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THE CAREER DISADVANTAGE OF UNEMPLOYMENT:

CUMULATING, PERSISTING OR ACCELARATING?

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ABSTRACT (189 words)

Although the negative relationship between unemployment and subsequent wages is well documented, far less is known about how unemployment effects emerge, evolve or change over workers' subsequent careers and how these careers differ from those equivalent workers in continuous employment. We derive mechanisms from the cumulating disadvantage theory and integrate different labor market theories to develop different hypotheses regarding the patterns of career inequality arising from unemployment. Using longitudinal data from the German Socio-Economic Panel (GSOEP) spanning over more than twenty years, and constructing an innovative measure of career success, we find that unemployment has a persisting negative effect on workers' career success. The career penalty from unemployment, decreases over time but is irrecoverable despite later accumulation of skills and experience. Our findings demonstrate that the effect of unemployment on career success is not evenly spread. Particularly, women who experience unemployment during ages of 21-30 recover from unemployment, while prime age workers, and in particular men, are the significant losers from unemployment. While our study underlines the negative and persisting effects of unemployment on workers' later career success, we find no evidence in favor of the cumulating disadvantage hypothesis.

INTRODUCTION

The study of unemployment has a long tradition in social research. There is a vast literature documenting the negative effects of unemployment on different aspects of workers' life course such as their future wages and subsequent unemployment spells. By now, it is well established that the wage penalty associated with unemployment is still evident years after unemployment (Stevens 1997; Jacobson et al. 1993; Gangl 2006; DiPrete and McManus 2000; Gregg and Tominey 2004; Gregory and Jukes 2003; Arulampalam et al. 2001; Mooi-Reci and Ganzeboom 2011) and that the risk of subsequent unemployment increases over time (Manzoni and Mooi-Reci 2011; Stijn et al. 2006; Luijkx and Wolbers 2009; Stewart 2007). The extensive attention on whether unemployment induces long-lasting wage penalties and increases the risk of future unemployment has meant that the question on whether and how unemployment deteriorates workers' career success over time has been overlooked. Specifically, we know very little about *how much* an initial unemployment spell scars workers' entire career success compared to otherwise equivalent workers who remained in continuous employment? Moreover, do previously unemployed recover from an earlier unemployment spell or do they carry a permanent career scar? In addition, it would be interesting to know which social groups experience the greatest career penalties over time: men or women; young or old?

There are two main reasons for the gap in this literature. First, most studies have analyzed the effect of unemployment on labor market outcomes using relatively short observation periods and in partial isolation from other labor market transitions that may occur over an extended period of time. Previous research, using arguments from the cumulative disadvantage theory, has argued that unemployment spells may deteriorate peoples' lives by setting up a negative chain of 'low-pay-no-pay' circles, also referred to as 'vicious circles'. Although a central element of the cumulative disadvantage theory, few studies have tried to

empirically model such cumulating unemployment disadvantage in a dynamic way. Substantively, this is important because early unemployment may affect subsequent employment careers as a whole, influencing not just the timing of a new unemployment spell, but also the sequencing and duration of subsequent labor market states.

Second, our limited knowledge on the long-term career effects of unemployment implies that we know very little about how unemployment dynamics *emerge* across different social groups and *evolve* over time. Some studies emphasize that unemployment effects are temporal and disappear over time with favorable periods of re-employment (DiPrete and McManus 2000) or by institutional support (Gangl 2004; 2006). Yet, other studies demonstrate a persisting negative effect of unemployment on workers' subsequent wages that does not diminish over time (Gregory 2002; Gregg 2001). Still, it is unclear why unemployment effects remain persistent for some while they fade away for others.

Our study advances our understanding of unemployment effects in three major ways. First, we use individual labor market histories from the German Socio-Economic Panel (GSOEP) – a panel survey of German adults over the periods 1985-2005 – that allow us to go far more back in time than previous research has done. Specifically, the rich data on labor market careers permit us to consider full career trajectories of men and women spanning much longer spells than previously considered. This provides an excellent opportunity to explore the underlying relationship between early unemployment and subsequent career success. Second, we make use of the heterogeneity in the career trajectories among different social groups (i.e., gender, age and tenure groups) that emerges following unemployment, to explore the strength and variation of unemployment on workers' subsequent career success over time. This allows us to gauge the career gaps of different groups more precisely and advances our understanding regarding how and under which circumstances unemployment inhibits workers' career development over time. Finally, we assess workers' subsequent

career success in an innovative way. Specifically, we develop a continuous, i.e., time-varying score for individual career success S_{it} that depends on the number, the duration and on the recency of favorable states like employment or unfavorable states like unemployment or non-employment (i.e., periods outside the labor market). This allows us to model career fluctuations in a dynamic and more effective way. We apply fixed effect panel models to analyze how the deviation from the unemployed workers' average S_{it} – relative to those who have remained in continuous employment – varies over time and whether such patterns are different across different gender, age or tenure groups.

Before we present our analyses, the next section summarizes evidence on the consequences of unemployment on workers' subsequent employment careers. We then use different labor market theories to derive our core hypotheses regarding unemployment and career success in the next section. Subsequently, we describe our data and discuss the formal definition and properties of our career success measure S_{it} before we present our results from the fixed effect panel models. In the final, we summarize, discuss labor market policy implications and formulate issues for further research.

THE EFFECTS OF UNEMPLOYMENT IN THE LABOR MARKET

What makes unemployment a critical determinant of social and economic inequality is its adverse effect on workers' career mobility; whereby disadvantaged groups, such as low-educated, minorities, or women, face disproportionally higher risks of repeated unemployment spells compared to those who remain continuously employed (DiPrete, 2002; England and Budig, 2003; Gangl, 2004, 2006; Jacobson et al. 1993; Gregg and Tominey 2004; Arulampalam et al., 2001). Literature on life course and social stratification has often used the concept of cumulative (dis)advantage (CAD) to understand how the dynamics of this inequality-generating phenomenon evolve and change over the life course. The notion of

"cumulative disadvantage" suggests that a (dis)advantage experienced early in life may lead to growing systematic inequality processes; the magnitude of which varies across individuals or groups and changes over time (Willson et al 2007; DiPrete and Eirich 2006; Dannefer 1987, 2003; Merton 1973; O'Rand 1996).

An abundance of empirical evidence for unemployment being an inequality-enhancing trigger event can be found in the extensive literature on unemployment effects. It is well established that unemployment imposes disadvantages on workers' careers that go above and beyond a direct loss of wages (Arulampalam 2000; Jacobson et al. 1993; Stevens 1997; Gangl 2004; 2006; Gregory and Jukes 2002; Gregg and Tominey 2004; Manzoni and Mooi-Reci 2011). Much of the evidence demonstrates a clear unemployment path-dependency such that experiencing unemployment makes future unemployment more likely and has both direct and indirect, long-term consequences for workers' employment prospects. This path-dependency varies over the life- and the business cycles and it exacerbates with increasing unemployment durations, age, ethnicity and tenure (Arulampalam 2002; Manzoni and Mooi-Reci 2011; Luijkx and Wolbers 2009; Omori 1997; Stijn et al. 2006). Omori (1997) adds that unemployment state dependence is stronger during economic upturns because stigma effects emerge when fewer are unemployed. These findings imply that in the case of unemployment, the disadvantage persists over time, with the previously unemployed workers permanently retaining worse positions than those who remain in continuous employment (Kuhn 2002; Gangl 2006). Similar results have been found in Germany too, indicating that unemployment and non-employment spells induce significant long-term effects on worker's future careers; effects which tend to be stronger with the duration of unemployment (Beblo and Wolf 2002; Gangl 2006; Geyer and Steiner 2010; Wunder 2006).

THE CAREER SCAR OF UNEMPLOYMENT

WHY DOES UNEMPLOYMENT SCAR?

