A new tool for old questions: A sequence-analysis multistate model. Women's employment trajectories before and after the German reunification.

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Abstract

This paper examines whether women's early employment trajectories converge or diverge in East and West Germany after the reunification in 1990, when the former communist East was abruptly absorbed into the social market economy of the West. To study how sudden social changes on the macro-level affects individuals' lives require to model trajectories as they evolve over time and asses simultaneously how they are associated with time-varying covariates on a macro-level. To this purpose, we propose a new methodology that combines event history multistate models with sequence analysis. We use the National Educational Panel Study (NEPS, Starting Cohort Six), which for the first time offers retrospective data for birth cohorts until 1990, allowing to study a long period after reunification. Our findings support the convergence of women's employment trajectories in East and West Germany. Increasingly difficult school-to-work transitions and multiple transitions in and out of the labor force characterized the trajectories after the reunification in the East. This reflects the difficult transition period from a centrally planned to a volatile transition economy of the West, where the casualization of employment process was a more general trend. Beyond previous research looking at single transitions between statuses of the prevalence of certain arrangements, our study highlights the volatility of East German women's early employment trajectories after the reunification as one of the main changes. We conclude that the sequence-analysis multistate model is a promising tool to address core research questions in the life-course theoretical approach that have been hardly addressed up to now on interaction between macro-institutional configurations and micro-individual patterns.

1 Introduction

How social changes on the macro level affect individuals' lives has been a core question in sociology. Classical sociological approaches as well as the more recent life-course

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approach (Elder, 1974; Elder et al., 2003) emphasize how changes in macro-structural conditions shape individual lives in different life domains, both in the short and the long run. Macro-structural changes might be gradual or abrupt, as for instance with sudden reunions, wars, reordering or states and regional borders.

The German reunification is one of sudden macro-changes. In 1990, the former communist East (GDR) with its centrally planned economy in which unemployment practically did not exist, was abruptly absorbed into the social market economy of the West (FRG). This resulted in a sudden major shift of the welfare and labor market systems in the East towards the Western institutions, which were following a trend of progressive deregulation of employment often related to the more general globalization process (Mills et al., 2008).

In the communist East, female employment was widely encouraged through universal public child-care, gender wage gaps were comparatively low and studies report no evidence of a motherhood penalty (Budig et al., 2012). In contrast, West Germany is known for one of the purest implementations of the male breadwinner model, in which female employment was traditionally discouraged in favour of a gendered household division of labor (Cooke, 2011). With the reunification, the shift in policies that regulate the compatibility of family and work might have affected Eastern women' life course due to their incorporation into the Western male-breadwinner framework.

Some evidence show convergence total fertility and in terms of postponement of fertility in the East. However, persisting divergence exists in other dimensions of family life course such as the prevalence of cohabitation and non marital childbirth, which remain strikingly higher in the East compare to the West (Kreyenfeld et al., 2015; Klüsener and Goldstein, 2014; Schneider et al., 2012). The same apply to employment: even though Western women increased their labor market participation, their biographies continued to be less career-centered than for Easter women (Bonin and Euwals, 2002; Hauschild, 2002; Trischler and Kistler, 2010; Klammer and Tillmann, 2001). However, these studies rely on data for old cohorts of individuals, and therefore we know little about if and to what extent longitudinal employment trajectories experienced by old as well as younger cohorts of Easter and Western women followed convergence and divergence pathways before and after reunification.

Both individual and contexts characteristics account for differences in employment trajectories. How changes on the micro- and the macro-level affect such trajectories are typical questions in life-course research that require methodological tools enabling us to estimate the effect of time-varying covariates on transitioning into specific trajectories. Until now, studies that tackled the longitudinal nature of trajectories are characterized either by a focus on the probability of occurrence of the transitions between certain states and their timing (e.g. (Grunow and Mayer, 2007; Aisenbrey et al., 2009; Mills et al., 2006) for labour market participation) or by emphasizing the holistic nature of trajectories (e.g. (Biemann et al., 2011; Brzinsky-Fay, 2007; Massoni et al., 2009) for employment and school-to-work trajectories). From a methodological point of view, the first approach relies on event history analysis, which allows estimating the effect of time-varying covariates but poorly account for longitudinal patterns configuration. The

second approach exploits sequence analysis, which provides a holistic view on trajectories, but is inadequate to study the effect of time-varying covariates on trajectories conceived as a whole. The holistic and the event-based approaches have been conceptualized as belonging to the data algorithmic and the data modelling culture respectively (Breiman, 2001). However, empirical questions in life-course research might alternatively benefit from following one approach or the other, and arguably even more from their combination (Billari, 2005)

In line with the call for combining methods to strengthen empirical research in a life-course perspective, this article therefore pursues a double goal. First, we seek to compare employment trajectories of women in East and West Germany and to understand the formative impact of the reunification on these trajectories. Second, we propose a new methodological framework combining multistate models and sequence analysis to model employment trajectories as they evolve over time and asses simultaneously how they are associated with time-varying covariates that capture social change on the macro-level. Instead of looking at single transition between states or complete employment trajectories, the sequence-analysis multistate models (SAMM) analyze subsequences following the transition out of a certain state. From a sociological point of view, this kind of subsequences are crucial in understanding the dynamics of employment trajectories over time because, for example, they can be known by the actors before the transition from a state to the subsequence occurs. Furthermore, subsequences capture the transition out of one state as well as the following potentially more profound transition lasting over a certain time period. In fact, transitions and turning points are not necessarily instantaneous and conceptualizing change as a single transition fail in detecting the dynamic of the trajectories (Abbott, 2009; Shanahan, 2000).

We use data from the German National Education Panel (NEPS), whose Starting Cohort Six provides retrospective data for a sample of women born in West and East Germany between 1944 and 1990. We limit our analyses on women, because men and women employment trajectories follow very different logics. This is particularly true in a male-breadwinner society such as West Germany. Since reunification might have trigger the convergence of the eastern dual-breadwinner model to the western one in which female labor market participation was very much shaped by the family status, women compared to men are more likely to have experienced important changes in this domain. For the first time, NEPS allows to study longer employment trajectories for a wide range of pre- and post-reunification cohorts.

Our findings support the convergence hypothesis of women's employment trajectories in East and West Germany after the reunification. Unstable and more volatile trajectories of moving in and out of the labor force multiple times have become more common after the reunification in the East, reflecting the difficult transition period from a centrally planned economy to the market capitalism of the West, where the process of casualization of employment was ongoing since the beginning of the '80s. Another more surprising finding is that increasing prolonged transitions out of the labor force and back expanded long after the first years after reunification, and such casualized patterns continued to characterize women's employment trajectories in the East. We demonstrate that

the methodological framework provided by the sequence-analysis multistate model is promising to deal with core research questions in the life-course paradigm that are under-researched on interaction between macro-institutional configurations and individual life-course trajectories.

In the next Section, we introduce the German case study, highlighting the characteristics of female employment in the East and the West before and after reunification. Section 3 presents the theoretical background, research questions and hypotheses. Section 4 is devoted to the description of the data. In Section 5 we present the sequence-analysis multistate model (SAMM): for each analytical step, we first introduce the methodological aspects of the technique and then the application to our data by discussing the results in light of our research questions. We additionally provide robustness checks by comparing results from SAMM to results from standard multistate models. Section 6 summarize the findings and discuss further extension of sequence-analysis multistate models.

