, German, into English by the author.

master, jobs in education and research (*teachers and professors)*, and jobs of medical doctors.

For the purposes of the empirical analysis, I map *Level 1* and *Level 2* to the low career level and levels 3 and 4 to the high career level, respectively. I choose to aggregate the four levels into two broad categories for the following reasons. Empirically, the higher two levels are very similar in terms of wage profiles and, by extension, the implied wage function. However, they differ substantially from the lower two levels. While *Level 1* and *Level 2* also seem to differ a lot from one another in terms of the wage function, less than 3% of the person-year observations accrue to *Level 1*. Therefore, I do not look at three levels but rather the career groups, low and high.

A promotion is observed whenever an individual, previously employed in a low career-level job, switches to a job on the high career level. A promotion is always associated with a switch in the tasks one performs on the job. In particular, a promotion implies that task complexity increases. Therefore, it can but must not entail switching occupations. Similarly, a promotion can be associated with but is not limited to a match with a new employer.

3.4 Reduced form evidence

This subsection provides descriptive evidence supporting the hypothesis that the choice of working hours has negative consequences for wage growth in the absence of promotion and for triggering a promotion. First, it discusses the raw differences between wages and working hours on both career levels. Second, it exemplifies the impact the introduction of a distinction between two career levels has on the analysis of human capital accumulation and wage growth. Third, it provides descriptive evidence that moving upward from the low to the high career level correlates positively with working high hours. Each point of the reduced form argument clarifies why the causal life-cycle analysis necessitates a structural model and, thus, represents motivation for the model design.

3.4.1 Descriptive analysis by career level

Table 3 summarizes principal differences in characteristics between individuals employed at the low and high career levels. For example, the mean gross hourly wage at the low level is 17.90 Euros, while the mean hourly wage at the high career level amounts to 24.90 Euros. Similarly, the agreed-upon and the overtime working hours are reported higher at the high career level, by 2.26 and 4.12 hours per week, respectively. All differences are statistically significant at all conventional significance levels.

The following two figures show wage and working hours profiles by age on each career level. Wages on the low career level are visibly lower. Low career-level individuals reach the highest average wage in their late forties. The peak wage is at about the same level as the starting average

Table 3: Descriptive Statistics by Career Level

	Career Leevel Low				Career Level High			
	Mean/Share	S.D.	Min	Max	Mean/Share	S.D.	Min	Max
Age	42.05	8.75	25.00	55.00	38.76	8.56	25.00	55.00
Number of Children in Household	0.61	0.87	0.00	5.00	0.57	0.87	0.00	5.00
Contractual Working Hours	31.95	8.93	2.00	60.00	34.21	8.02	3.00	70.00
Overtime Hours	1.60	2.56	0.00	23.00	2.32	3.08	0.00	23.00
Gross Hourly Wage	17.90	6.70	8.36	59.11	24.90	8.74	8.46	59.21
Observations	2620				6057			

Notes: Estimation sample. SOEP 2013-2020. Unbalanced panel of women with high education (N=3,443). Ages 26 to 55. Years in employment in a job classified as *Level 1* or *Level 2* are aggregated to 'Career Level Low' observations. Years in employment in a job classified as *Level 3* or *Level 4* are aggregated to 'Career Level High' observations. 3,665 person-year-observation amount to periods individuals spent out of work, which is not assigned a career level.

wage that individuals on the high level get in their late twenties. The wage increases workers on the high career level get are much steeper than the wage development of workers at the low-level experience. Peak average wages on the high level are reached at around 40. The wage profile flattens out for the remaining 15 years of the analysis period. Reported working hours on the high career level are higher over the entire life cycle. While hours on the low career level constantly stay around 35 per week for ages 30-55, working hours at the high-level drop in the middle of the life cycle and increase back to 40 hours per week at the end of the observation period.

(a) **Gross Hourly Wages** (b) **Working Hours**

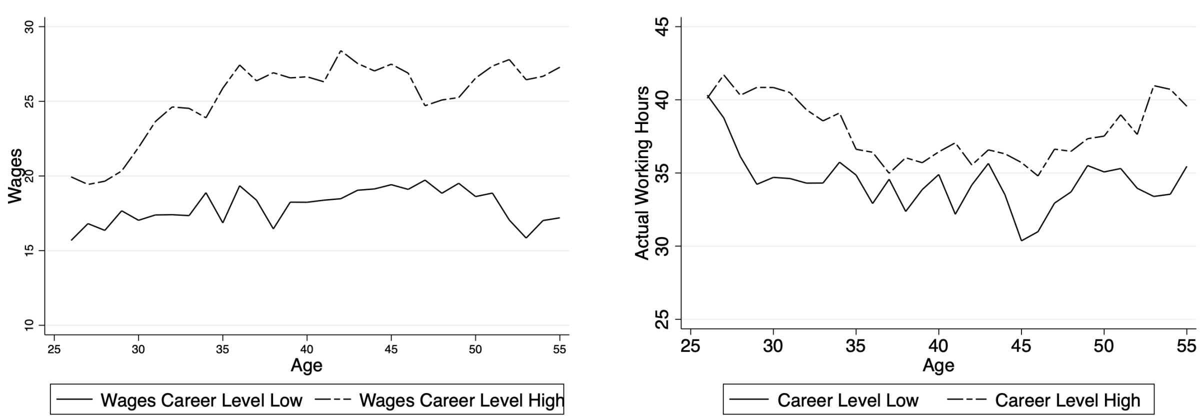


Figure 1: Age profiles of gross hourly wages and working hours by age and career level
Estimation sample. SOEP 2013-2020. Unbalanced panel of women with high education (N=3,443). Ages 26 to 55. Mean gross hourly wages by age and career level shown in panel (a). Mean working hours per week by age and career level shown in panel (b).

The graphical illustration in Panel (a) suggests that, even after conditioning on a high level of education, the dispersion of gross hourly wages individuals earn is substantial. The career level appears to be a significant predictor of the wage level. Further, a detailed look at wages' evolution on both trajectories suggests that the returns to experience also differ by career level. Panel (b) suggests that working hours are lower on the low career level. It is unclear whether low rewards induce low hours or the wage penalties for reduced hours of work lead to a flat wage profile. Finally, the low level of wages, stagnant wage growth, and lower working hours can also be driven by selection along observed and unobserved dimensions. A structural framework encompassing labor supply choices, the wage-generating process, and unobserved heterogeneity allows for estimating the causal effect of experience penalties in wage growth. Obtaining such causal estimates and performing counterfactual policy simulations motivates the structural model described in the next section of this paper.

3.4.2 Working hours choices, experience, and promotions

To gauge the existence of an interaction between hours choices, the resulting level of work experience accumulated, and promotions, I estimate a simple promotion probability model. I run a standard Probit model for promotions, where an individual's probability of finding employment is characterized by a stochastic function of a linear combination of individual full-time and part-time work experience. Experience is normalized on the $[0, 1]$ interval, where one corresponds to an individual having worked full-time the entire time since she was 26; 0 means the individual spent all years out of employment. According to the regression, there is a positive relationship between the experience level on the 0-1 experience grid. The increase appears approximately linear.