Two underlying mechanisms have been put forward to explain the unemployment disadvantage: depreciation of human capital and adverse signaling. Originating from human capital models (Becker 1964; 1993), the first explanation is based on the assumption that early investment in education (i.e., general skills) and obtained training and skills during employment (i.e., specific skills) increase workers' marginal productivity. With unemployment *occurrence*, workers' valuable firm-specific knowledge is instantly and completely lost while occupation-related skills are assumed to slowly depreciate with increasing *duration* of unemployment. It is this loss and depreciation of human capital that urges individuals to accept jobs of poorer quality or jobs in other industries. We know that loss of human capital further aggravates when previously unemployed workers change industries. Job dislocations and the difficulties to adapt to new industry specific requirements make these workers more vulnerable to future lay-offs. (Stevens 1997; Gangl 2006; Narendranathan and Elias 1993; Omori 1997; Gregg 2001).

The second explanation, relates to unemployment stigma: an unemployment spell stigmatizes workers and influences the hiring decision of an employer who judges workers' productivity and performance by their employment history (Spence 1973, Lockwood 1991; Eliason 1995). In a situation where workers' past labor force history is used as a 'cheap' screening device, more *recent*, and more *frequent* unemployment spells are viewed as a signal of inferior worker quality. Research has shown that previously unemployed workers are likely to receive fewer and worse job offers, which in turn leads to 'low-pay-no-pay' cycles (Jacobson et al., 1993; Arulampalam, 2001; Gregory and Jukes, 2004; Stevens, 1997; Stewart, 2000). It is for this employers' perception that unemployment effects may carry a penalty of a persisting nature.

Common to each explanation is that the recency of unemployment, duration and incidence (i.e., the number of previous job losses) are the dimensions that drive the systematic process of cumulative disadvantage. For instance, according to human capital theory unemployment disadvantage increases over unemployment *duration* because of depreciation of work-related skills and social networks. Thus, human capital theory implies a disadvantage that, relative to the employed, increases or accumulates with time, perhaps forcing the unemployed to accept worse or lower paid jobs in contracts that offer less protection or in less well regulated industries. Signaling theory explains why *recency* and *frequency* of unemployment cause employers to offer 'no-contracts' or 'worse-contracts' to unemployed and therewith increasing workers' vulnerability to future lay-offs due to industry or employer related circumstances. The explanations offered by both human capital theory and the signaling theory imply that the effect of unemployment is persistent, long after the unemployment spell. The mechanisms hypothesized by both theories may well cooperate to the effect that the disadvantage of unemployment is permanent and increases with duration, frequency and recency and that it permanently affects the subsequent labor market career. Accordingly, we expect:

> *Hypothesis 1: All else equal, previously unemployed will experience a <u>persisting</u> negative effect on their subsequent employment career success that will <u>grow</u> larger over time, compared to those who have remained in continuous employment.*

WHEN DOES UNEMPLOYMENT SCAR MOST?

Previous studies that examined the causal relationship between youth unemployment and future scarring show that the *occurrence* of unemployment has substantial effects among older workers, but that the *duration* of unemployment determines the later career prospects among the young (Gregg 2001; Gregg and Tominey 2004; Stewart 2007; Borland et al. 2002). Consistent with this evidence, Stevens (1997) suggests that a spell of unemployment during older ages increases the likelihood of experiencing future unemployment. This can be explained by the underlying assumption that employers expect (signaling theory) younger workers to show a more pronounced 'job-shopping' behavior that is often characterized by short periods of unemployment. Such early spells of unemployment are expected to produce less of a scar if younger workers succeed to find a job and maintain an uninterrupted work career thereafter. A human capital explanation would be that, with young employers, the loss of firm-specific human capital is only small because it cannot have accumulated to a great extent.

One question emerges from this evidence, which is largely based on the British and U.S. workers. Are these unequal effects of unemployment on different age groups universal? We anticipate that in the context of the flexible labor market structures, policies and institutions of the UK and the US, unemployment during younger ages may be perceived as less negative. However, in the context of the restrictive employment regulations, rigid labor market structures and strongly regulated school-to-work transitions in Germany, unemployment during younger ages could be less common or accepted. This would therefore result into higher career penalties if experienced during younger ages (Brzinsky-Fay 2007; Gangl 2002). The German context, combined with the widening gap in career success as result of the cumulating disadvantage process, should result in larger career penalties if

unemployment is experienced during younger ages. This brings us to the following hypothesis:

Hypothesis 2: All else equal, among those who experienced unemployment, younger workers will experience larger penalties in their subsequent careers.

Another question that emerges from the above considerations is whether the process of cumulating unemployment disadvantage slows down with time in employment or is age-dependent? A number of studies suggest, consistent with human capital theory, that unemployment disadvantages disappear with the time spent in employment (DiPrete 2002; Ellwood 1982). Specifically, the more an individual engages in employment and builds up employment tenure, the lower the subsequent employment career penalties if (s)he gets laid-off because workers improve their firm-specific skills and build up work-specific networks and experience that help them remain at work or create new employment opportunities. This brings us to the final hypothesis:

Hypothesis 3: The accumulated unemployment disadvantage diminishes with tenure after unemployment.

This hypothesis is consistent with human capital theory because it considers the rebuild of relevant skills and networks and it is consistent with signaling theory because tenure causes the last unemployment spell to become less recent and "corroborates" aptness to work. The above considered persisting and cumulating effects may differ as the result of variation across gender and social groups and relate closely to the institutional settings and economic periods in which unemployment has been experienced. Economic and historical changes, for instance, can exert substantial effects on the sequencing of life course events which in turn affect the persistence of unemployment disadvantage over time. A vast

literature on life course research has established that peoples' life courses have become more *complex* and have reverted to more erratic patterns since the 1960s (Shanahan 2000; Buchman 1989; DeWilde 2003; DiPrete and Nonnemaker, 1997; Elzinga and Liefbroer, 2007; Liefbroer and Elzinga, 2011; Martin et al. 2008). Especially, since the early 1990s, transitions from temporary to permanent jobs have increasingly become more difficult, while transitions from inactivity-to-work have shown an explosion among women in many Western societies in general, and in Germany in particular (Shanahan 2000; Mills et al. 2008).

Despite the tendency towards more deregulation in the labor market and an increase in part-time employment among women, life course patterns have remained quite stable and predictable in Germany; with women continuing to specialize in household commodities while men more often have specialized in paid employment (Mills et al. 2008; Schmitt 2008). Especially social policies, fueled by generous tax transfers in favor of families with non-working or – more recently – part-time working mothers – have encouraged the persistence of the traditional labor division with men as the 'male-breadwinner' (Bruckner and Mayer 2005; Schmitt 2008; DiPrete 2002; Mills et al. 2008). Obviously, an implication of this division is that – relative to men – German women's employment careers are more often disrupted by periods of unemployment and non-employment. A growing amount of empirical support for this argument demonstrates that, for women, negative effects of unemployment are driven mainly by human capital depreciation while for men stigma effects prevail (Mooi-Reci and Ganzeboom 2011). The larger human capital effects for women underscore the unequal gender divide in the family: women's employment careers are strongly influenced by the organization of their families and undermine a stable employment career (Schmitt 2008; Van Bavel 2010; Wiedmer and Ritschard 2009). Following these arguments we expect:

Hypothesis 4: All else equal, among those who experience unemployment, women will suffer more severe penalties in their career success than men.

DATA, MEASURES AND METHODOLOGY

DATA

To examine our main hypotheses we use data from the German Socio Economic Panel (GSOEP). The GSOEP is a panel study that was first collected among 12,200 randomly selected respondents between 18 and 64 years old in West-Germany in 1984 (Frick, 2005). The panel has later been extended with 4,500 respondents in 1989 after the German reunification. The data that we use in our study ranges from 1984-2005 for West Germany and from 1990-2005 for East Germany. Apart from a wide range of socioeconomic information on private households, the GSOEP data also provide detailed retrospective information about one's labor force status. This allows us to track workers' employment careers on a monthly basis. For the purpose of our study, we limit our analyses on men and women that are attached to the labor force between 21 and 54 years. Given these requirements our sample contains 849,994 monthly observations over 10,101 respondents, 3,518 of whom experienced unemployment at some time during the observation period.