2 West and East Germany before and after reunification

Between 1961 and 1990 Germany was divided into the Federal Republic of Germany (FRG) in the West and the German Democratic Republic (GDR) in the East. The two sub-societies differed to a great extent on ideational level as well as institutional characteristics of labor market and the welfare system. While female employment in the West was embedded in a male-breadwinner system, a wide range of options to conciliate work and family set up a different employment opportunity structure for Eastern women.

Specifically, the former GDR in the East promoted a universal breadwinner model in a communist egalitarian stratification system and aimed at population growth through pro-natalist family policies. The constitution guaranteed the "right to work", which was replaced by the "right and duty to work" in 1961 (Kreyenfeld, 2004). Female labor market participation rates around 90% (Huinink et al., 1995) were consistent with a "ideology that glorified the working woman" (Kreyenfeld, 2004). The abundance of open positions in the centrally planned economy and the availability of almost universal and daylong child-care facilitated labor market participation also for mothers (Huinink et al., 1995). The strong commitment to integrate women in the labor market increased women's share in high prestige occupations and lead to unknown levels of gender equality given the unprecedented decrease in the gender wage gap and the motherhood penalty (Budig et al., 2012; Rosenfeld et al., 2004; Trappe and Rosenfeld, 1998).

In the FRG the male-breadwinner model was the core organizing principle of social policies (Brückner, 2004). The capitalist market economy coupled with strong labor market segmentation between insiders and outsiders (Diewald et al., 2006). Tax-splitting among spouses reinforced incentives for marriage and a male breadwinner/female homemaker specialization (Fasang, 2014). Foreseeing women in the role of home-makers and care-takers, the infrastructure for public childcare was limited, particularly for children under the age of three. In addition, the FRG was characterized by a normative climate in which mother's employment was regarded harmful for small children (Treas and Widmer, 2000). During the decades before reunification, female labor market participation was

only around 50%. Furthermore, compared to East Germany, women's employment was more discontinuous, often characterized by long-lasting spells of unpaid caregiving, and lower prestige part-time jobs in the secondary labor market segment (Buchholz and Grunow, 2006; Hauschild, 2002). As a result, West German women were much more economically dependent on a male breadwinner to sustain themselves and their children.

With the reunification, the Eastern federal states adopted Western labor market institutions. During the first years after reunification (a period called "window of opportunity", cf. Mayer et al. (1999) the rapid privatization of the economy was counterbalanced by huge shares of subsidized jobs in the public sector, early retirement schemes, and generous social security contributions (Franz and Steiner, 2000). However, after this short period of time, the dramatic changes in the occupational structure, the destruction of about one third of the jobs in the East, and the devaluation of skills and of the tenure of Eastern workers, led to a persistent disadvantage of the economy of the former GDR area (Goldstein and Kreyenfeld, 2011; Kreyenfeld, 2003). Lower wages and higher unemployment rates still continue to characterize the East compared to the West after reunification (Goldstein and Kreyenfeld, 2011).

In the West, even though women started to take decision on their engagement in the labor market increasingly independently from their partner situation (Trappe and Sørensen, 2006), during the first decade after reunification the gap in gender beliefs between Western and Easter women even increased (Lee et al., 2007). Much of the female employment increase in the West was in part-time jobs, and full-time employment remained a prerogative of Eastern women. Long unemployment affected especially younger cohorts of workers in general (Kurz et al., 2005; Grunow and Mayer, 2007; Mayer et al., 2010), but especially women in the East (Hauschild, 2002; Sommerkorn and Liebsch, 2002). Even though child-care availability continued to be higher in the East after reunification (Engstler and Menning, 2003), women's labor market participation seemed to converged to the West (Rosenfeld et al., 2004; Aisenbrey et al., 2009).

Many previous studies on labor market participation over time in Germany, have focused only on the West (e.g. Manzoni et al. (2014); Gundert and Mayer (2012); Aisenbrey et al. (2009); Mayer et al. (2010); Biemann et al. (2011); Brückner and Mayer (2005); Berger et al. (1993), or on East-West comparisons before or after the reunification (Diewald et al., 2006; Diewald and Mach, 2006; Solga and Diewald, 2001), and East vs. West before or after the reunification (Diewald, 2006; Diewald et al., 2006). Few studies compare across the four contexts, but rely on data for relatively old cohorts of individuals, i.e. up to 1970 (Simonson et al., 2011; Mayer et al., 1999; Rosenfeld et al., 2004). Therefore, we know little on lasting consequences of the reunification process on younger cohorts' labor market experience, which are crucial to understand the features of "prolonged transformation" (Mayer, 2006) that followed the reunification "shock therapy".

3 Background and hypotheses

We contribute to the debate on the development of individual life courses in the two German sub-societies before and after the reunification by adopting a holistic approach

to study longitudinal employment trajectories of women born between 1944 and 1990. We aim to assess whether institutional changes and labor market triggered convergence or divergence of Western and Eastern female employment trajectories.

The convergence hypothesis builds on the modernization theory (Castells, 1996; Beck, 1992). Globalization and modernization are thought to drive a convergence in the long-term in all life domains, arguably adapting the East to the Western model. Consequences in the labor market include increasing individualization and casualization of employment due to both progressive external and internal flexibilization (Mills et al., 2008).

The case of women's employment trajectories is especially enlightening because either preferences towards labor market participation might have remained stronger in East (REF), or their higher household economic necessity could have kept them more attached to the labor market also because female-dominated occupations in the GDR were revaluated through the creation of temporary public jobs in the first phase of the reunification (REF). Nevertheless, in the East unemployment risk reached levels previously unknown, and discouraged by the scarcer availability of work-family reconciliation policies configuration might have altogether undermined Eastern women's labor market participation and made their employment trajectories more volatile.

. Convergence and divergence in employment trajectories can be actually conceptualized as a "double question" (Diewald, 2006). First, we should assess whether individual employment trajectories became more volatile in the West itself, and, second, whether the East experience flexibility besides adopting the Western institutions.

Against this scenario, following a convergence argument we can advance two competing hypotheses. First, if deregulation did not affect women employment trajectories in the West, convergence would result in adaptation of the East to a system characterized by sharp differences between insiders and outsiders (hypothesis 1a). Second, if deregulation of female employment trajectories were in place in the West, East would converge towards increasing casualization (hypothesis 1b).

On the contrary, a divergence (or differentiation) perspective would suggest two other hypotheses. On the one hand, in the East deregulation might have been pushed to an extent that would have been unacceptable in the West, and therefore we would expect highly volatile employment trajectories in the East compared to the West (hypothesis 2a). On the other hand, if a shift toward more volatile employment trajectory occurred in the West, the adoption of old Western labor market institutions in the East could have make it hard to adapt to the deregulation demand at the same time. It follows that we would then expect divergent traditional trajectories in the East and more casualized in the West (hypothesis 2b).

4 Data

We use retrospective data of the Starting Cohort Six of the National Educational Panel Study (NEPS) (Blossfeld et al., 2011) for women born in East and West Germany ($N = 731$ and $N = 3'406$ respectively) between 1944 and 1990.