(a) **Frequency of Promotions by Age** (b) **Promotion Probability by Experience**

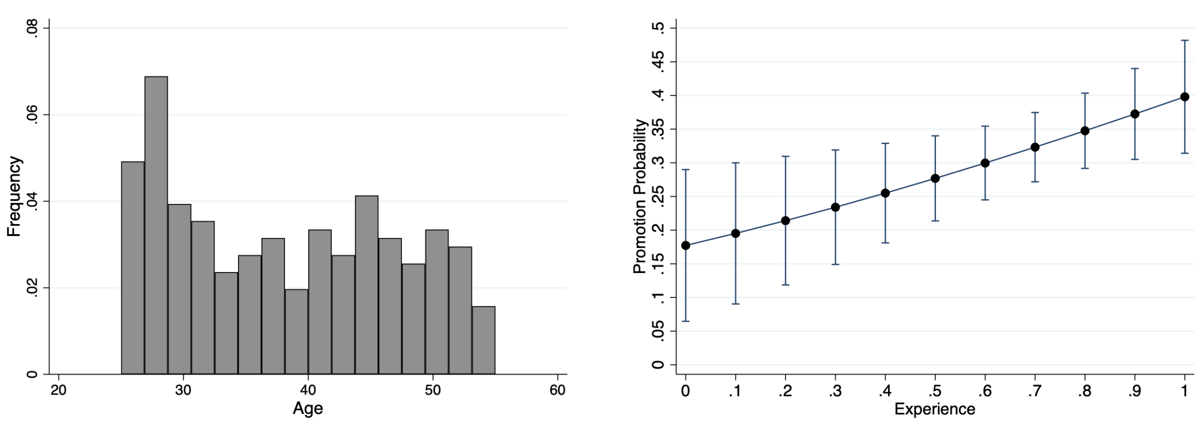


Figure 2: Expected wage growth in full-time and in part-time employment
Describe

Figure 2b shows descriptively the positive dependence of promotions on experience and, implicitly, on working hours. The graph displays adjusted predictions for promotions probabilities and their 90% confidence interval conditional on experience level.

Figure 2a shows the fraction of low level individuals who make a move to the high career level at every age. Most upward moves happen at the very beginning of working life - between the ages of 26 and 33. After that, there is a dip in promotions, with densities increasing again in the mid-forties.

4. A life-cycle model of labor supply, human capital accumulation, and promotions

In this section, I present the model of career hierarchies that I develop to analyze the life-cycle evolution of wages as a function of individual choices of work hours. The model's design allows me to distinguish between experience gaps that open up conditional on the career level of the worker as opposed to between workers employed at different levels on the career ladder. This feature is critical for understanding the mechanisms behind the dynamic part-time pay gap based on the SOEP data. It is further essential for developing policy advice based on counterfactual simulations of policies that target each channel to a different degree.

This section first gives a general overview of the model. Then, it extensively describes all processes in the model and discusses all associated assumptions. In particular, it refers to i) general assumptions; ii) the utility function and the budget constraint; iii) the heterogeneity in the model; iv) the wage process and the human capital accumulation process; v) the hierarchical firms and promotions; and vi) the child arrival process.

General setup Time in the model is finite and discrete. Workers are rational, forward-looking agents who decide how many hours to work from a continuum of possible choices. They solve a dynamic optimization problem, which weighs the utility of consumption against the disutility of work. The workers do not differ in their productivity, but they are heterogeneous regarding the disutility of work. This preference heterogeneity has two components, an unobserved and an observed one. First, there is unobserved time-constant preference heterogeneity specific to each individual. In addition, workers of different observed characteristics experience different added disutility of work. In each period, an agent may get a newborn child with a certain probability that depends on the person's age. Individuals have complete information and rational expectations about the stochastic fertility process. The presence of a child in a particular age group is the key determinant of the level of added observable-related disutility from work faced by the individual.

The wages earned in the labor market depend on the human capital the individual has accumulated up until each period. They further depend on the career level of the individual. Each worker employed at the low career level can receive a promotion to the high career level with some probability strictly lower than one, which also depends on the individual's accumulated human capital. Crucially, the model allows for a convex relationship between the hours of work chosen in the period and the amount of human capital accumulated in that period. In other words, it allows for the possibility that working, e.g., half a work day, adds less than half a unit of human capital to the human capital stock of the worker. By extension, the within-career-level wage growth and the probability of promotion depend on the history of working hours choices. Should the individual choose not to work, she does not accumulate additional human capital in that period. She does not earn a wage but finances her consumption through the benefits she receives. These benefits depend on whether or not the agent worked last period and the presence of children.

Choice set Individuals enter the model after completing higher education at the age of 26. Every period for the next thirty years, each agent chooses how many hours to work. Individual wages and careers evolve until the age of 55. The workers then continue to earn the same wage they earned at age 55 for another ten years. The model ends shortly before individuals reach retirement entry age.

The individuals have a continuous set of choices of hours to work on the interval $[0, 48]$, which I normalize to $[0, 1]$ for computational convenience. Zero corresponds to the choice not to work; 1 corresponds to the choice to work overtime, with overtime capped at 48 hours of work per week. For example, the choice of 0.2 corresponds to working 8 hours per week.

Utility function I assume that the instantaneous period utility of consumption is isoelastic with constant relative risk aversion. The disutility of work is additively separable from the utility of consumption and quadratic in the hours worked as in Gicheva (2013).

$$u_{itj}(h_{it}) = \frac{c(w_{itj})^{1-\eta} - 1}{1-\eta} + (F(\theta_{0p}, i) + \theta_1 X_{it})h_{it}^2 \tag{1}$$

The level of disutility agents experience is determined by observed and unobserved factors. There are two types of individuals in terms of individual-specific unobservables. Unobserved heterogeneity follows a χ^2 distribution with 10 degrees of freedom and a scaling factor θ_{0p}, so that $F(\theta_{0p}) = \frac{\chi^2_{10}}{\theta_{0p}}$. p denotes the unobserved disutility type.

In addition, the individual disutility of work differs along observable characteristics of the agent related to the presence and the age of children. In particular, X is a vector of dummy variables indicating if, in period t, the individual has her youngest child in one of the following age groups: 0, 1-2, 3-5, and 6 or older. The four model parameters in the vector θ_1 measure the added disutility of an additional hour of work in case the woman's youngest child falls in one of the age groups. The bins are chosen in relation to the kinks in the child-related payments the woman may receive, the cost of childcare the woman faces, and social norms on child-rearing in Germany. A mother is eligible for a motherhood replacement if she decides to stay not employed in the first year after the child's birth. Childcare costs drop for children older than three years of age. Popular opinion suggests that it is beneficial for the child to be taken care of by the mother in the first year and, if possible, even longer, until around three years of age.

Budget constraint

$$c(w_{itj}) = w_{itj}(exp_{itj}) + T(h_{it}, X_{it}) - CHC(ch\_age). \tag{2}$$

Period consumption is the sum of the wage the individual earns on the labor market, the transfers she receives from the government, the taxes she pays, and the childcare costs she incurs. The taxes and transfers $T(h_{it}, X_{it})$ depend on the presence of children and the choice of hours of work. The latter determines if the individual pays income taxes ($h > 0$), if she receives unemployment benefits, or if she receives unemployment insurance ($h = 0$).