In Figure 2, we show the distribution of age at first unemployment in our sample. This figure indicates the presence of two groups of men and women in our sample. First, we have a group of men and women who experience their first unemployment around their 20s and 30s, at which point the high proportion indicates a possible mismatch between their attained education and the labor force entry. Second, we find a group of women who experience their first unemployment in their mid-30s or 40s, which is likely to be related to fertility and child-rearing.

FIGURE 1 ABOUT HERE

MEASURES

Measure of Career Success

Career success has many facets: wage, status, labor market position, satisfaction, etc. Here, we will confine ourselves to the career as a sequence of labor market positions and disregard all other aspects. First, we will state a few simple requirements that such a measure should satisfy and then informally[1] discuss one specific measure that fulfills these requirements.

A career consists of a sequence of labor market states, each of which can be hold for a different amount of time. We count time in months, and define four possible labor market positions: employment (E), unemployment (U), inactivity (I) or retirement (R). For example, the sequence $x = UEEUIE$ represents a career that starts with one month of unemployment, followed by a two-month spell of employment; another month of unemployment, then a one-month spell of inactivity and ends with a month in employment. Complete and successful careers consist of stable employment, perhaps interrupted by spells of vocational training or education and ending in retirement. Less successful careers contain spells of unemployment or inactivity. So, when we want to quantify the successfulness $S(x)$ of a career x, $S(x)$ should increase with the total duration of employment and decrease with total amount of unemployment. However, consider the two toy-careers:

$$x = EEU \text{ and } y = UEE.$$

Clearly, both careers contain unemployment and employment in equal amounts and yet most people will consider y the most successful of the two, because x ends in unemployment while y apparently has overcome unemployment and ends in employment. Thus, it seems that not only the duration of time in unemployment counts; also the recency of unemployment has to be taken into account. To summarize our requirements of $S(x)$, we demand that

[1] In Appendix 1, we present a formal discussion of the measure, its properties and its calculation.

I. $S(x)$ increases with the amount of employment,

II. $S(x)$ decreases with the amount of unemployment,

III. $S(x)$ decreases with the recency of unemployment

and, for convenience and the sake of interpretability, we furthermore require

IV. $0 \leq S(x) \leq 1$ with $S(x) = 1$ only if x contains no unemployment and $S(x) = 0$ precisely when x shows no employment.

Clearly, these requirements are not tight enough to fully determine the function S; there will be many different solutions for S that satisfy these four requirements. So, the nature of our quantification of career success will, to some degree, be arbitrary. If it appears that our measure leads to sensible applications, this arbitrariness will be considered acceptable.

In order to discuss the construction of our proposal for S, we first concisely discuss the concept of a sub-career or subsequence. A career can be considered as a sequence of states as in, say, $x = EEUE$. A sub-career or subsequence of x arises by picking any number of states from x and putting them in the same (time-)order as in the original x. Hence, E, EEE and UE are subsequences of x. The reader easily verifies that our x contains 9 distinct non-empty subsequences which we denote by writing $\varphi(x) = 9$. We use the concept of subsequences in the construction of a measure of career success by reasoning as follows: when all the subsequences of x end with E, the career must have been maximally successful since unemployment U did apparently not occur and hence, we must have that $S(x) = 1$. If, on the other hand, none of the subsequence ends with E, we must have that $S(x) = 0$ since the career consists of spells of unemployment only. Now let us write $\varphi_U(x)$ to denote the number of subsequences of x that end in unemployment. Then the bigger the difference

between the total number of subsequences $\varphi(x)$ and the number of subsequences φ_U, the more successful the career x. However, this difference also depends on the length of the career, i.e. the number of states observed. Therefore, it seems wise to relate the difference to the total number of subsequences and define or measure S of career success as

$$S(x) = \frac{\varphi(x) - \varphi_U(x)}{\varphi(x)}. \qquad (1)$$

It is not difficult to see that $S(x)$ satisfies requirement I: when we elongate a given career x with employment, $\varphi(x)$ will increase without affecting $\varphi_U(x)$. That $S(x)$ also satisfies requirement IV follows from the inequality $0 \leq \varphi_U(x) \leq \varphi(x)$. That $S(x)$ also satisfies requirements II and III is far from trivial; a proof is beyond the scope of this paper but it is available upon request. Here it suffices to illustrate the behavior of $S(x)$ as shown in Table 1.

TABLE 1 HERE

In the left part of Table 1, we show how the distribution of a fixed amount or duration of unemployment affects $S(x)$: the later unemployment occurs during the career, the less successful is the career. The right part of the table focuses on the effect of more unemployment in a career of fixed length.

Determining the quantities φ and φ_U is quite laborious. The reason is that the number of subsequences exponentially increases with the length of the career. This fact has two consequences. Firstly, to count subsequences in a reasonable amount of time, we need algorithms that are discussed in the Appendix B. Secondly, in practice, with careers consisting of hundreds of monthly statuses, $\varphi_U(x)$ will often be very small compared to $\varphi(x)$ and hence, $S(x)$ will be very close to 1, even if the amount of unemployment in the

careers is substantial. Therefore, it is convenient, to re-scale the counts of the subsequences in log-units and redefine $S(x)$ as

$$S(x) = \begin{cases} 0 & if \quad \varphi_U(x) = \varphi(x) \\ \dfrac{\log_2(\varphi(x) - \varphi_U(x))}{\log_2 \varphi(x)} & otherwise \end{cases} \qquad (2)$$

and this re-scaled measure of course still satisfies the properties I-IV.

A further complication is that we also allow for spells of non-employment (N) to affect career success and hence we refine our definition to

$$S(x) = \begin{cases} 0 & if \quad \varphi_U(x) + \varphi_N(x) = \varphi(x) \\ \dfrac{\log_2(\varphi(x) - \varphi_U(x) - \varphi_N(x))}{\log_2 \varphi(x)} & otherwise \end{cases} \qquad (3)$$

Clearly, careers develop over time and we are interested in the question if and how negative events affect the remainder of the career. To study the career dynamics, we write a career $x = x_1 x_2 \cdots x_n$ as a sequence of, say n where states wherein x_i denotes the labor market status in the i^{th} spell. We then study the prefix-development

$$x^1 = x_1,\ x^2 = x_1 x_2,\ \cdots\ x^j = x_1 \cdots x_j,\ \ \cdots x^n = x$$

through calculating the series

$$S(x^1), S(x^2), \cdots, S(x^n = x)$$

which describes the dynamics of a single career over time. In Figure 1 we show a plot of two such series, based on two careers as shown below and wherein e.g. $E/26$ denotes an employment spell of 26 months and $U/5$ a 5-month spell of unemployment.

$$x = \ E/26\ U/5\ \ E/109\ U/37\ \ E/87$$

$$y = \ E/73\ U/15\ E/39\ U/16\ \ E/33\ U/18$$

So, the first career generates the series $S(x^1), S(x^2), \cdots, S(x^{264})$ and the second career generates the series $S(y^1), S(y^2), \cdots, S(y^{194})$.