To ensure a rigorous comparison of the GDR and the FRG, we only included re-

spondents in the sub-society samples, who were born in the respective region and were still living there at the time of the interview in 2009/2010. We excluded foreign-born individuals, respondents who migrated between East and West, and individuals living in Berlin. This was necessary because the NEPS did not distinguish between the former East and West regions of Berlin at the time of the interview in 2009/2010 and thus they could not unambiguously be assigned to either the East or West regions. Since we only observe women that did not migrate between East and West, this is only partly a time-varying covariate. Women can change between before or after reunification, but not between East and West.

We reconstruct individual employment trajectories from ages 15 to 40 by coding each month according to one of three states, namely being in education, employed, or out of the labor force (OLF). For reason of simplicity, we do not distinguish between the different kind of education nor the different reasons to be OLF. Since unemployment as well as parental leave schemes differ to a great extent in the two context before reunification and reporting of such nuances are not clear in the data, we regrouped unemployment, military service, gaps in trajectories, and parental leaves in OLF.

Under-reporting of unemployment or short employment spells is a known issue when analyzing retrospective data. These recall errors were minimized by the NEPS Starting Cohort Six team by combining modularized self-reports and event history calendars (Drasch and Matthes, 2013). This technique combines event history calendars with an automated data revision tool that detects gaps, overlapping events and inconsistencies during the interviews, prompting the reviewer to immediately ask for clarification and therefore helping the respondents' memory to minimize inconsistencies in the data. We therefore assume that memory bias is not a major issue in the NEPS. These recall errors are probably not systematically different in East and West Germany to an extent that would fundamentally invalidate the comparison between the two sub-societies.

5 Previous methodological approaches

Our research question poses a recurrent methodological challenge in life course research. We want to assess if and to what extent the reunification of East and West Germany influenced individual employment trajectories. This specific topic refers to a more general and central issue within the life course paradigm, which insists on the need to study how socio-historical conditions shape the unfolding of individual life courses (Elder et al., 2003; Mayer and Tuma, 1990; Kok, 2007).

From a more methodological point of view, this challenge raises the issue of measuring the influence of a time-varying covariate on individual trajectories. However, it is not possible to tackle this issue with the methodological tools available at the time being. On the one hand, sequence analysis has the advantage of providing a holistic view on pathways and allows considering the unfolding of a trajectory over several status as well as their interdependencies. However, the effect of time-varying covariates can not currently be analyzed as the trajectories are studied as a whole. On the other hand, event history analysis provides a rich set of methods to analyze the effect

time-varying covariate. However, contrary to the emphasis life course research puts on the importance of interdependencies between events and transitions, event history analysis allows modelling only the timing and the probability of specific single events and transitions. In the literature, the holistic and the event-based approaches have been counterposed as belonging to two different "cultures" in life course analysis, namely the data algorithmic and the data modelling culture respectively (Breiman 2001).

However, complementing rather than opposing the two approaches (Billari 2005) represents a preferred strategy to provide life course research with novel empirical evidence. In the following sections, we present sequences analysis and event history analysis, highlighting their strengths and weaknesses from both a methodological and a theoretical point of view. We then presents our proposition to combine them in the sequence-analysis multistate model (SAMM), which allows describing how time-varying covariates are related to individual trajectories. We further provide robustness checks for SAMM by estimating classic MM.

5.1 Sequence analysis (SA)

Sequence analysis (SA), also called optimal matching, provides a holistic view on processes described as a succession of states (Abbott, 1995). Technically speaking, SA relies on a distance measure between these sequences that allows pairwise comparisons between whole sequences (Abbott and Forrest, 1986; Elzinga, 2005; Müller et al., 2008). Most of the time, these distances are then used to create a typology, where the types are thought to describe the main typical trajectories or ideal-typical processes.

This approach is in line with the notion of trajectory described by the life course paradigm as a sequence of roles and social status (Elder et al., 2003). Because SA analyzes the unfolding of the trajectories over several states (or statuses) at once, it also implicitly analyzes the transitions between these states.[1] These features convinced several authors that SA is one of the most promising methods for studies from a life course perspective (e.g., Shanahan, 2000; Brzinsky-Fay, 2007; Mayer, 2009; Brzinsky-Fay, 2010; Liefbroer and Toulemon, 2010; Brzinsky-Fay, 2014).

With SA, change is operationalized as lasting over a period of time and not only as instantaneous: this is a key aspect in life course research. As Shanahan (2000) points out, important transitions can last for several months or years and are usually less well defined than the study of a single event would suggest. He even argues that important transitions may results from a succession of events. Abbott (2009) put forward similar argument when discussing the notion of "turning points" within processes. Finally, Brzinsky-Fay (2014, p. 218) states that "measuring transitions means capturing a process with a specific time dimension".

Shanahan (2000) gives the example of leaving parental home that is often analyzed as a specific and non-recurrent event. However, this transition is often gradual (or at least, more often than we tend to think), marked by back and forth movements from the

[1] Since transitions can be formalized as the simultaneous occurrence of a set of events, SA also implicitly analyzes events (Studer et al., 2010).

parental home. Furthermore, this gradualness might well be a research question in itself, as it might have known increasing complexity for more recent cohorts as byproduct of the democratization of education and the changes in the economic conditions (Billari et al., 2001; Aassve et al., 2013). Brzinsky-Fay (2007) also advocates for considering longer periods of time when studying employment trajectories, as labor market integration or exclusion are processes that last over extended periods (see also Brzinsky-Fay, 2010). Furthermore, the casualization of the labor market may well have made the early careers more complex, i.e. composed by an increasing number of internships, temporary jobs and unemployment spells (Brzinsky-Fay, 2007).

SA allows studying several states by looking at their *sequencing* (Abbott and Forrest, 1986; Studer and Ritschard, 2015). The sequencing describes the transitions within the sequences. It might reveal i) possible interdependencies between the states the trajectories are composed of, ii) the internal logic of the trajectories, and iii) the most important turning points. By describing the sequencing, the choices and events are situated along individual trajectories. This is a key aspect, because the social interpretation and/or the consequence of an event may depend on previous, but also on later events (Elder et al., 2003).

SA also examines at the *duration* of the spells spent in a state, meant as another way to account for possible dependencies between states and transitions. Duration also refers to the *spacing* between two transitions or events (Studer and Ritschard, 2015). Spacing (or duration) allows thinking of short- or long-term logics (dependencies) within sequences. This is a central concept in the study of employment trajectories, given that the social interpretation of unemployment depends on its duration (Brzinsky-Fay, 2014). The same applies to job length, internship, and so on, as well as to episodes in other life domains.

To sum up, the strength of SA is to provide a holistic view on trajectories. It allows studying several states in the same analysis while taking into account their possible interdependencies. This is done by looking at the sequencing and the spacing of these states or events. Finally, changes and transitions within trajectories are conceptualized as lasting over a period. These features make the SA framework particularly suitable to study research question framed within the life course paradigm.