Individuals without children who choose non-employment receive unemployment insurance in the first year of unemployment and social security if not employed for longer than one year. Mothers, who choose not to be employed in the first year after their child is born, receive a motherhood replacement of 67% of the labor market wage they would have otherwise earned in the period. In addition, all individuals with a child receive a means-tested child benefit. Women with children younger than 6 incur childcare costs if they choose to work and, thus, cannot take care of the child full-time. Childcare cost is assumed to be higher for children aged 0-3 and lower for children aged 3-6. There is no cost to be paid once children enter school at the age of six.

Wages The log wage in the model is given by:

$$\ln w_{itj}(exp_{it}) = \delta_j + \gamma_{1j} exp_{it} + \gamma_{2j} exp_{it}^2 + \xi_{it} \tag{3}$$

$$exp_{it} = e_{it} t \tag{4}$$

$$e_{it} = e_{it-1} + \Gamma(h_{it}) \tag{5}$$

The specification in equation 3 corresponds to a Mincer (Mincer 1958) wage regression where the linear contribution of the years of education is contained in the constant $d = \ln(w_0) + \rho s$. This representation is in line with the fact that all agents have the same level of education and enter the model at the same age. The important contributor to wage formation, which differs endogenously by period and individual, is the level of accumulated experience, exp_{it}. Wages are measured with error ξ_{it}.

The wage equation specifies that wages depend on the hierarchy level the individual is employed in j. The wage functions of the different career levels have the same structure but differ in the parameters d_j, c_{1j}, and c_{2j}.

Experience accumulation The wage-relevant level of experience in each period exp_{it}, equation 4, is measured in effective years of experience. It is a function of each individual's past choices of work hours. The period value of this key variable is obtained by multiplying the fraction of years spent working effectively, e_{it}, by the maximum potential experience in the respective period $e_{it_{max}} = t$.

The evolution of the effective normalized stock of experience, e_{it}, is formalized in equation 5. Effective units of experience accumulate such that individuals who choose to work less than h_{max} experience a penalty in experience accumulation in a fashion similar to Blundell et al. (2016). $\Gamma(h)$ represents a weighting function that determines what fraction of a full unit of experience is added to the experience stock depending on the current period hours choice h_{it}. I normalize $\Gamma(0) = 0$ and $\Gamma(h_{max}) = 1$. The normalization implies that choosing not to work adds no human capital to the human capital stock in the coming period; working the maximum amount of hours possible in the model adds one until of human capital to the human capital stock in the coming period.

On the interval $(0, 1)$, the chosen amount of time to work adds a fraction of a unit of experience to the next period's human capital stock. The size of the penalty for working less hours, $h_{it} < h_{max}$, can vary from 'no penalty', to 'zero experience added' if $h_{it} < h_{max}$. The structural assumption on the functional form of the penalty is represented by the transformation $\Gamma(.) = (y_2 - y_1)\frac{m^{(x-x_1)}-1}{m^{(x_2-x_1)-1}} + y_1$ of the line $(x_1, y_1) = (0, 0)$, $(x_2, y_2) = (1, 1)$. The key parameter governing the penalty's size in experience accumulation in the model is m. $m > 1$ implies that working less than h_{max} hours per week adds less than h to the experience stock, i.e., $\Gamma(.)$ is convex.

The dependency of the size of the penalty on m is illustrated graphically in Figure 3.

The black line, $m = 1$, corresponds to the 'no penalty' case. The absence of a penalty has been the standard assumption in the vast majority of research on female human capital accumulations, with the notable exceptions of Blundell et al. (2016) and Adda et al. (2017). If there is no penalty for experience accumulation, choosing to work half a day in the period adds 0.5 units of experience to the human capital stock in the period to follow. A convexity in experience accumulation, $m > 1$, translates to an hourly wage penalty for working less than h_{max}. The value of the coefficient m governs the degree of convexity implied. For example, $m = 2$ and $m = 20$ imply a gain of 0.4 and 0.2 effective experience units, respectively.

In sum, equation 5 gives the effective, wage-relevant, stock of full-time experience equivalents in period t normalized on the interval $[0, 1]$. An individual who has chosen to work the maximum number of hours in every period up until t has $e_{it} = 1$, while an individual who has never worked until t has $e_{it} = 0$. Correspondingly, $exp_{it} = exp_{it_{max}} = tg(h_{max}) = t$ for the former set of individuals, and $exp_{it} = 0$ for the latter.

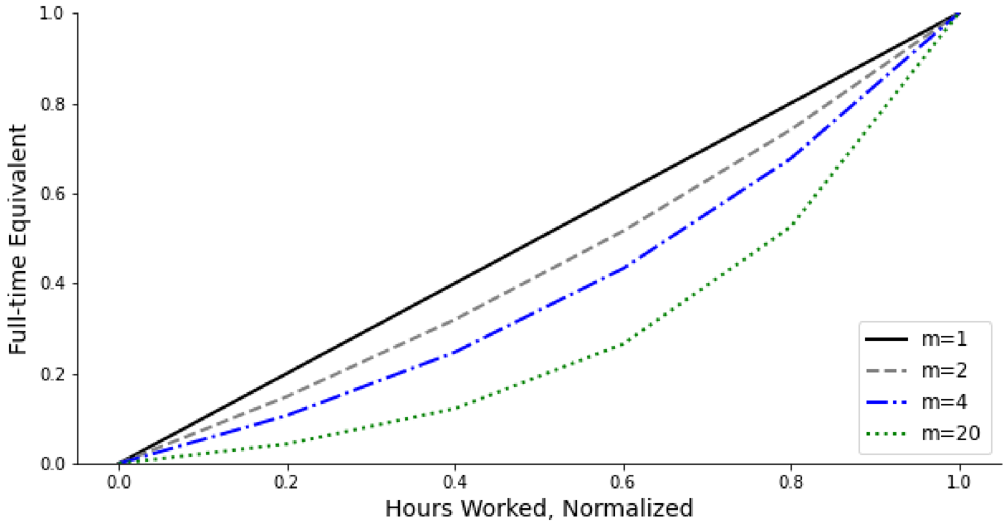


Figure 3: Degree of convexity
Full-time experience equivalents added to the human capital stock according to the size of the experience accumulation penalty as governed by m. The 45 degree line corresponds to 'no penalty'. The higher the degree of convexity of the transformation of this line, the higher the penalty.

Career levels and promotions mployment in the model is possible on two career levels. I assume that the supply of low-level jobs is fully elastic for individuals with high education. This proposition results in the fact that if the wage offered at the junior career level exceeds the reservation wage of the agent, she always chooses to be employed and receives $w_{it1}(e_{it})$. Jobs on the high career level, in contrast, are assumed to be in limited supply. Employment at the high level is, thus, subject to constraints. The constraints manifest in that individuals employed on the low career level who would prefer a high-level position are promoted with a probability $p(e_{it})$, bounded away from one.