FIGURE 2 HERE

Independent Variables

To test our hypotheses regarding the emergence and evolution of career success after an unemployment spell, we construct a time variable that consists of leads and lags from the first unemployment experience recorded in our data. The monthly retrospective information on men's and women's labor force status and their duration in employment, unemployment or non-employment spells allows us to construct such a measure and trace efficiently the periods before and after the occurrence of unemployment. To each respondent, we assign a vector $\boldsymbol{u_i} = (u_{i-1}, \ldots, u_{i-5})$ of dummy variables which indicate if the observation was recorded *k* years prior the first unemployment occurrence. For example, workers who had participated in the panel and reported an employment status 3 years before their first unemployment occurrence were assigned the vector $\boldsymbol{u_i} = (0,0,1,0,0)$. We use the same approach to record the period after the first unemployment occurrence which records the period up to more than 10 years after first employment $\boldsymbol{u_i} = (u_{i+1}, \ldots, u_{i+11>})$

We also include control variables capturing socio-demographic characteristics such as *age* (ranging between 21-54 years) and *age squared. Birth cohort* specified as a categorical variable with 5 categories: <1932 (ref.); 1932-1945; 1946-1953; 1954-1963 and 1964 and after. Marital status (1= married and 0 otherwise); *number of children in the household* (ranging between 0-10). We include a number of variables that measure human capital. *Education*, defined as the highest attained educational level at the moment of interview, is specified as a categorical variable with *low* education level as the reference category and

three additional categories for *low intermediate*, *high intermediate* and *tertiary education*; *tenure* indicates the years of experience with the same employer; *occupational status is* measured using the International Socio-Economic Index (ISEI) (Ganzeboom et al. 1992). We also control for job characteristics related to the sector (public vs. private). Finally, to control for business cycle effects, we use aggregate data from Statics Germany about the *GDP change* and the *survey year*.

METHODOLOGY

To test our hypotheses we make use of fixed effects panel models. The strength of fixed effects models relates to the fact of eliminating the bias that occurs by the failure to include controls for unmeasured personal characteristics such as motivation to work or ability to keep a job. In fixed effects models comparisons within individuals are conducted by averaging at least two sequences of observations and by averaging these differences across individuals in the sample. The unobserved heterogeneity in fixed effects models is assumed to be time constant, hence, when estimating differences, such constants cancel. The model yields the following career success specification:

$$\ln S_{it} = \boldsymbol{\beta}' \boldsymbol{x_{it}} + \alpha_i + \varepsilon_{it} \qquad (1)$$

where, $\ln(S_{it})$ is the natural logarithm of the career success at time *t* for individual *i*. $\boldsymbol{x'}_{it}$ refers to a vector of observable variables on individual characteristics; $\boldsymbol{\beta}$ refers to the vector of coefficients associated with the observables characteristics; the value α_i refers to the time-invariant individual specific error that captures the unobserved heterogeneity and the ε_{it} is the general error term.

To guard against the possibility that the career outcomes are driven by career fluctuations that existed before the first unemployment (for instance due to periods of non-employment) we need to consider the level of career success *before* unemployment in our model specification as well. This can be captured by extending equation (1) with our earlier defined time-varying dummy variables recording the time from/to unemployment. The model yields the following specification:

$$\ln S_{it} = \boldsymbol{\beta}'\boldsymbol{x_{it}} + \boldsymbol{\nu}'\boldsymbol{u}_{-ik} + \boldsymbol{\mu}'\boldsymbol{u}_{+ik} + \alpha_i + \varepsilon_{it} \quad (2)$$

where $\boldsymbol{\nu}'$ refers to the vector of coefficients associated with the period before the first unemployment and $\boldsymbol{\mu}'$ refers to the vector of coefficents after the first occurrence of unemployment. To capture gender-specific unemployment effects we run each model separately for men and women. In addition, to examine how career penalties evolve or diminish after unemployment and across different social groups, we introduce interaction effects between the time-varying dummy variables after unemployment and the different tenure and age groups.

RESULTS

DESCRIPTIVES

Table 2 presents the average descriptive characteristics regarding how men and women differ in some key socio-demographic characteristics depending on whether they have been continuously employed or unemployed at some time during the observation period. It is interesting to note that the majority of those in continuous employment are more often men (68 percent), better educated, and married with children around their forties. Compared to

those previously unemployed, this group has on average higher employment tenure and occupies jobs with relatively higher occupational status.

TABLE 2

Figure 3 presents the evolution of career success between continuously employed and previously unemployed over the observation period 1983-2005. Workers in the latter group might experience unemployment at any time over their life course which influences the course of career success over the observation years. Interestingly, the average career gap across the two groups grows larger over time, suggesting growing career inequality between those with and without unemployment spells over time. We should, however, be cautious when interpreting this figure. Over the observation period more workers might experience unemployment affecting the composition of the unemployed group and thereby pulling down the average level of career success that we observe in this figure.

FIGURE 3

In Figure 4 we show how the average career success evolves among men and women before and after the first unemployment spell. Again the level of career success for those in continuous employment equals 1 in this figure. It is interesting to note that both men and women who experience unemployment are already disadvantaged before unemployment compared to otherwise equivalent workers in continuous employment. In addition, compared to men, women have on average a lower level of career success both before and after the occurrence of first unemployment spell. As theoretically expected, and earlier presented in the descriptive characteristics in Table 2, the lower career success among women indicates

the relatively higher proportion of non-employment transitions during their employment career. The higher score of career success after the first unemployment spell among men indicates that on average men re-enter employment swifter than women. However, a considerable career penalty persists between the previously unemployed and those in continuous employment.

FIGURE 4

Although these figures are very interesting, they only reflect the average distribution of the career success between the two gender groups, without controlling for observed individual, job or macro characteristics and unobserved heterogeneity. In the next section we continue with more elaborate models that predict the development of career success within an individual worker over time compared to the career development of those in continuous employment.

PERSISTING OR CUMULATING CAREER DISADVANTAGES?

As stated in Hypothesis 1, we expect that the negative effects of unemployment on workers' career success persist and grow over time due to stigma and human capital depreciation effects. To test the first hypothesis, we estimated the parameters of the model specified in Equation (2) separately for males and females. The results are presented in Table 3, which show coefficients from fixed-effects models indicating the expected percentage change in the dependent variable (i.e., the natural log of career success) for a 1 unit change in the respective independent variables. To capture the full impact of unemployment our model encompasses relatively long periods before and after unemployment compared to the change in career success for those who remained in continuous employment (i.e., our reference category). Unemployment observations that take place within the current year, specified as (u_{i+0}) are

truncated from these models. A full set of estimated coefficients can be found in Table 1A of Appendix 1.

Two interesting results emerge from these estimates. Looking first at the level of career success before the occurrence of first unemployment ($\beta u_{i-1}, \dots, \beta u_{i-5}$), we note a positive and significant change in the level of career success in the years preceding unemployment compared to the relative change of those in continuous employment. The positive change may relate to an increasing trend of employment transitions which influences positively the level of career success. Second, we notice that any unemployment that occurs in the subsequent years ($\beta u_{i+1}, \dots, \beta u_{i+11>}$) depresses careers by between 0.26 and 0.12 percent for women, and by 0.33 and 0.19 percent for men. The decreasing coefficients in the years after the first unemployment suggest that as unemployment recedes further into the past, career penalty becomes lower. However, the persisting negative development of unemployed workers' subsequent career indicates that future labor market trajectories become more erratic and embed multiple unemployment and inactivity periods over time; effects of which do not diminish over time.

TABLE 3

So far our estimates have compared unemployed workers' average level of career success before and after unemployment to that of workers in continuous employment. To assess whether previously unemployed workers recover from unemployment and catch up with the level of career success that they attained before the occurrence of unemployment, we estimate two fixed effects models in Table 4. The results presented in Table 4 are conducted among the sample of previously unemployed and show the average level of career success before and after unemployment relative to the level of career success at the year of unemployment (u_{i+0}).

TABLE 4

Results from these tables are not different from those described earlier in Table 3 regarding the decreasing and persisting patterns in the level of career success over time. Figure 5, depicts the pattern of career penalty that emerges after taking the difference between the coefficients estimated in Table 3 and Table 4. The difference in the coefficient estimates is the expected 'net' loss in the average level of career success between those with and without an unemployment interruption.

FIGURE 5

Interestingly, results from figure 5 show that men experience a higher career penalty compared to women and that the pattern of the difference in career success between previously unemployed and continuously employed remains largely constant over time. An interpretation for the higher career penalty for men can be related to the cultural understandings and traditional labor division in Germany where it is more common and widely accepted for women to experience unemployment or non-employment period compared to men (DiPrete 2002; Gangl 2006; Budig 2010). In sum, our first hypothesis can be partly corroborated in the sense that we find a persisting but not a cumulating pattern of career penalty to evolve over time.