However, SA also has several weaknesses. First, since trajectories are analyzed as a whole, one can only measure the effect of conditions measured before the starting point of the trajectory. Therefore, SA cannot be used to study the influence of contextual or individual time-varying factors.[2] Second, SA cannot fully handle censored observations, and one usually ends up analyzing only fully observed trajectories. For these reasons, we cannot use SA to study how reunification shaped the unfolding of employment trajectories because, for some women, reunification occurred during their active period in the labor market. Moreover, analyzing employment trajectories from ages 15 to 40 would constraint us to exclude from the analysis all individuals born after 1970. None of the trajectories would have started after reunification.

[2]Including covariates measured at the middle or at the end of the trajectories may lead to conceptual issues. One explains the trajectories (or at least part of it) by what happens in the future.

5.2 Multistate models (MM)

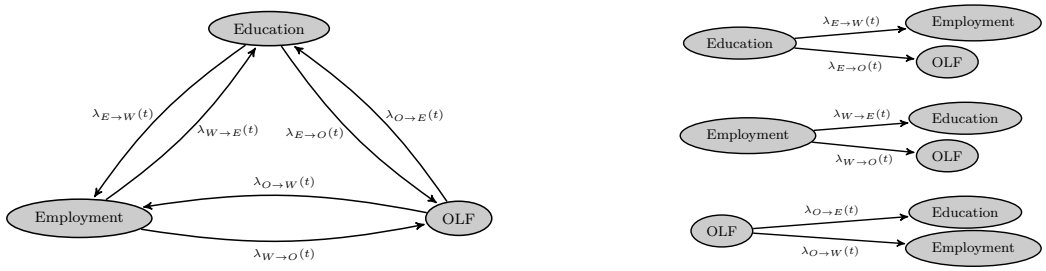
Event history analysis (EHA) is another framework widely used in life course research. It regroups a number of methods for estimating duration between two events, such as birth and death or starting and stopping an employment spell. The method aims at describing the probability distribution to "survive" an event, or, more precisely, the probability not to experience this event at time t. By doing so, it jointly analyzes the timing and the occurrence of the considered event. One of the main advantage of EHA is that it handles censored observations, and thus allows including in the analysis individuals that were not fully observed (Allison, 1984; Yamaguchi, 1991; Courgeau and Lelièvre, 1993; Hosmer and Lemeshow, 1999; Blossfeld and Rohwer, 2002).

Several extensions of EHA, such as the semi-parametric Cox model (Cox, 1972) or discrete time model (Yamaguchi, 1991), allow measuring the influence of explanatory factors on a given event. In our case, this allows us to measure the influence of time-varying covariates (family status and East-West reunification) on the occurrence of employment-related events. Thus, relying on EHA enables us to deal with these methodological challenges.

Among the extensions of EHA multistate models (MM) represent a very interesting attempt to study trajectories as whole (Therneau and Grambsch, 2000; Andersen and Keiding, 2002; Steele et al., 2004; Putter et al., 2007; de Wreede et al., 2011). MM aims at analyzing state sequences by focusing on the hazard to observe transitions between states and the time spent in each state.

Figure 1 presents the MM as a graph showing the possible transitions between the states making the trajectory. The sub-figure 1a displays the MM graph for our sequences made of three distinct states: education, employment and out-of-the-labor-force (OLF). In our case, all theoretical transitions can be observed. [3]

Figure 1: Multistate model.



(a) Multistate model.

(b) Estimation strategy.

MM focus on the risks to experience a transition $\lambda_{a\to b}(t)$ over time t between two states a and b. The risks (and the effect of explanatory factors) are estimated using the

[3] One usually distinguishes between *transient* states, if individuals can leave a state, and *absorbing* (sometimes called *terminal*) states, if individuals are not followed after having reached this state. Being dead is an example of an absorbing state.

following strategy. We first focus on given state, say "Education", before estimating the risks/chances of a transition to one of the other states, i.e. "Employment" or "OLF" in our example. The two transitions "Education → Employment" and "Education → OLF" can be seen as competing risks, because once one of the two occurred, an individual is not at-risk of experiencing the other one anymore. Then, another state is taken into consideration, say "Employment", and the risks associated with the transitions "Employment→ Education" and "Employment→ OLF" are estimated, and so on for all possible states. The estimation strategy is displayed in Figure 1b.

By focusing on the risks to leave a spell, MM implicitly analyze the time spent within each spell, while considering several ways to leave the spell, i.e. the transitions to the other states. MM therefore aim at describing the sequences by focusing on the transitions and the time spent within each spell.

Any estimation methods suitable for competing risks can be used to estimate a MM, e.g. Cox model (Cox, 1972) or logistic or multinomial discrete-time models (Allison, 1982) among others. When spells can be recurrent as in our case, a model including a frailty term should be preferred because they provides more accurate estimates of individual level covariates(Bijwaard, 2014). In fact, frailty models allow to relax the independence assumption in the presence of multiple observations for each individual (Mayer and Tuma, 1990; Blossfeld and Hamerle, 1990; Galler and Poetter, 1990; Wu, 2003) because they take into account unobserved heterogeneity[4]. Several methods fulfil these conditions. Among others, we can cite cause-specific Cox proportional hazard models for competing risks with frailty (Therneau and Grambsch, 2000; Lunn and McNeil, 1995; Putter et al., 2007), multinomial or logistic discrete-time models with random intercept (Steele et al., 2004).

A number of estimation strategies can be used (see Andersen and Keiding, 2002, for instance). The simplest one is to estimate a separate model for each transition (i.e., competing risks). This leads to the assumptions that the effect of covariates are transition-dependent and that cause-specific hazards are non-proportional (a separate risk curve is used for each transitions). These loose assumptions come at the cost of a more complex model. One may also estimate one model per spell, which may result in a more parsimonious model, and allows correlated frailties (Bijwaard, 2014). Finally, all transition-specific hazards can be estimated in a single model (Steele et al., 2004). However, this later approach makes it difficult to include a frailty term in the model.

MM present several advantage to study life courses. First, they allow analyzing simultaneously several events and transitions, as well as the time spent in each spell. Second, the influence of time-varying covariates, such as family or contextual changes, can be estimated. Finally, it can handle censored observation.

However, some limitations of MM have to be acknowledged. First, as already pointed out, MM assume instantaneous transitions and events and we already stressed the importance to analyze changes over a given time period. Second, By focusing on single events and transitions, one loose the sight of longitudinal patterns and sequencing. It

[4]Individual level characteristics that are not included in the model, such as employment motivation for instance.

is therefore difficult to have a global view on the trajectories, and interdependencies between states, transitions and events are difficult to identify.

6 SAMM: sequence-analysis multistate models

As we have seen so far, none of the two approaches fully address the methodological challenges posed by our research questions. On one hand, SA provides a holistic view on trajectories, taking into account sequencing, spacing, and interdependencies between states and events, but it does not allow studying the effect of time-varying covariate. On the other hand, MM can be used for the latter purpose, but it requires to focus on specific, well-defined, and instantaneous events and transitions.

In this section, we propose the sequence-analysis multistate model (SAMM) to combine these two approaches to study how time-varying explanatory covariates shape women's employment trajectories in East and West Germany before and after the reunification. In a first step, we use an adaptation of SA to study the typical sequencing and the spacing between the main events marking the trajectories over a mid-term period. Then, we implement MM to study the chances (or risks) to follow each kind of typical sequences identified in the first step.