The promotion probability process is modeled as an increasing, linear function of the experience stock e_{it}, which tracks the fraction of the time since the age of 26 each woman has spent working effectively:

$$p(e_{it}) = \pi_a + \pi_b e_{it}. \tag{6}$$

Individuals who choose to work the maximum number of hours every period have a higher chance of being promoted than those who choose to work part-time or be away from the labor market. The promotion probability function is known to the agents. Individuals can start their working life at either level on the career ladder, and demotions are assumed away.

Given the assumptions of partially constrained choices, taking into account the level of disutility the worker faces, she considers two types of trade-offs when choosing her preferred working hours arrangement. First, fewer hours worked are associated with low disutility of work but will result in a lower wage in the current period and slower wage growth in the following periods. Second, with the promotion probability being an increasing function of working hours, choosing to work fewer hours implies lower chances of being employed in a high-level job.

The desirability of employment at the high level depends on the level-specific wage functions. If the wage on the high career level is lower than the wage on the low career level over the entire range of exp_t, then no one would be interested in a high-level position. All employment would be on the low level, and the promotion probability cannot be identified. I consider this case to be empirically irrelevant. Conversely, suppose the high-level wage function dominates the low-level wage function over the entire range of years of experience. In that case, every individual will always prefer a high-level over a low-level position. As a result, all individuals will wish for a high-level job, and only a fraction will land the desired position as prescribed by the promotion probability function. Finally, for specific values of the parameters, it can be the case that the part of the population that prefers to aim for a promotion is a function of the agent's disutility in the respective period. In particular, some individuals will never be interested in the promotion. Others will always prefer employment at the high career level. The final group will get a higher lifetime utility of promotion only if it happens early enough in the life cycle. I consider the latter two cases possible empirically and apply parameter constraints in the estimation procedure, respectively.

Child arrival Child arrival in the model is exogenous. The birth of a child is a probabilistic event, and the probability of getting a newborn depends on the woman's age. It does not depend on the number of children the woman already has. The probability distribution of child arrival is known by agents and accounted for in their decisions. The probability of child arrival is estimated from the data. It corresponds to the empirical share of newborns among women of each age. The empirical probability and the resulting exogenous probability of child arrival in the model is zero after age 44.

Maximization problem The agents in the model maximize the discounted sum of expected lifetime utilities:

$$V_t(Z_t) = \max_{\{h_\tau\}_{\tau=t,\dots,\bar{t}}} E\{\sum_{\tau=t}^{\tau=\bar{t}} \beta^{\tau=t} u(h_t)|Z_t\}, \tag{7}$$

by choosing optimal working hours h_τ conditional on the state Z_t. The state space includes the age of the youngest child determined by the exogenous child arrival process and updated in a deterministic fashion if no new child is born. It further comprises the age of the individual, the evolution of which is also deterministic. The final state space components are related to the working hours choice and include both the level of human capital and the career level of employment. The rate at which individuals discount future utility is denoted by β.

5. Estimation

The estimation of the structural parameters of the model is performed with the Method of Simulated Moments (MSM). Before running the MSM procedure, the probability distribution of the exogenous process of child arrival and the distributions governing the initial conditions are estimated outside the model. This section discusses pre-set parameters, estimations performed outside the structural model, and the MSM. It gives an intuition about the identification of the different sets of parameters.

5.1 Pre-set parameters

Before running the MSM estimation, I specify and fix several parameters. The pre-set parameters can be separated into two groups: parameters that are set based on the fact that the empirical application concerns Germany; and parameters not specific to the German case. Latter are taken from previous literature, as they cannot be estimated given the structure of the model as described in the previous section and the data at hand.

The cost of childcare for children below three years of age is set to 64 Euros per week, and the cost of childcare for children aged 3-6 to 32 Euros per week, in alignment with the childcare cost calculations in Geyer et al. (2015). The child benefits in the model amount to 51 Euros per week, purposefully 10 to 30% percent higher than the allowance for mothers with one child in the analysis period. I introduce a higher level of the benefits to account for the fact that child benefits in the model do not depend on the number of children the way they do in reality. As most women have only one child, with very few having three or more, I consider the approximation suitable to account for the occasional presence of mothers of two children.

As far as payments in unemployment are concerned, the replacement rate for parental leave and unemployment insurance is 67%, per German legislation effective in 2022. Unemployment benefits amount to 100 Euros per week, which I view as a suitable approximation of the average benefits received across German federal states in the period I analyze.

Finally, as regards the group of pre-set structural parameters that are not specific to the German case, the discount factor β is fixed to 0.98, as in Blundell et al. (2016). The coefficient of the degree of relative risk aversion η is set to 1.1, thus introducing risk aversion in the model only to a mild degree. I refrain from setting the parameter high because strong concerns about risk may impact the labor supply choice too heavily. As savings are assumed away, it represents the only channel agents can use to ensure against risk.

5.2 Exogenous process and initial conditions

Child arrival is assumed exogenous in the model. The probability of child arrival is set equal to the empirical frequency of births given the woman's age in the data. Figure 4 shows the distribution of child arrival probabilities by the age of the mother (Panel (a)) and the evolution of the proportion of women who have become mothers over the life cycle (Panel (b)). The highest probabilities of child arrival correspond to ages 30 and 37, with a peak of over 14% at 32. The probability decreases abruptly after the age of 37. Finally, the number of mothers stops growing at age 44. The probability of child arrival for individuals older than 44 years of age is set to zero[6].

(a) **Probability distribution of child arrival** (b) **Simulated share of mothers**

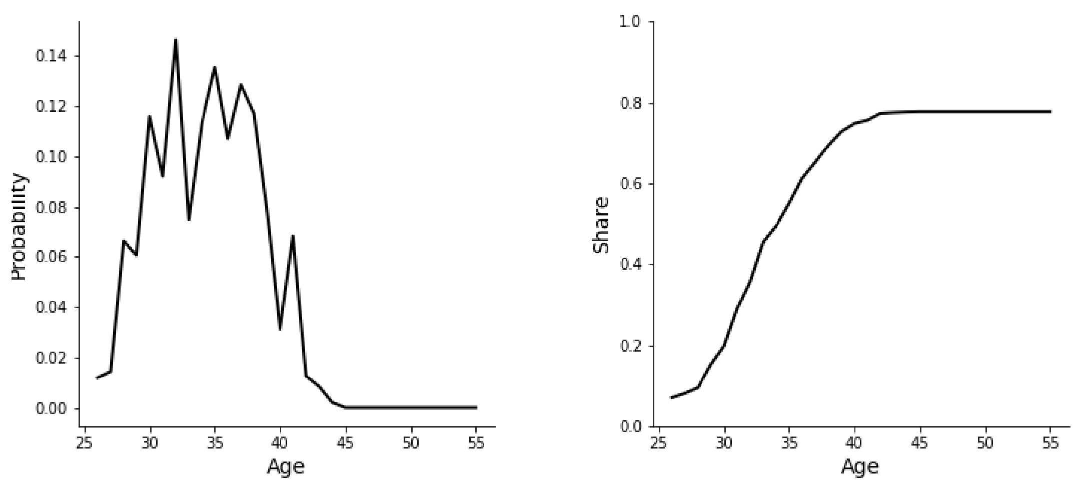


Figure 4: Exogenous child arrival process
Panel (a) shows the probability distribution that agents in the model take into account when building an expectation about child arrival in the period given their own age. The probabilities correspond to the observed shares of newborn children by age of the mother in the estimation sample. Panel (b) plots the share of mothers in the simulated sample that results from newborn children arriving according to the probability distribution in Panel (a).