UNEMPLOYMENT AND CAREER EFFECTS ACROSS AGE AND TENURE GROUPS

To examine whether unemployment effects on the average level of career success varies over different ages we estimated the same model for different age categories, separately for men and women, as presented in Table 3. According to the second hypothesis, we expected to find

more severe career penalties among workers who experienced unemployment during younger ages due to the process of cumulating disadvantage. The four models presented in Table 5 unveil some striking results.

Among women who experience unemployment at younger ages (between 21 and 30 years), career penalties related to unemployment vanish entirely after six years in consecutive employment. However, women's career penalties remain substantial when experienced beyond age 31 compared to those women in continuous employment. Across the different age groups, the career penalty is particularly the highest among women who experience unemployment between their 30s and 40s. For men, another picture emerges which is in line with previous findings in other countries (Gregg 2001; Gregg and Tominey 2004; Stewart 2005; Borland et al. 2002). Specifically, men who experience unemployment during the ages 21 and 30, still suffer from career penalties ten years after the occurrence of unemployment. The career penalty for other age groups remains substantial and higher among prime-age groups reaching its peak among those between 41 and 50 years. These findings imply that for younger women, the cultural understandings and common expectation of fragmented careers due to child rearing periods 'shield' them from persisting career penalties. However, the traditional division of labor in Germany leads to more severe career penalties for men of different age categories, with the highest penalties among prime-age workers. These findings partly corroborate with our theoretical expectations in the sense that we find an age-specific career penalty to result from unemployment. However, different from our expectations, we also find that these penalties are the highest among workers in the middle (for women) and upper (for men) age-distribution rather than in the bottom age distribution. In addition, the separate analyses among men and women show a gender-specific effect, with career penalties being higher among men than women, contrasting our gender specific expectations in hypothesis 4.

TABLE 5

To test our final hypothesis regarding the mitigating effects of employment tenure, in Table 6 we present two models that include a wide range of interactions between time from unemployment and employment tenure. Also here a couple of interesting results emerge. First, results for both men and women (partly) support our hypothesis that employment tenure mitigates the negative effects of unemployment. Specifically, every additional tenure year attained after unemployment leads to a smaller level of career penalty for both men and women. Strikingly, this mitigating effect slows down over time for both men and women, while it even exacerbates in the opposite direction for women after eight years in employment. This effect may reflect the long-term penalty that emerges from foregone human capital and job dislocation after the occurrence of unemployment. Several researchers (Stevens 1997; Gangl 2006; Narendranathan and Elias, 1993; Omori, 1997; Gregg, 2001) have shown that job dislocations and difficulties to adapt to new industry specific human capital make men and women more vulnerable to new unemployment or non-employment spells over time.

TABLE 6

CONCLUSION AND DISCUSSION

Our study addresses two issues regarding the relationship between unemployment and subsequent career success. First, while several studies have argued that a first spell of unemployment may lead to cumulating career disadvantages over time, few studies have tried to empirically model such patterns of disadvantage in a dynamic way. Second, we tried to dynamically model the effects of unemployment using a rich panel dataset and constructing a

new measure for career success. Focusing on workers' career development before and after unemployment and in comparison with workers who remained in continuous employment, our results demonstrate three key findings.

First, different from arguments of cumulating disadvantage theory, our results demonstrate a persisting negative rather than a cumulating pattern of unemployment effects on workers' future career success. This negative effect decreases over time but remains permanent and irrecoverable despite later accumulation of skills and experience. Second, our results show that the career penalty is higher among men than women. This is in line with a growing body of research showing higher negative effects to emerge among men than women due to stigma (Kuhn 2002; Mooi-Reci and Ganzeboom 2011). Finally, our findings demonstrate that the effect of unemployment on career success is not evenly spread and that among those who experience unemployment, younger workers are less penalized in their subsequent careers. Strikingly, young women between ages of 21-30 fully recover from unemployment, indicating that common expectations and cultural understandings regarding motherhood roles may counteract the stigmatizing effects that relate to unemployment. Prime-age working men (41-50) and women (31-40) on the other hand, experience the highest penalties of a permanent nature. Furthermore, our estimations are in line with research that demonstrates decreasing penalizing career effects with increasing employment tenure. Surprisingly, while underlining the mitigating effects of employment tenure, our results demonstrate that this effect slows down over time. This finding can be explained in the light of job mismatches whereby the loss of previously attained human capital becomes an added disadvantage and leads to growing inequalities between those who remain and those who change industries after unemployment.

Our findings regarding workers' career success are a first attempt to capture the effect of unemployment on the entire career, but more research is needed to provide a long-term

assessment of what drives the disadvantageous effects of unemployment. Our analyses (not shown but available upon request) showed that a series of complex career trajectories emerge after unemployment. However, neither the circumstances under which complex trajectories emerge nor the factors which drive such deviating career pathways are well understood yet. In addition, our study distinguished between four possible transitions over the labor market career. However, it would be interesting to include more variety in transitions and also distinguish between transitions into “better” or “worse” jobs compared to the period before unemployment.

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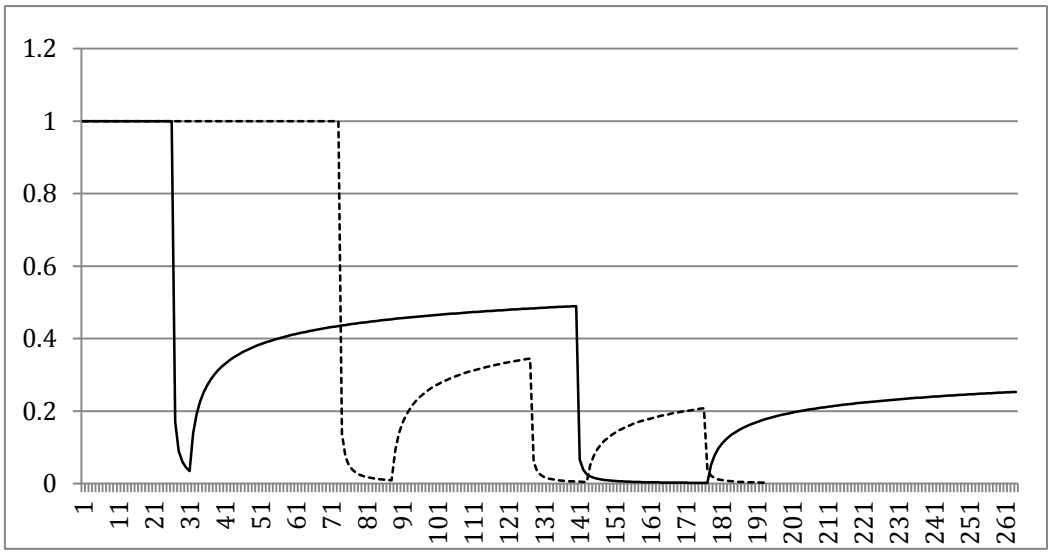
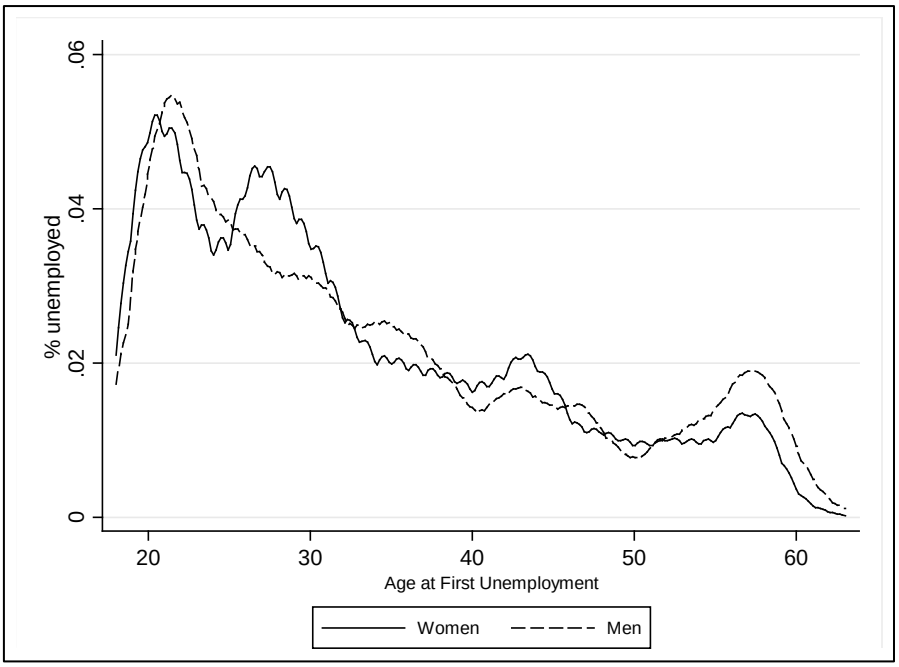
Figure 1: Plot of t (horizontal) vs $S(x^t)$ (vertical) for 2 careers of different length



Source: Authors' calculations.