6.1 Typical combinations of events

The first step of our analysis aims to identify typical sequences of changes along the trajectories over a mid-term period. We do so by studying subsequences that describe the transitions observed in our data set over five years.

6.1.1 Extracting subsequences

We start by extracting *subsequences of consecutive states* from each individual sequence as follows. First, we set the time span, noted ℓ, over which the subsequences are to be analyzed. Then, for each transition between two states starting at time t, we extract a new *subsequence of consecutive states* made out of the states from time t to $(t + \ell - 1)$ in the original sequence.[5] In other word, we extract the subsequence starting with a transition and lasting for ℓ time units. By doing so, our subsequences describe the transitions between two states as well as what follows over a period of ℓ time units. Since we do it for each transition observed in a sequence, there may be several subsequences for the same individual.

Since we extract subsequences *of consecutive states*, our definition of subsequence is therefore more restrictive than the one of Elzinga (2005), where a subsequence x of a sequence X is defined as a sequence obtained by deleting any number of states in X.In his definition, the states in x are therefore not necessarily consecutive in X. Our definition of subsequences, where we impose the states in x to be consecutive in X, is usually referred to as substring in computer sciences. However, we prefer to use the word "subsequence"

[5]Using -1 ensures the subsequence is of length ℓ.

here, because the concept of string has no interpretation in the social science context. By using the word subsequence, we refer to a small part of a trajectory, which can be conceived as a "sub-trajectory".

If $\ell = 2$, then our subsequences are of length two and fully describe transitions. As ℓ increases, we analyze longer subsequences describing potentially more complex interdependencies between a first and the next transitions. In our analyses, we used $\ell = 60$ months, following Brzinsky-Fay (2014) who analyzes school-to-work transition over the same time span. We therefore consider subsequences i) whose starting point is a transition from one state to another (Employment, OLF, Education), and ii) that are composed by the states that follow this starting transition over a five-year window.

On a sociological ground, there are several theoretical justifications to study subsequences. First, and most importantly, the subsequences after a certain transition may be known (at least to some extent) by the actors. For instance, students may plan to engage in a short job during summer break before restarting their studies in autumn. The same applies in the case of a women who accepts a new job even if (or because) she knows that it is only a short term contract. Second, the subsequence that follows the first transition may be a consequence of it. In other words, the first transition may have been the first step of a more profound transition lasting over a certain time period. Finally, transitions and turning points are not necessarily instantaneous (Abbott, 2009), but may last for some time.[6] Decomposing the change in single transitions may fail to describe the underlying dynamic of the trajectory (Shanahan, 2000).

We only consider transitions occurring before $L - \ell$ time units, where L is the total length of the sequence, because subsequences occurring after this time limit cannot be fully observed. In other words, our censoring time limit do not equal L, but $L - \ell$, leaving aside the last ℓ time units. As we will discuss in depth when presenting its application, MM makes it possible to consider all the sequences until that point, because we can handle censored information. We come back to that when discussing MM.

Figure 2 provides three examples of the extraction procedure. Sequence 1 represents a woman's employment trajectory that starts with an education spell. After 46 time units, she experienced a transition from education to employment. We extracted the subsequence starting at position 46 (the last month spent in education) and lasting for 60 months (5 years) spent in employment. This subsequence is framed in a green rectangle in Figure 2. The employment spell that starts after education lasts 193 months, and then this women experienced a transition from employment to OLF. We thus extracted a second subsequence starting at position 238 and lasting for 60 months (same duration as before). Finally, she experienced one last transition at time 268, but we cannot extract a subsequence of 60 months and therefore we discarded this subsequence. More generally, any transition occurring after 240 time unit (the length of the sequence $L = 300$ minus $\ell = 60$) are not included in the analysis. This censoring time limit is represented with a vertical red bar in Figure 2.

In our data set, many women experienced several transitions between states. In this

[6] Abbott (2009) rightly notes that turning points are defined ex-post. They may be defined as sequences of changes that lead to a profound change in the trajectory.

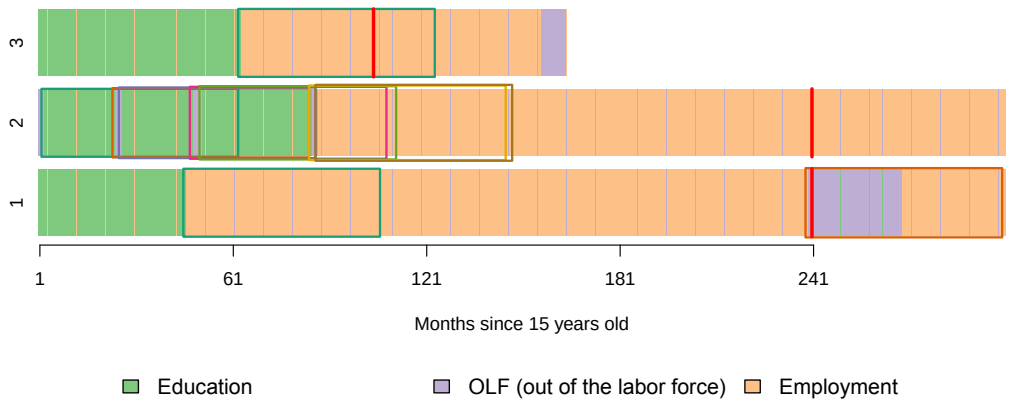


Figure 2: Examples of the subsequences extraction procedure. Extracted subsequences are marked with colored rectangle. Censored time is represented by vertical red bar.

case, the extracted subsequences potentially overlap as shown for sequence 2 in Figure 2. Here, the first extracted subsequence embeds the next four transitions.

Finally, the length of our third sequence equals $L = 164$ time units. All transitions occurring before $164 - 60 = 104$ time units can be included in the analysis.