Individuals can have children born before entering the model at age 26. This is the case for ca. 8% of the women in the SOEP sample. The distribution of the ages of the youngest children in the first period of the model equals the empirical distribution of the youngest child ages among

[6] Childbirth does not occur after 44 years of age, as the few women who give birth at a higher age according to the SOEP are not included in the sample.

individuals aged 25 in the data.

The estimation sample includes only women with high education. The number of years of education is not a choice variable in the model. Thus, the level of education can be viewed as an initial condition. Individuals can start their working life at either level of the career ladder. I let as many individuals enter the model at the high career level to match the proportion of high-level employment at age 25 in the SOEP estimation sample.-level employment at age 25 in the SOEP estimation sample.

5.3 Structural parameters

5.3.1 Method of simulated moments

I estimate the model using indirect inference. Intuitively, I use the method of simulated moments to choose a vector of parameters to minimize a criterion function representing distance. The criterion function measures the weighted distance between a collection of moments of the observed data and their counterparts from a data set simulated using the specified model. The moments summarize the essential aspects of individual decision-making and behavior in the data and inform the identification of the model's parameters.

Formally, let ω denote the collection of parameters to be estimated in the MSM procedure. Then, the indirect inference estimator of ω is given by:

$$\widehat{\omega} = \underset{\omega}{\operatorname{argmin}} \left(\widehat{mom\_obs} - \widehat{mom\_sim}(\omega)\right)' \Sigma \left(\widehat{mom\_obs} - \widehat{mom\_sim}(\omega)\right), \tag{8}$$

where $\widehat{mom\_obs}$ denotes the vector of moments related to the behavior observed in the estimation sample and $\widehat{mom\_sim}(\omega)$ denotes the vector of moments calculated based on the simulated data from the life-cycle model with parameter values ω.

The minimization problem is based on the weighted squared difference of the moments with a diagonal weighting matrix, Σ. I obtain an estimator of the optimal weighting matrix, $\widehat{\Sigma}$, by bootstrapping the variance of the observed moments. $\widehat{\Sigma}$ is a diagonal matrix containing the standard deviation of each moment on the diagonal.

Standard errors of the estimated parameters correspond to the elements on the square root of the diagonal of the variance-covariance matrix:

$$(\widehat{D}'\widehat{\Sigma}\widehat{D})^{-1}\widehat{D}'\widehat{\Sigma}\widehat{\Omega}\widehat{\Sigma}\widehat{D}(\widehat{D}'\widehat{\Sigma}\widehat{D})^{-1}, \tag{9}$$

with

$$\widehat{D} = \frac{1}{2}\left.\frac{dM(\omega_l)}{d\omega_l'}\right|_{\omega_l=\omega} \tag{10}$$

The simulated moments are denoted M. Ω is the variance-covariance matrix of the observed moments. $\hat{\Omega}$ is estimated in the same bootstrapping procedure as $\widehat{\Sigma}$.

5.3.2 Moments and identification

The estimation procedure uses 115 moments that describe the behavior of females on each level of the career ladder, given their observable characteristics, as well as the wages these females earn. The moments can be calculated both given the information available in the SOEP estimation sample as described in Section 3 and from the data simulated using the model described in Section 4.

Establishing the identification of each of the model's parameters formally is challenging. In the following, I provide a heuristic identification argument for each parameter group by discussing the variation in the data that informs the value of each respective parameter. First, wage equation parameters are associated with the empirically observed evolution of wages. In particular, constants are strongly related to wages earned at the beginning of the life cycle, when individuals are just starting to accumulate job-relevant experience. The returns to experience are, in turn, determined by wage gains due to working the maximum number of hours. The degree of convexity of experience accumulation, m, is driven by the downward deviation in wage gains when working less than the maximum number of working hours. The vector of moments used in the MSM procedure includes log wages by the level of experience and log wages by the woman's age on both levels of the career ladder to capture the identifying variation for the wage parameters.

Second, disutility parameters are associated with individual choices. The observed disutility component θ_1 is strongly related to the working-hours choices of individuals with respective X_i. The unobserved component of the disutility, θ_0, drives the hours' choices of workers with baseline X_i given the career level. The moments used to describe the relevant variation in choices include the average working hours by the youngest child's age and the faction of individuals with a child in each age group, as specified in Section 4, choosing different numbers of working hours. Importantly, choice moments and wage moments, while most likely primarily associated with a disutility and a wage parameter, also inform other parameter groups via selection mechanisms and dynamic human capital accumulation. Choices are related to the level of wages; reversely, wages are related to the level of experience, which is the product of past choices.

Finally, the probability of promotion is informed by the number of promoted individuals, the ratios of promotions given the history of hours choices, and hours choices unexplained by the wage equations.

6. Results

This section presents the estimation results based on the structural model and the SOEP data. It discusses the parameter estimates, the model fit, and the estimates' implications for the decomposition of the wage penalty in a i) within versus a ii) between-career-level component.

6.1 Parameter estimates

Table 4 presents the parameter estimates from the endogenous model coefficients obtained in the MSM procedure.

The parameters of the wage equation imply that both the general level of wages as well as the experience rewards are higher on the high career level. The concavity of experience accumulation is also higher. There is no stark difference in the disutility of work between the two unobserved heterogeneity types. 42.8% of individuals are estimated to belong to the 'low type' group.

Individuals differ more strongly in the level of disutility they experience, as predicted by observables. The baseline level of disutility is assigned to individuals without children. Compared to the baseline group, disutility associated with the presence of children is highest for children aged one to two and decreases with the increasing age of the youngest child. Individuals whose youngest child is already in school - six years old or older - have almost the same disutility of work as the group of individuals who do not have a child, with $\theta_4 = 0.010$. At first glance, the parameter on newborn children seems at odds with the general pattern in the group of observed heterogeneity parameters. It is estimated to be the lowest of the group, $\theta_0 = -0.032$. The estimate is explained by the transfers mothers receive in the first year after childbirth. The transfers function in Germany is generous, replacing 67% of the mother's net labor income in the year before the birth, with a cap at 1,800 Euros per month. This transfer, plus the child benefits the mother receives on top, is estimated to overcompensate young mothers, who work around eight hours per week on average, maintaining their labor market attachment even in the presence of newborn children.

Finally, the slope of the promotion probability function on the interval $[0, 1]$ is estimated at 0.063. For example, this corresponds to a promotion probability of 4.5% for an individual working $0.5 * h_{max}$ in the first year after completion of education. The promotion probability of a worker choosing to work h_{max} hours is around 2% higher.