Figure 2: Probability of first unemployment for males and females by age

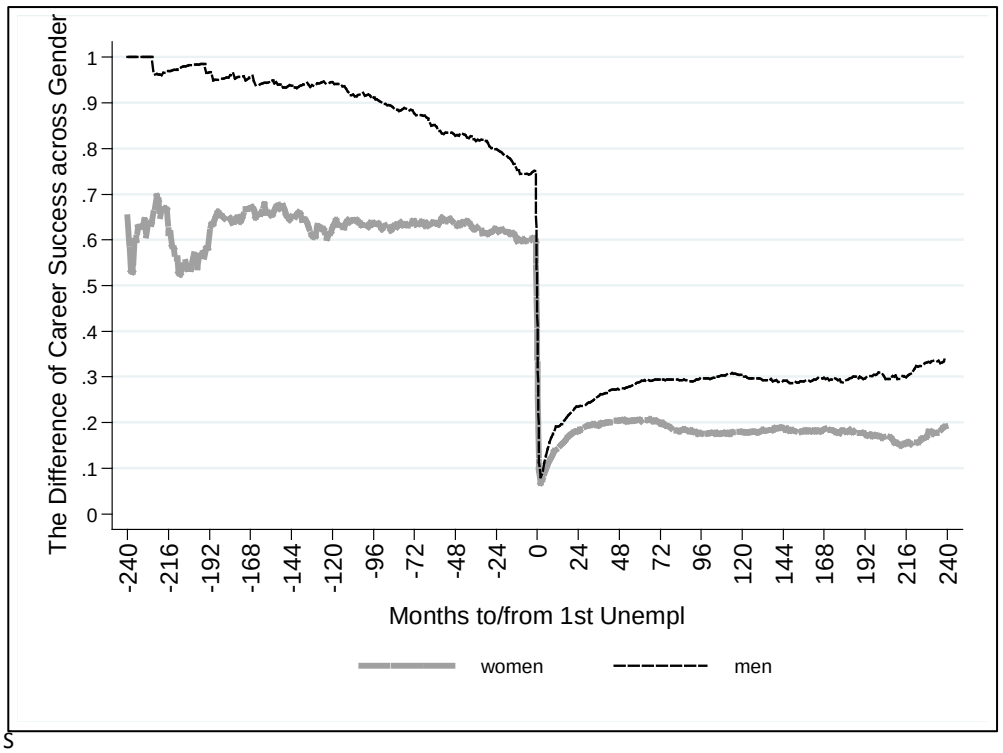


Source: Authors' calculations based on the GSOEP data, 1984-2005.

Figure 3: Difference of career success between continuously employed vs. those at least once unemployed

Source: Authors' calculations based on the GSOEP data, 1984-2005.

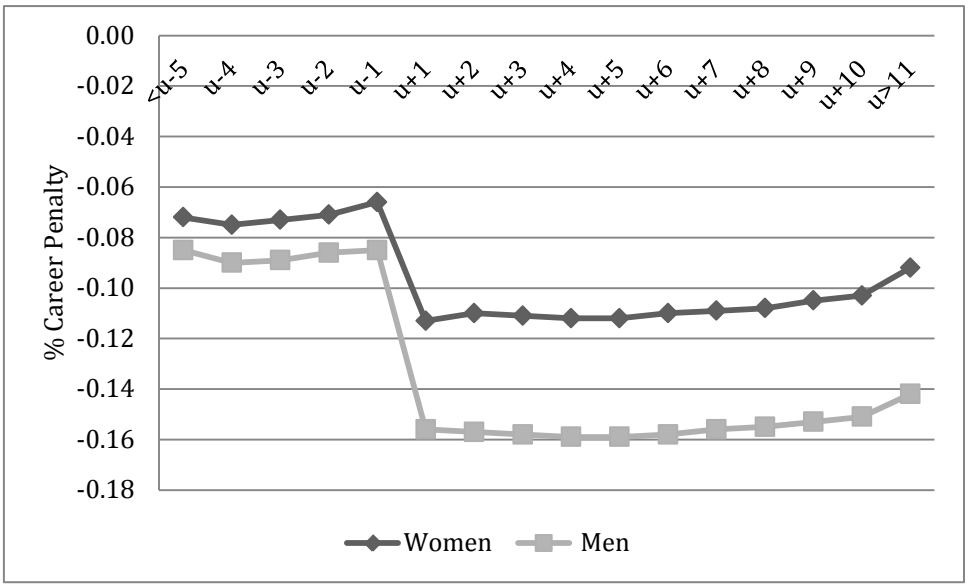
Figure 4: Difference of Career Success among Gender



s

Source: Authors' calculations based on the GSOEP data, 1984-2005.

Figure 5. The Difference in Career Penalties among Men and Women



Source: Authors' calculations based on the GSOEP data, 1984-2005.

Table 1. Illustrations of the behavior of $S(x)$ Left: effect of recent unemployment. Right: effect of more unemployment

x	$\varphi(x)$	$\varphi_U(x)$	$S(x)$
UUUEEE	15	3	0.80
UUEUEE	23	6	0.74
UEUUEE	25	7	0.72
EUUUEE	21	6	0.71
EUUEUE	29	11	0.62
EUEUUE	29	12	0.59
EEUUUE	21	9	0.57
EEUUEU	25	16	0.36
EEUEUU	23	17	0.26
EEEUUU	15	12	0.20

x	$\varphi(x)$	$\varphi_U(x)$	$S(x)$
EEEE	4	0	1.00
EUEE	9	2	0.78
EEUE	9	3	0.67
EEEU	7	4	0.43
UEEU	10	6	0.40
EUEU	11	7	0.36
EEUU	8	6	0.25
UEUU	9	7	0.22
EUUU	7	6	0.14
UUUU	4	4	0.00

Table 2. Mean of Observable Characteristics by Labor Force Status, 1984-2005.

	Continuous Employed		Unemployed	
	Mean	*Std. Dev*	*Mean*	*Std. Dev*
Female	0.32	0.47	0.50	0.50
Low Education Level	0.40	0.49	0.55	0.50
Low Intermediate Level	0.28	0.45	0.24	0.43
High Intermediate Level	0.09	0.29	0.09	0.29
Tertiary Level	0.23	0.42	0.11	0.32
Sector (public)	0.30	0.46	0.16	0.37
# Home living children	0.74	0.99	0.75	0.96
Married	0.81	0.40	0.80	0.43
Age	39.34	8.54	36.05	9.11
Tenure	4.69	4.86	2.55	3.86
ISEI level	48.04	16.02	42.14	15.13
Monthly Observations	489,189		360,810	
Respondents	7,010		3,518	

Source: Authors' calculations based on the GSOEP data, 1984-2005.

Table 3.(Partially) Fixed Effect Regression Estimates for predicting career success, by gender, according to Equation (2).