6.1.2 Subsequences clustering

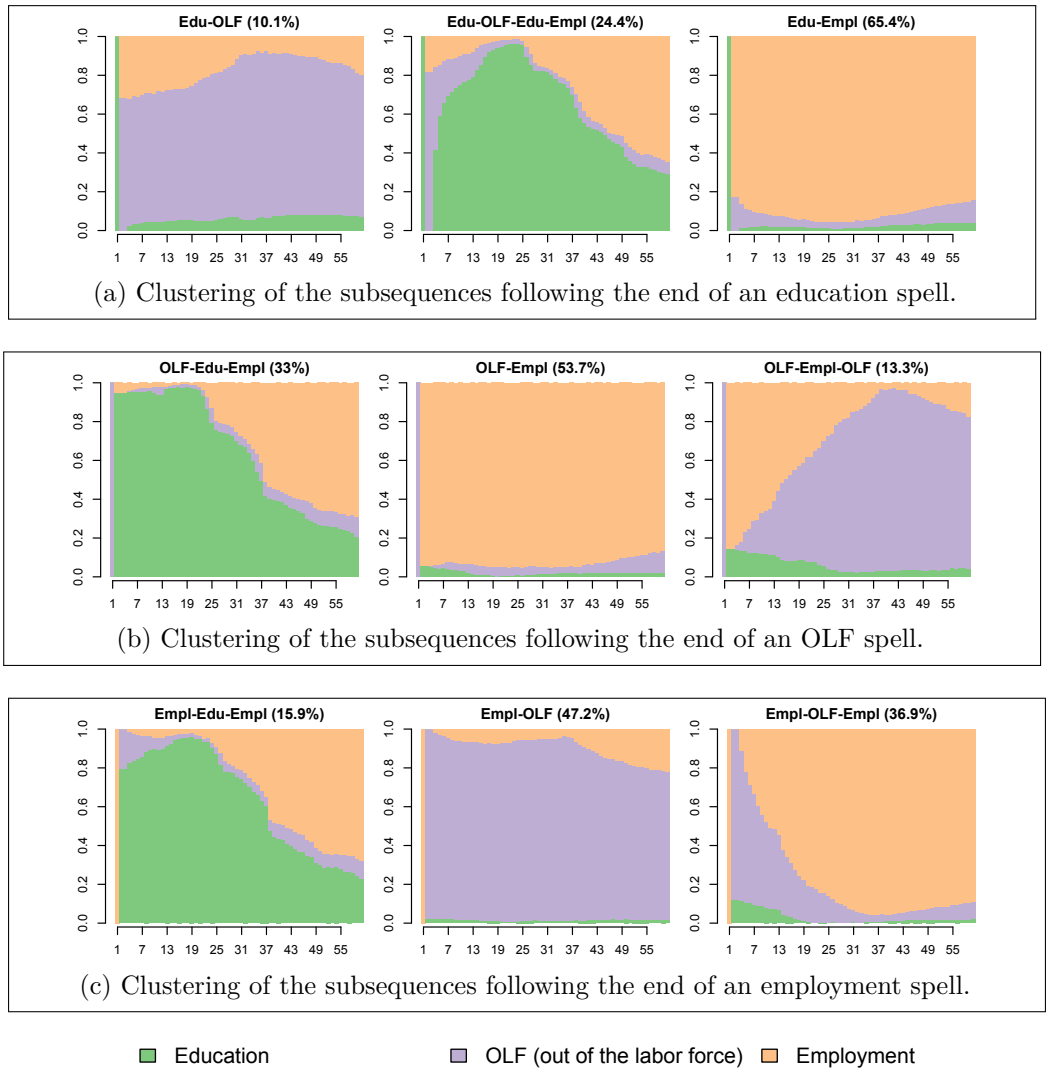
Once all subsequences have been extracted, we cluster them using SA to find ideal-typical subsequences, which can be interpreted as typical changes along the trajectories that follow certain transitions between states.Cluster analysis implies choosing a clustering algorithm and a distance measure for comparing the sequences. Here, we briefly review some consideration about both procedures.

As argued by Studer and Ritschard (2015), the choice of a distance measure should be grounded on its performance in accounting for three dimensions: timing, duration (or spacing) and sequencing. Here, it should be noticed that these dimensions are defined related to the first transition.[7] Given that duration is a key aspect of employment trajectories, we chose here the optimal matching distance with constant costs, known to be sensitive to duration.

The standard sequences clustering procedure (Studer, 2013) needs to be adapted. In the following MM analysis, we analyze the hazard to follow a given subsequences, *while being in a given state*. In other words, we run separate analysis for each starting state. For this reason, all subsequences clustered in a same group should start with the same state. If it is not the case, they will be clustered according to their first state anyway (event if it leads to make distinctions within a cluster). We therefore need to conduct a separate cluster analysis on each pool of subsequences defined according to their starting state, i.e. education, employment, or OLF. This clustering procedure has the advantage to i) build groups with a sufficient number of case in each cluster, and ii)

[7]Hence, timing would refers to the time elapsed from this first transition, for instance.

produce meaningful distinctions for trajectories following a given spell.



(a) Clustering of the subsequences following the end of an education spell.

(b) Clustering of the subsequences following the end of an OLF spell.

(c) Clustering of the subsequences following the end of an employment spell.

Figure 3: Distribution plots of the subsequence clustering. Percentage are computed as the proportion of the ending spells.

We used the partitioning around medoid (PAM) clustering. The number of groups was chosen according to the average silhouette width (ASW) criteria (Studer, 2013). We obtained good quality clustering solutions (ASW was above 0.6) with 3 groups for each pool of subsequences, i.e. starting with education, OLF, or emplyoment. However, the choice of the same number of groups for each group of subsequences is not compulsory. For example, we could very well have chosen only 1 type of transition for leaving education spell (no matter the destination) and 3 for the others.

Figure 3 shows the distribution plots for the clustering solution for each starting state. Each subsequence type was labelled according to the medoid subsequence. For Figure 3a,

Figure 3b, (Figure 3c the percentages refer to the share of extracted subsequences out of education, OLF, and employment respectively assigned to each cluster.

Figure 3a presents the typical "sub-trajectories" following a spell of education. We identified three kind of subsequences following a spell of **education**. First, in almost two thirds of the cases, individuals started working and remained in employment for the following 5 years. Notice that some women experienced a short OLF spell before starting their employment. Second, for around 10% of the subsequences, the transition leads to OLF, directly or over a mid-term period. Finally, in almost 25% of the cases, the transition is only temporary as individuals are going back to education, usually after two months OLF, but some do also work during this break. This pattern highlights that a significant part of the transitions out of education should be considered as an intermediate step towards the start of a new education spell.

Figure 3b presents the three clusters of subsequences identified when moving out from an **OLF** spell. First, in one third of the cases, women go back to education. This pattern is likely to follow the two month break in OLF identified previously. This subsequence often leads to a transition to employment in the following five years. Second, OLF spells end as a consequence of the start of an unemployment spell (54% of the cases). Finally, 13% of the transitions out of OLF lead to temporary/short employment spell.

We have also detected three ways to leave an **employment** spell (Figure 3c). First, women might go back to education (around 16% of the cases). In this group, some women experience many employment–education transitions in both directions. Second, most of the transitions (47%) end in the OLF state over a mid-term period. Finally, in around 37% of the cases, the sub-trajectory leads back to employment within a short term period, often less than one year.

Clustering subsequences allowed us to observe mid-term dynamics of transitions between states during a five-year time window, and to detect typical subsequences characterized by back-and-forth dynamics, such as "Edu–OLF–Edu", "OLF–Empl–OLF" or "Empl–OLF–Empl". These kinds of subsequences situate the transitions within a broader dynamic of the trajectories and allow distinguishing for instance between short summer jobs and more stable transition into the labor market. The "OLF–Empl–OLF" and "Empl–OLF–Empl" are of special interest for our studies, because they could reflect the casualization of the labor market.

These mid-term dynamics are not equivalent to the direct transitions ending a spell. This is highlighted with Table 1, which presents the contingency table between the two. We can notice that more than 50% of the "Education–OLF" direct transitions are classified in the education break subsequence "Edu–OLF–Edu–Empl". "Education–OLF" direct transitions are therefore not easily interpreted. They can effectively lead to OLF, but they might also be the starting point of a new education spell. SAMM could detect these prolonged transitions to OLF, which would not have been effectively distinguished from summer breaks during education using standard MM or clustering over complete employment trajectories.