6.2 Model fit

Figure 5 illustrates how the data simulated using the model fit the empirically observed SOEP data. It shows the model fit for the central life-cycle patterns modeled in the structural framework: hours choices (Panel (a)) and wages by career level (Panels (b) and (c)). Data generated by the model further align well with moments by the age of the youngest child and, as

Table 4: MSM Estimates of structural model parameters

Group	Parameter	Description	Value
Wage equation	δ_1	constant level low	2.653
			(0.002)
	δ_2	constant level high	2.732
			(0.001)
	γ_{11}	linear exp. term level low	0.042
			(0.000)
	γ_{12}	linear exp. term level high	0.161
			(0.000)
	γ_{21}	quadratic exp. term level low	-0.002
			(0.000)
	γ_{22}	quadratic exp. term level high	-0.008
			(0.000)
	m	degree of convexity exp. accum.	2.166
			(0.008)
Heterogeneity unobs.	θ_{01}	scaling factor type low	42.362
			(1.748)
	θ_{02}	scaling factor type high	47.112
			(3.173)
	$prob_{low}$	probability low type	0.428
			(0.000)
Heterogeneity obs.	θ_0	disutility child age 0	-0.032
			(0.000)
	θ_2	disutility child age 1,2	2.939
			(0.006)
	θ_3	disutility child age 3, 4, 5	1.186
			(0.001)
	θ_4	disutility child 6 or older	0.010
			(0.000)
Promotions	π_b	promotion probability slope	0.063
			(0.000)

Notes: Estimates of the structural parameters of the model presented in Section 4 based on the SOEP estimation sample discussed in Section 3. MSM estimation based on 115 moments. Estimates rounded to three digits. Standard errors in parenthesis.

well as moments not targeted in the estimation procedure.

6.3 Wage processes by career level

The estimated empirical structural model offers insights into the wage dynamics on the different levels of the career ladder. These are critical inputs to the decisions the modeled individuals make. While some patterns of interest are harder to quantify without the help of additional calculations, several interesting conclusions can be drawn directly from the parameters of the wage equations.

The first key finding concerns the level of the constants of the wage processes. They are structurally related to the earnings of individuals as predicted by the occupation level without a history of work experience. Having taken selection into account, the baseline earnings on the high career level are estimated to be higher than those on the low career level: $\delta_2 = 2.732$ and $\delta_1 = 2.653$, respectively. Some micro-theoretical applications, e.g., Gicheva (2013), assume that, without much relevant work experience, earnings in simple junior jobs are higher. In contrast, advanced senior jobs pay more if workers are already experienced. However, I do not find support for this assumption in the data at hand.

The second central finding is related to the estimated returns to experience accumulation. The linear component of the returns to experience is markedly higher on the high career level - $\gamma_{12} = 0.161$ versus $\gamma_{11} = 0.042$. These generous experience rewards drive the steep wage increases experienced by young individuals on the high level. However, the convexity of experience accumulation, $\gamma_{22} = -0.008$, is also much more pronounced on the high career level. Correspondingly, the more human capital the individual has already accumulated, the less attractive to collect further experience on the job, as the convexity in returns kicks in.

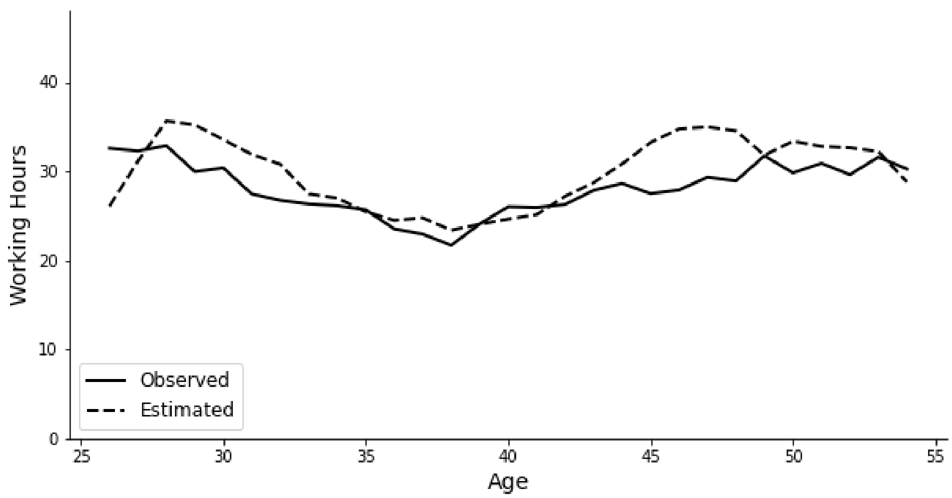
In sum, wages at the high career level dominate wages at the low career level over the entire range of the experience distribution[7]. A promotion is, thus, desirable for all agents in the model. It is optimal at every stage of the life cycle regardless of the level of disutility of work the individual faces. Promotions to the high career level permanently transfer workers to a higher wage trajectory. The implications of this result for the efficacy of policy interventions are discussed in the next section. In the following, I now turn to a discussion of the part-time penalty and its decomposition.

6.4 Part-time penalty in experience accumulation

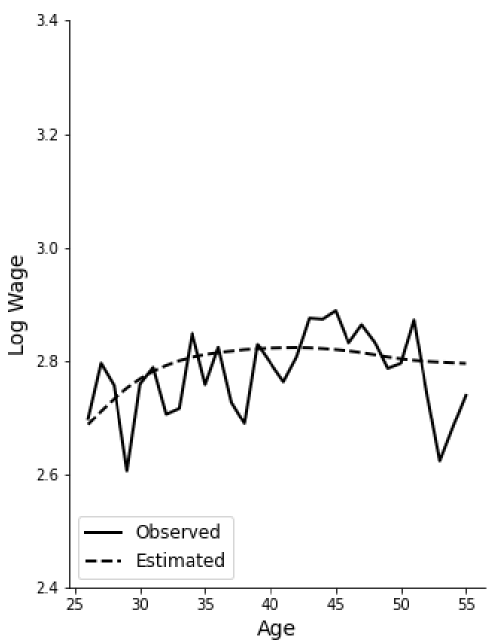
The part-time penalty in experience accumulation in the model is determined by the degree of convexity of the experience accumulation function $\Gamma(h_{it})$. The convexity parameter m equals 2.116, which implies that working 20 hours a week increases the experience stock by ca. 0.42

[7] This statement considers both the linear and the squared terms in the wage processes, eq. 3. It holds true in the presence of part-time penalties as estimated using the SOEP sample and in the absence of a part-time experience accumulation penalty, i.e., if convexity in experience accumulation is assumed away.