Dependent Variable: ln career success

	Females	**Males**
	Model 1	Model 2
Years to/from Unemployment		
$\leq u-5$	0.016	0.021
$u-4$	0.010	0.013
$u-3$	0.010	0.014
$u-2$	0.013	0.024
$u-1$	0.017	0.037
Continuous Employed (ref.)	-	-
$u+1$	-0.264	-0.329
$u+2$	-0.232	-0.301
$u+3$	-0.215	-0.285
$u+4$	-0.203	-0.271
$u+5$	-0.189	-0.261
$u+6$	-0.179	-0.251
$u+7$	-0.173	-0.240
$u+8$	-0.160	-0.235
$u+9$	-0.151	-0.225
$u+10$	-0.141	-0.218
$u \geq 11$	-0.117	-0.187
Individual, socio-demographic vars. included	*Yes*	*Yes*
Year fixed effects included	*Yes*	*Yes*
Constant	0.821	0.589
(t-value)	(51.00)	(73.28)
Observations	220,196	383,914
Respondents	3,795	5,415
R-Squared	0.764	0.820

Source: Authors' calculations based on the GSOEP data, 1984-2005. **Note: For all coefficients estimated: p < .001**; The model includes controls for age, age squared, birth cohort, marital status, number of children, tenure, occupational status, education, GDP change as well as for the fixed year effects.

Table 4. (Partial) Fixed Effect Regression Estimates for predicting career success, by gender, according to Equation (2).

Dependent Variable: ln career success

	Females	**Males**
	Model 1	Model 2
Years to/from Unemployment		
$\leq u-5$	0.088	0.106
$u-4$	0.085	0.103
$u-3$	0.083	0.103
$u-2$	0.084	0.110
$u-1$	0.083	0.122
Year of Unemployment (ref.)	-	-
$u+1$	-0.151	-0.173
$u+2$	-0.122	-0.144
$u+3$	-0.104	-0.127
$u+4$	-0.091	-0.112
$u+5$	-0.077	-0.102
$u+6$	-0.069	-0.093
$u+7$	-0.064	-0.084
$u+8$	-0.052	-0.080
$u+9$	-0.046	-0.072
$u+10$	-0.038	-0.067
$u \geq 11$	-0.025	-0.045
Individual, socio-demographic vars. included	*Yes*	*Yes*
Year fixed effects included	*Yes*	*Yes*
Constant	0.767	0.663
(t-value)	(19.22)	(20.26)
Observations	104,730	126,819
Respondents	1,389	1,497
R-Squared	0.724	0.742

Source: Authors' calculations based on the GSOEP data, 1984-2005. **Note: For all coefficients estimated: p < .001**; The model includes controls for age, age squared, birth cohort, marital status, number of children, tenure, occupational status, education, GDP change as well as for the fixed year effects.

Table 5. (Partial) Fixed Effect Regression Estimates for the Development of Career Success, by Age

Dependent Variable: ln career success

	Female				Male			
	21-30	31-40	41-50	51-60	21-30	31-40	41-50	51-60
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Continuous Employed (ref.)								
$u+1$	-0.166***	-0.296***	-0.258***	-0.304***	-0.201***	-0.310***	-0.423***	-0.279***
$u+2$	-0.133***	-0.261***	-0.226***	-0.242***	-0.180***	-0.277***	-0.390***	-0.229***
$u+3$	-0.108***	-0.250***	-0.203***	-0.204***	-0.159***	-0.259***	-0.372***	-0.213***
$u+4$	-0.076***	-0.238***	-0.182***	-0.202***	-0.141***	-0.244***	-0.358***	-0.208***
$u+5$	-0.044***	-0.227***	-0.173***	-0.184***	-0.120***	-0.237***	-0.358***	-0.206***
$u+6$	-0.017	-0.215***	-0.173***	-0.178***	-0.103***	-0.228***	-0.350***	-0.202***
$u+7$	0.006	-0.204***	-0.167***	-0.172***	-0.090***	-0.217***	-0.338***	-0.185***
$u+8$	0.040***	-0.190***	-0.166***	-0.171***	-0.074***	-0.212***	-0.332***	-0.173***
$u+9$	0.056***	-0.182***	-0.157***	-0.162***	-0.059***	-0.203***	-0.323***	-0.165***
$u+10$	0.065***	-0.173***	-0.146***	-0.153***	-0.045***	-0.197***	-0.316***	-0.154***
$u \geq 11$	0.120***	-0.155***	-0.137***	-0.132***	0.001	-0.176***	-0.298***	-0.130***
Individual, socio-demographic vars. included	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects included	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.703***	1.042***	0.145***	1.777***	0.631***	0.496***	0.778***	0.615***
(*t*-value)	(17.24)	(25.59)	(3.02)	(19.29)	(22.46)	(27.30)	(31.64)	(12.32)
Observations	50,029	72,517	76,362	37,761	70,136	140,671	133,712	73,274
Respondents	1,421	1,717	1,809	932	1,865	2,729	2,719	1,716
R-Squared	0.763	0.699	0.671	0.705	0.733	0.781	0.808	0.805

Source: Authors' calculations based on the GSOEP data, 1984-2005. Note: ***p < .001; All models include controls for age, age squared, birth cohort, marital status, number of children, tenure, occupational status, education, GDP change as well as for fixed year effects.

Table 6. (Partial) Fixed Effect Regression Estimates for the Development of Career Success, by Tenure

Dependent Variable: ln career success

	Female	Male
	Model 1	Model 2
Continuous Employed (ref.)		
$(u+1)$ × Tenure	0.061***	0.073***
$(u+2)$ × Tenure	0.053***	0.064***
$(u+3)$ × Tenure	0.040***	0.049***
$(u+4)$ × Tenure	0.026***	0.038***
$(u+5)$ × Tenure	0.017***	0.031***
$(u+6)$ × Tenure	0.010***	0.025***
$(u+7)$ × Tenure	0.006***	0.020***
$(u+8)$ × Tenure	-0.001**	0.015***
$(u+9)$ × Tenure	-0.004***	0.011***
$(u+10)$ × Tenure	-0.006***	0.009***
$(u \geq 11)$ × Tenure	-0.010***	0.001***
Individual, socio-demographic vars. included	*Yes*	*Yes*
Year fixed effects included	*Yes*	*Yes*
Constant	0.801***	0.640***
(t-value)	(51.32)	(83.77)
Observations	220,196	383,914
Respondents	3,795	5,415
R-Squared	0.778	0.839

Source: Authors' calculations based on the GSOEP data, 1984-2005. Note: ***p < .001; **p<0.05; All models include main effects and control for age, age squared, birth cohort, marital status, number of children, tenure, occupational status, education, GDP change as well as for fixed year effects.

APPENDIX A

Table 1A. Fixed Effect Regression Estimates for predicting career success, by gender, according to Equation (2): *Further Full Variables.*

Dependent Variable: ln career success

	Female	**Male**
	Model 1	Model2
$\leq u-5$	0.016***	0.021***
	(5.05)	(10.43)
$u-4$	0.010***	0.013***
	(3.17)	(6.56)
$u-3$	0.010***	0.014***
	(3.23)	(7.19)
$u-2$	0.013***	0.024***
	(4.12)	(12.02)
$u-1$	0.017***	0.037***
	(5.59)	(18.98)
Continuous employed (ref.)		
$u+1$	-0.264***	-0.329***
	(79.90)	(160.21)
$u+2$	-0.232***	-0.301***
	(70.06)	(146.19)
$u+3$	-0.215***	-0.285***
	(64.65)	(137.84)
$u+4$	-0.203***	-0.271***
	(60.59)	(130.24)
$u+5$	-0.189***	-0.261***
	(55.97)	(124.72)
$u+6$	-0.179***	-0.251***
	(52.49)	(119.32)
$u+7$	-0.173***	-0.240***
	(50.32)	(113.44)
$u+8$	-0.160***	-0.235***
	(45.75)	(110.27)
$u+9$	-0.151***	-0.225***
	(42.95)	(104.70)
$u+10$	-0.141***	-0.218***
	(39.52)	(100.54)
$u\geq 11$	-0.117***	-0.187***
	(33.19)	(87.40)
Low education level (ref.)	-	-
Low intermediate level	-0.001	-0.002***
	(0.61)	(2.64)
High intermediate level	-0.003	-0.002*
	(1.48)	(1.79)
Tertiary Level	0.012***	0.013***
	(4.95)	(12.40)
Public sector (ref. private)	-0.002***	-0.008***
	(2.94)	(19.46)