	From education to		From OLF to		From employment to	
Clustering	OLF	Empl	Edu	Empl	Edu	OLF
Edu–OLF	18.02	5.23				
Edu–OLF–Edu–Empl	52.07	7.21				
Edu–Empl	29.92	87.56				
OLF–Edu–Empl			86.14	2.78		
OLF–Empl			8.49	79.47		
OLF–Empl–OLF			5.37	17.75		
Empl–Edu–Empl					69.45	3.93
Empl–OLF					6.07	56.35
Empl–OLF–Empl					24.48	39.72

Table 1: Percentage of direct transition classified in each subsequence cluster.

6.1.3 Descriptive analyses using typical subsequences

The typology of the subsequences describes the patterns of changes within trajectories. To visualize these changes over the life course, Figure 4 presents the monthly hazard rate to experience each type of subsequences at each age.[8] Education-related subsequences are roughly concentrated between ages 15 and 20, except the "Edu–Empl" subsequence which occur until age 25 and represents the smoother school-to-work transition option. Interestingly, the education-break pattern ("Edu–OLF–Edu–Empl") shows two local maximums around ages 16 and 19, that are followed by local maximum of the "OLF–Edu–Empl" subsequence's hazard. This is likely to be due to the unemployment spells after concluding and before starting a school-cycle. The hazards of most of employment related sub-trajectories rise until 22 years old and stay quite stable starting from that point. The "Empl–OLF" prolonged transition shows an increasing hazard until 25 years old followed by a decrease, showing that transitions to prolonged transition to OLF occurs in correspondence with the onset of the family formation process.

The same graphical representation can be used to look at the employment trajectories in East and West Germany. Figure 5 presents the hazard rate to experience each type of subsequence but for each time period this time. Some words of caution are needed before interpreting the Figure, since some of the trends are driven by the evolution of the age distribution over the periods. Since we use retrospective data, the hazard rates computed in the '60s are based almost only on younger people, but this is not true for the latest period. We observe an interesting rise in back and forth movement in and out the OLF state over time. After the mid '80s, the hazard to experience pauses within employments (Empl–OLF–Empl), long-term OLF (Empl–OLF) or temporary employment (OLF–Empl–OLF) increases in both contexts. We also observe a casualization of the transition from education to employment with a decrease for the subsequence (Edu–Empl) and an increase for the subsequence Edu–OLF.

[8] A separate figure for each context (EB, EA, WB and WA) could be used to describe contextuals differences. However, we do not present them here, because we use MM to analyze these differences.

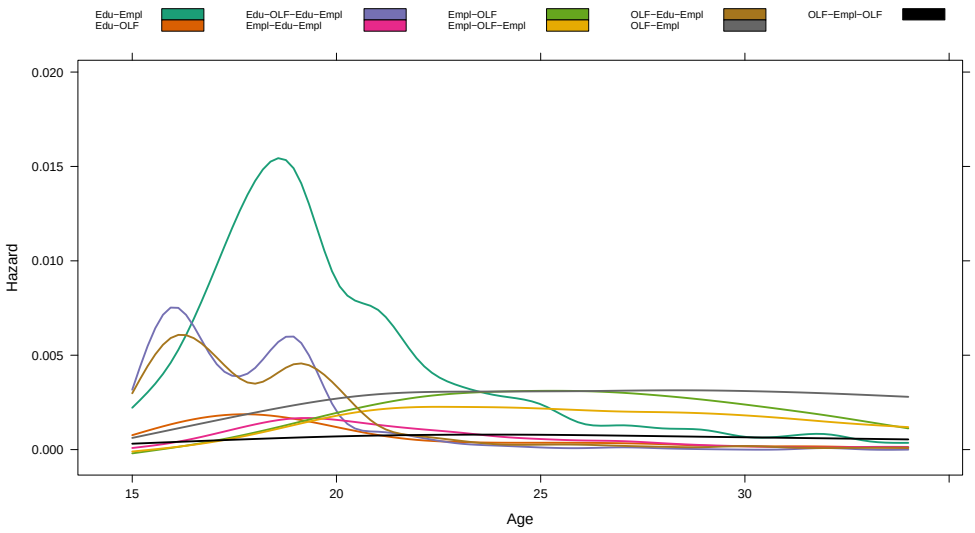


Figure 4: Monthly hazard rate to experience each kind of subsequences. The curves were smoothed using splines (Forsythe et al., 1977) to improve the graphic's readability.

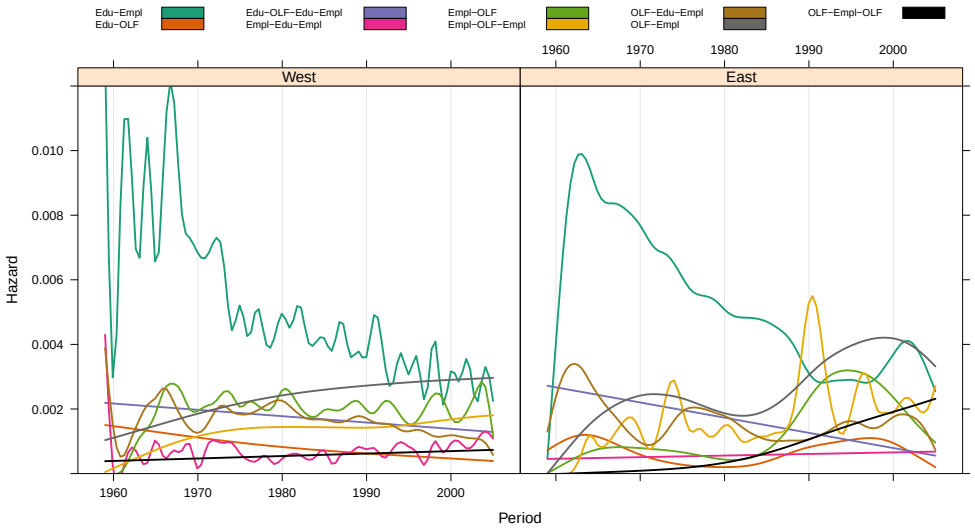


Figure 5: Yearly hazard rate to experience each kind of subsequences. Curves were smoothed using splines to improve readability.

6.2 Multistate models

Once the typology is built, the effect of explanatory factors on the previously identified clusters of typical subsequences can be estimated using MM. More precisely, we estimate the hazard to follow each type of subsequence cluster while being in a given spell. Figure 6 presents the graph associated with this MM where each arrow is a hazard to be estimated.

In our case, this involves estimating 9 hazard functions one for each pair of ending spell–typical subsequence cluster. For instance, when analyzing spells of employment, we consider three ways they can end up with: a short break (toward a new employment pattern), a new spell of education (which also lead to employment later on) or a mid-term period spent out of the labor force.

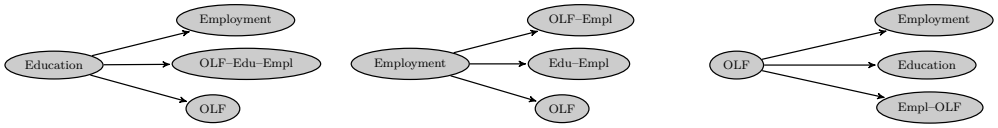


Figure 6: Estimation strategy for the multistate model combined with sequence analysis. Each path is a hazard to be estimated by the model.