(a) **Working hours per week**



(b) **Log hourly wage, Level low**



(c) **Log hourly wage, Level high**

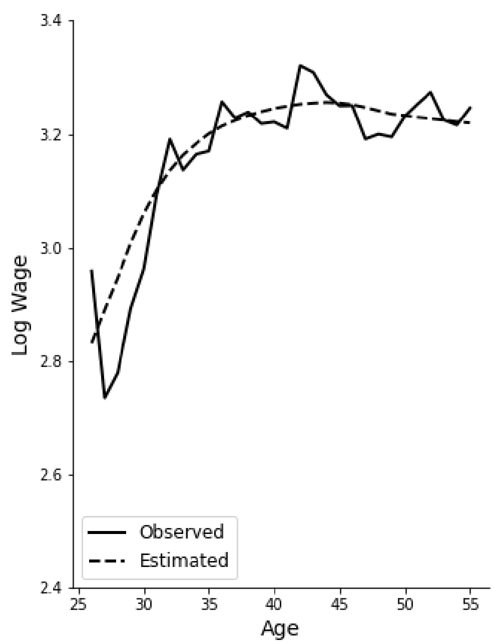


Figure 5: Model fit

The figure shows how data simulated with the model and the estimated parameter vector matches key patterns in the data. Panel (a) shows the fit between observed and simulated average weekly working hours by age. Based on actual working hours reported in the GSOEP estimation sample. This statistic is not directly targeted in the estimation process. Panels (b) and (c) show observed and simulated average age profiles of log wages at the low and the high career level, respectively.

full-time equivalence units. This estimate corresponds to almost a threefold decrease in the estimated experience accumulation penalty for working part-time compared to the penalty estimates in previous literature that does not explicitly include promotions. As a comparison, Blundell et al. (2016) estimate that, depending on the level of education, working part-time adds only up to .15 units of a full-time experience equivalent to the human capital stock of the worker.

The difference in the result is directly related to the differences in the model design. In the absence of career levels, a wage raise following a promotion is interpreted as a wage increase following directly from the accumulation of human capital. When experience accumulation is assumed to determine the probability of promotion, a significant part of the observed wage growth is attributed to the increase in the probability of promotion to the higher paying high career level. Consequently, introducing promotions results in lower experience penalty estimates.

The implications of the varied dynamics of the part-time penalty in experience in the presence of hierarchical wage structures and promotions for policy are discussed in Section 7. In the remainder of this section, given the parameters of the wage generating processes on both career levels and the estimate of the part-time penalty in experience accumulation, I quantify the wage penalty an average individual experiences, and the decomposition of the wage stagnation due to part-time work in a *i) promotions penalty* and a *ii) within-career-level penalty.*

6.5 Dynamic implications of the part-time penalty in experience accumulation

6.5.1 Average individual part-time penalty

To ease exposition, I evaluate the size of the wage penalty in the model framework with promotions for an individual who reduces her working hours for two years in a row starting at age 31. I assume that the individual worked 40 hours a week between the ages of 26 and 30 and then spent a year not working following the birth of a child. This trajectory corresponds to a pattern commonly observed in the data; thus, I call the model agent 'the median individual'. Next, to measure the total part-time wage penalty, I compare the part-time wage trajectory of the worker with the wages she would have earned had she returned to work full-time. Finally, I focus the following arguments on full-time, defined as $h = 40$, and part-time, defined as 50% of full-time, $h = 20$. In this way, I can ensure comparability with the vast body of previous work that analyses part-time, assuming that part-time work amounts to working half a day, or around 20 hours per week.

At 33, the median individual earns 22.24 Euros per hour. This amount corresponds to the hourly wages on the low and the high level weighted by the probability that the worker received a promotion given her history of working hours choices. In comparison, she would have received 23.20 Euros per hour if she had returned to work full-time after the employment interruption.

This implies a penalty of 0.96 Euros per hour[8].

The one Euro penalty is the gap between the full-time and the part-time trajectory for the average individual after two years of part-time work. It is the sum of hampered wage growth conditional on the career level and forgone chances of a promotion. The penalty is more considerable if part-time employment implies less than 20 hours of work per week. The penalty will grow larger the longer the worker stays on a part-time trajectory. The question of primary interest in this paper - the decomposition of the penalty in i) the penalty in promotions and ii) the penalty in wage growth conditional on the career level - is discussed next.

6.5.2 Within-career-level penalty

(a) **Career level low** (b) **Career level high**

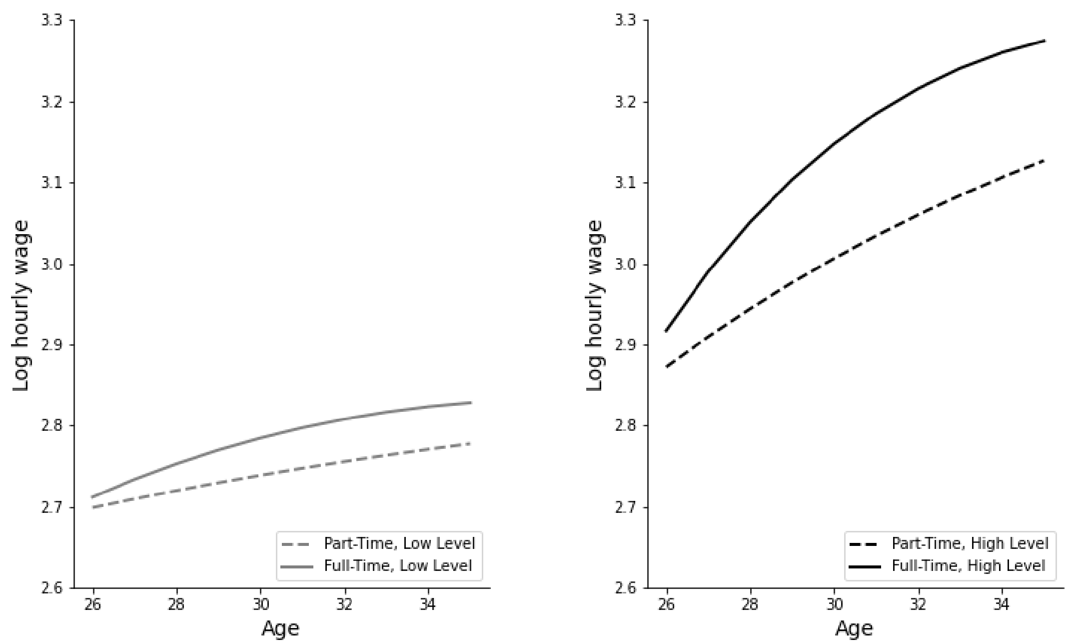


Figure 6: Part-time wage penalties by career level
Panel (a) shows the trajectories of hourly wages for employees on the low career level. Solid lines label full-time workers, dashed lines - part-time workers. Full-time corresponds to 40 hours of work per week; part-time corresponds to 24 hours pf work per week. In an analogous fashion, panel (b) plots the hourly wage trajectories for full-time and part-time workers on the high career level.

Figure 6 shows the wage trajectories for full-time and part-time workers on both career levels, as the empirical structural model implies. The graph provides a visualization of the relative size of

[8] Or appx. 4% of the full-time trajectory wage.

the part-time penalty within each level. The average hourly wage penalty over the first ten years of the life-cycle amounts to 0.66 and 2.82 Euros per hour, or 12.17% and 4.10%, on the low and on the high level, respectively. The penalty for working half a day is around three times larger on the high career level.

At first glance, the within-level-penalty pattern is less visible in calculating cumulative gross earnings for the two career levels. Earnings on the part-time trajectories appear much lower than suggested by the hourly wage penalty. This result is due to the mechanical loss of earnings in part-time employment: part-time workers earn only half as much as full-time workers, even without penalties, simply because they spend less time working. Therefore, earnings calculations need to be adjusted for the difference in working hours on the two trajectories to isolate the implication of the part-time penalties. The adjusted penalty in gross yearly labor earnings measures 5,423 Euros per year on the high career level and 1,273 Euros per year on the low career level.