Home living children	-0.105***	-0.001**
	(119.78)	(2.21)
Married (ref. single and widowed)	-0.006***	-0.000
	(8.17)	(0.93)
Age	-0.011***	-0.005***
	(27.28)	(23.56)
Age squared	0.000***	-0.000
	(15.60)	(1.53)
Tenure (in years)	0.033***	0.032***
	(313.33)	(544.40)
ISEI-level	0.000	-0.000***
	(1.53)	(3.20)
GDP change	0.046***	0.054***
	(69.77)	(165.21)
1984	0.399***	0.395***
	(87.48)	(176.19)
1985	0.377***	0.382***
	(83.66)	(171.78)
1986	0.302***	0.304***
	(82.66)	(169.13)
1987	0.385***	0.418***
	(76.66)	(168.35)
1988	0.221***	0.239***
	(74.53)	(163.96)
1989	0.119***	0.133***
	(65.03)	(149.86)
1990 (ref.)	-	-
1991	-0.001	-0.004***
	(0.99)	(9.53)
1992	0.023***	0.025***
	(22.68)	(53.37)
1993	0.201***	0.235***
	(66.64)	(157.33)
1994	0.076***	0.088***
	(52.02)	(124.16)
1995	0.114***	0.130***
	(60.49)	(140.08)
1996	0.201***	0.230***
	(67.35)	(155.06)
1997	0.154***	0.172***
	(66.39)	(148.94)
1998	0.112***	0.121***
	(64.85)	(140.44)
1999	0.102***	0.107***
	(64.10)	(134.85)
2000	0.078***	0.079***
	(65.10)	(130.80)
2001	0.055***	0.055***
	(54.50)	(107.62)
2002	0.077***	0.083***

	(61.13)	(129.71)
2003	0.072***	0.080***
	(56.89)	(122.96)
2004	-0.009***	-0.013***
	(10.59)	(30.04)
Constant	0.821***	0.589***
(*t*-value)	(51.00)	(73.28)
Observations	220,196	383,914
Respondents	3,795	5,415
R-squared	0.764	0.820

Source: Authors' calculations based on the GSOEP data, 1984-2005. Note: ***p < .001; **p<0.05; *p<0.01;

APPENDIX B: An efficient algorithm for $\varphi(x)$.

In this appendix, we discuss calculating the basic quantities of $S(x)$: the number of distinct subsequences $\varphi(x)$ and the number of distinct subsequences that end on a specific character $\varphi_U(x)$. Once we have done with that, we will comment on some of the properties of $S(x)$. Before we are in a position to discuss efficient algorithms, we will have to deal with some concepts and notation that is convenient when dealing with sequences or, equivalently, strings[2].

Strings are defined over an alphabet $A = \{a_1, \dots, a_k\}$ of distinct characters and the strings arise by right-concatenating characters at will from that alphabet. The length of a sequence equals the number of, not necessarily distinct, characters concatenated. A special character is the empty character λ that is neutral with respect to concatenation, i.e. $\lambda x = x = x\lambda$. In the present context, characters are naturally interpreted as states in the labor market and a string or sequence as a labor market career consisting of observed or remembered states occupied. Let $x = x_1 \cdots x_n$ be a sequence of length n. The k-th prefix of x is the sequence $x^k = x_1 \cdots x_k$ for $k \in \{1, \cdots, n\}$ with $x^n = x$. A subsequence u of x is a sequence that arises from x by taking any number of characters from x. So, the subsequences

$$u_1 = x_1 x_2 x_4 x_{12},$$

$$u_2 = x_5 x_7,$$

$$u_3 = \lambda, \;\; u_4 = x,$$

are all, but not the only, subsequences of x. Note that characters that are adjacent in a subsequence u_i need not be adjacent in the sequence x, note that each subsequence contains

[2] For a thorough introduction into the subject of strings and algorithms on strings, the reader is referred to Crochemore, Hancart and Lecrocq (2001) or Sperschneider (2008).

the empty subsequence λ and that each sequence is a subsequence of itself as we can decide to take all or none of the characters of x away. By convention, we write $x^0 = \lambda$. When u is a subsequence of x, we write $u \prec x$ and we let $\varphi(x)$ denote the number of distinct subsequences of the sequence x. We know that $\varphi(x)$ depends on the *length* of the sequence, the *number* of distinct characters it contains and the *order* in which they appear in the sequence: we have that (Elzinga, 2010), for an n-long sequence,

$$n + 1 \leq \varphi(x) \leq 2^n.$$

The lower bound is attained when all the characters of the string are equal and the subsequences can only be discerned by length. The upper bound is attained when all the characters are distinct: concatenating a new character will multiply the number of subsequences by 2 since all subsequences already contained in the elongated sequence are retained and new subsequences are created by elongating each of these with the new character, thus creating a new subsequence. This doubling of $\varphi(x)$ through elongation (first expression below) is the basis of the algorithm presented below; the second expression amounts to a correction that prevents doubly counting when the elongating character is not new to the elongated sequence.

Efficient algorithms to determine $\varphi(x)$ have been proposed in Wang and Lin (2007), Elzinga, Rahmann and Wang (2008), Elzinga (2010), Elzinga, Wang, Lin and Kumar (2011) and in Kasá (2011). A particularly efficient and general algorithm (e.g. Elzinga, 2010) is given by the recursion:

$$\varphi(x^n) = \begin{cases} 2\varphi(x^{n-1}) & if \quad x_n \nprec x^{n-1} \\ 2\varphi(x^{n-1}) - \varphi(x^{l-1}) & if \quad x_n \prec x^{n-1} \end{cases}$$

wherein l denotes the last position of the character x_n in the prefix x^{n-1} and the recursion is initiated by setting $\varphi(x^0) = 1$. Let $\varphi_i(x)$ denote the number of subsequences of x that end on the character $\sigma_i \in \Sigma$. Then it is not difficult to see (see also Chase, 1976) that:

$$\varphi_i(x^n) = \begin{cases} \varphi(x^{n-1}) & if \quad x_n = \sigma_i \\ \varphi_i(x^{n-1}) & if \quad x_n \neq \sigma_i \end{cases}, \ \forall i: \varphi_i(x^0) = 0.$$

The first expression is true since when $x_n = \sigma_i$, all $\varphi(x^{n-1})$ distinct subsequences can be elongated with $x_n = \sigma_i$ and still be distinct while now (again) ending on σ_i. The second expression is obvious: when $x_n \neq \sigma_i$, the number φ_i does not change. We illustrate the algorithm with a toy example below: we calculate the number $\varphi_a(x^n)$ of subsequences ending an a in the string $x = abacbcaabc$, proceeding column by column.

i	0	1	2	3	4	5	6	7	8	9	10
x^i	λ	a	b	a	c	b	c	a	a	b	c
$l(a)$	0	0	1	1	3	3	3	3	7	8	8
$l(b)$	0	0	0	2	2	2	5	5	5	5	9
$l(c)$	0	0	0	0	0	4	4	6	6	6	6
$\varphi(x^i)$	1	2	4	7	14	26	45	86	127	240	374
$\varphi_a(x^i)$	0	1	1	2	2	2	2	45	86	86	86

The above recursion implies that $\phi_i(x)$ will tend to be bigger, relative to $\phi(x)$, the later the σ_i occur in the sequence. This effect is nicely illustrated in the last column of Table 1 in the main text.