The fact that the within-career-level penalty is lower on the low career level is closely related to the finding that wage growth at the low career level is limited, even for workers who accumulate experience fast. The wage profile on the low career level is generally flat. The low returns to experience, in turn, induce optimality of part-time work. In sum, the lack of wage growth on the low career level is the consequence of both low returns and slow experience accumulation. Working high hours cannot entirely escape the low-wage trap at the low career level. Earning low wages is best avoided by moving to a high career-level job.

6.6 Part-time penalty decomposition

In this section, I add the dimension of the penalty in promotions and turn to the penalties decomposition. For the analysis, I again look at the average individual example. I assume that at age 31, she is still employed at the low career level. I trace her path in two scenarios: i) she chooses to work full-time, $h = 40$, for the next four years, or ii) she chooses to work part-time, $h = 20$, in the next four years.

At age 35, the gross labor earnings of the individual, cumulative over the four years, amount to 171,655 Euros on the full-time and 162,175 Euros on the part-time trajectory, respectively[9]. The implied total penalty is 9,480 Euros or 2,370 Euros per year. The amount part-time workers lose in a year is thus comparable with the average net monthly earnings on the high career level. On top of earning half the amount full-time workers earn due to working 20 hours a week every year, part-time workers are additionally penalized by a monthly wage's worth.

In order to juxtapose the wage losses due to forgone chances to get a promotion and the within-level wage penalty, I simulate the average earnings trajectory of the worker in the part-time

[9]Part-time calculation adjusted for the mechanical effect of working lower hours.

scenario while setting the probability of promotion equal to the probability of promotion in the full-time scenario. Adjusting for the difference in promotion chances, I find that 55% of the overall penalty accrues to the forgone possibility of promotion. If individuals on the part-time trajectory faced the same probability of promotion as full-time workers, their average gross earnings would amount to 167 356 Euros over the four years. The career prospects penalty dominates more strongly the longer the part-time spell. For short part-time spells, the larger part of the penalty is attributed to wage losses within level. As discussed in the previous subsection, these are generally higher on the high career level. If part-time work comprises less than 20 hours per week, the break-even duration of the part-time spell is shorter than four years. In sum, this suggests that, for short career interruptions, both channels are roughly equally important for the part-time wage gap. The longer the part-time spell, the more critical the promotion penalty becomes.

7. Counterfactual analysis

The results discussed in Section 6 suggest that both channels - promotions and within-level wage stagnation - are relevant for the part-time wage gap. In this section, I demonstrate that analyzing the differential impact of part-time work on wage growth within career level and promotion prospects is pivotal for policy design. I perform two counterfactual simulations that showcase different ways in which policies can reduce the part-time wage gap.

7.1 Child care costs

The first policy I analyze envisions reductions in the cost of child care. As families in Germany greatly rely on the government's childcare provision, the costs of sending children to kindergarten are a key topic in the policy debate. A reduction in the cost of childcare is expected to increase the labor market attachment of mothers of small children and increase the time individuals spend working.

Using the structural framework and the parameter estimates discussed above, I perform a counterfactual simulation where childcare costs for children aged 0-2 and 3-6 are decreased by 10%. As anticipated, the new regime induces higher working hours. The increase is particularly pronounced at the beginning of the life cycle for ages 26-30. On average, increases in the intensive margin of labor supply amount to 1.75 hours of work per week, or 5.8%. They translate into a 6% increase in lifetime earnings from employment. The effect's size amounts to 59,017 Euros gross, or around 1.5 years' wages. However, the increase in hourly wages is markedly lower. These increase by 9 Cents per hour, corresponding to 0.41% of the average wage.

The positive change in lifetime earnings the reform induced is mainly driven by the mechanical effects of the working hours increase rather than by a mitigation of the part-time penalty. Part-time penalties are mitigated only to a small degree because the reform targets individuals who choose not to work at all or to work very few hours in the baseline scenario. The generated increase in working hours is insufficient to increase promotions significantly, nor to compensate much of the within-career-level penalty.

7.2 Promotion prospects

The second policy I evaluate is directly targeted at the promotion prospects channel. It envisions the implementation of coaching and mentoring practices and equality of opportunity programs designed to increase women's chances of receiving a promotion. To quantify the effects of such a policy, I analyze an increase in the probability of promotion by 2%.

The effects of the promotion stimulus policy are very different from those of the childcare reform analyzed previously. The increase in promotion probabilities results in a 1.16% decrease in the hours of work on average. While at the beginning of the life-cycle, individuals work similar hours, or even slightly more, compared to the baseline case, the hours they choose to work in the last ten years decrease. The negative change is a consequence of the fact that by the age of 45, the number of individuals who reach the senior career level is 0.05 log points higher compared to the baseline case. High-career individuals have an incentive to decrease their labor input once a certain level of human capital has been accumulated due to the convexity of the returns to experience.

The higher rate of promotions has positive implications for the average hourly wage. On average gross hourly wages in the economy increase by 33 Euro Cents. This effect is transmitted solely through the promotions channel. As working hours do not increase but rather fall, there are no mechanical increases in earnings. All gains are attributed to more individuals reaching the high career level where they receive higher wages.

8. Conclusion

In this paper, I study the relative importance of the lack of promotions and the lack of within-career-level wage growth for the part-time wage gap over the life cycle of female employees. First, I introduce a career ladder and the notion of promotions to higher-paying career levels in the dynamic life-cycle framework of Keane & Wolpin (1997, 2010). Second, I quantify the contribution of each separate channel to the part-time penalty for highly educated women using data from the SOEP survey for 2013-2020. Finally, based on the proposed model and its empirical estimation, I present counterfactual evidence on the degree of effectiveness of two reforms for combating the part-time wage gap - a reduction of childcare costs and a promotions stimulus policy.

The life-cycle analysis in the promotion framework reveals a strong effect of promotions on wages and lifetime earnings. This is because wage trajectories on the two career levels are estimated to differ substantially: returns to experience are more than three times higher on the high career level. Findings show that part-time employment triggers both within-level as well as promotion penalties. Wage growth penalties within-level are transmitted through a slowdown in experience accumulation while working part-time. In particular, I estimate that a year of part-employment is equivalent to 0.41 full-time units of experience. Given the unequal returns to experience on both levels, the within-level penalty on the high level is approximately three times higher than on the low level.

The part-time penalty in promotions is a product of the penalty in human capital accumulation and the positive dependence between the probability of being promoted and the level of human capital. The part-time spell length of 4 years marks the point at which the forgone chances of promotion and the wage losses within the levels contribute to the penalty to an equal degree. For longer periods of part-time work, the higher share of the long-run part-time penalty accrues to foregone opportunities to be promoted. The policy analysis I perform using the estimated life-cycle model shows that a reduction in the cost of child care and an increase in the promotion probability can generate increases in wages and lifetime earnings from employment. High labor market attachment and a high tendency to work long hours among young professionals are predicted to result in a higher rate of promotions among women, which ensures higher earnings and simultaneously contributes to establishing gender balance at the high levels of the career ladder

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