Strictly speaking, in our proposition, the competing risks are not transitions between states, but rather transition from one state to a sequence of states over a mid-term period, i.e. our subsequences. This does not prevent us from using the MM framework. As stated by Steele et al. (2004), MM can be applied in much more general cases. They are adapted to study competing risks when observing several states that are interpreted as different starting conditions for the competing events under analysis.

In our clustering procedure, we ensured that each typical subsequence clusters started with a specific state. This is needed, because a separate hazard function is estimated for each couple of starting state and competing events (typical subsequences in our case). If we used a unique pattern for all transitions leading to employment (whatever the starting state), we would have ended up with a separated hazard function to estimate for each combination of ending spell–transition to employment. By running separate cluster analysis for each ending spell, we made sure that the identified typical following subsequences are meaningful when focusing on this spell only. This also minimize the risk of having clusters with very few cases given the empirical distribution of the pool of our subsequences.

6.2.1 Estimation

As explained in section A, several estimation strategies can be used. Here, the model was estimated using a separate Cox model for each subsequence-specific hazards (for more information see the excellent tutorial of Putter et al., 2007).[9] As recurrent spells are possible and even frequent, we used Cox models with frailties computed using the "coxme" package (Therneau, 2015). As already presented in section 5.2, this is needed to properly handle multiple spells by individuals and unobserved heterogeneity. The time spent within a spell was used as the main timing over which the hazard baseline is computed. The durations are measured in months, hence in a discrete time-unit. However, this should not prevent us from using Cox models, since the *true* durations to be estimated are continuous (Hertz-Picciotto and Rockhill, 1997). Following Hertz-Picciotto and Rockhill

[9]In usual EHA, this is usually called "cause-specific" hazard. We adapted the terminology to our methodology.

(1997), we used the Efron method to properly handle ties in timing that result from the discrete measure of duration.

With this estimation procedure, the coefficients can be interpreted as the effect of a covariate on a subsequence-specific hazard. More precisely, the coefficient stands for the effect on the hazard to follow a given subsequence cluster instead of any other **or** staying in the spell. Due to that, the effect on the overall risk to end a given spell should be interpreted with caution. When the coefficients for each subsequence-specific hazard have the same sign, we can safely interpret the effect on the overall risk to end that spell. However, if a covariate positively affects the hazard of some subsequences and negatively some others, then the effect on the overall risk is undetermined, as it will depend on the frequencies of each subsequences and the magnitude of the coefficients.

6.2.2 Modelling

Our research question is related to the effect of reunification on female employment trajectories in East and West Germany. We therefore included a covariate to compare East and West, and two dummies to estimate the effect of reunification for East and West separately. We additionally controlled for the period measured in month since 1900 and coded as a continuous variable. In fact, several reasons besides reunification, such as cultural changes, educational expansion, etc., might have affected employment trajectories over our observational window. By not including a covariate for the period in our models, we would have attributed all potential changes in employment trajectories to the reunification of the two German sub-societies. However, a more complex transformation of the period covariate is not needed here, because the reunification dummies may only estimate a somewhat linear relationship. Moreover, this complex transformation could catch part of the effect of reunification itself.

We include two covariates for family status: being in a union or not and having at least one child or not. Since women with children are cohabiting or married most of the time, both effect tends to cumulate when having children.[10]

Three additional control variables are included in both models. First, we added age as a 3-degree polynomial.[11] Even though age-related effects are not the focus here, including a polynomial transform of age ensures the other effects not to be related to age. Second, the intergenerational transmission of education is expected to shape employment trajectories to different extent for some cohorts in East and West Germany, and thus we included parental education as a control. This is measured as the highest number of years in education between both parents. Third, we included dummies for the month of the year. Education-related transitions (starting or stopping) are strongly linked to

[10]These two family dimensions are strongly associated (Cramer's $v = 0.57$). Considering person-months data, around 62% of women in union have children and only 8% of women with children are not cohabiting nor married. We do not distinguish between marriage and cohabitation, because there were strong differences in East and West Germany in this respect. For this reason, marriage would not measure the same concept in East and West Germany. We do not distinguish between women living with their child or not, because the latter is very uncommon.

[11]The degree of the polynom was set in order to maximize the Akaike information criterion (AIC).

the month within the year, since they typically occurs between June and September. Moreover, given the retrospective nature of our data, the recall biases could result in a higher number of transition during some key months, such as trimesters, semesters or new years. Finally, by including months we control for yearly economic cycles, such as the ones related to unemployment.

In order to facilitate the interpretation, all continuous covariates were standardized and their coefficients are thus unit free.

6.2.3 Interpreting frailties

The estimated MMs include a frailty term, which it is worth looking at because the standard deviation of the frailty measures the inter-individual variation of the hazard to follow a subsequence, and this can also be interpreted as the inter-individual variation of the time spent within a spell before each subsequence. For instance, one of the highest values was estimated for the subsequence "Empl–OLF". This means, for example, that the duration of the employment spell leading to this subsequence has a higher inter-individual variation than the duration of the other spells leading to the other subsequences.

The value of the frailty estimated for each individual accounts for the unobserved heterogeneity, i.e. the propensity of an individual to follow a given pattern that is not explained by the covariates in the model. For instance, the unobserved heterogeneity could reflect differences in motivation.

Clustering	Edu–OLF	Edu–OLF–Edu–Empl	Edu–Empl	OLF–Edu–Empl	OLF–Empl	OLF–Empl–OLF	Empl–Edu–Empl	Empl–OLF	Empl–OLF–Empl
Edu–OLF				−0.43				0.34	
Edu–OLF–Edu–Empl				0.40					
Edu–Empl							−0.38		
OLF–Edu–Empl	−0.43	0.40							
OLF–Empl								−0.60	0.44
OLF–Empl–OLF								0.37	
Empl–Edu–Empl			−0.38						
Empl–OLF	0.34				−0.60	0.37			
Empl–OLF–Empl					0.44				

Table 2: Correlations between individual frailties in the main effect model.

Individual frailties can be used to highlight the interrelations between the different subsequences. Table 2 presents the correlations between these frailties. To improve the reading of the Table, only correlations higher than 0.3 are reported.

A positive correlation means that two subsequences are experienced by individuals with the same unobserved characteristics. On the contrary, a negative correlation indicates that the subsequences are experienced by individuals with different unobserved characteristics. Within our combination of SA and multistate, we expect quite high correlations. Indeed, as we mentioned, extracted subsequences might embed future transitions by definition. There are therefore structural relationships between typical subsequences and correlations presented in Table 2 provide insights on these links.

Having a pause within education ("Edu–OLF–Edu–Empl") is positively associated with restarting education after an OLF spell ("OLF–Edu–Empl"). This is consistent with the fact that the second pattern is embedded in the first one. This is one of the relationships between subsequences we would expect. More interestingly, the "Edu–OLF"

pattern is positively correlated with the "Empl–OLF" subsequences. This might give support to the idea that unemployment spells generate scarring effects that increase the likelihood of recursive OLF episodes.

6.2.4 Interpretation of the multistate models: convergence or divergence?

Our research question concerns whether institutional changes and labor market after reunification triggered convergence or divergence of Western and Eastern female employment trajectories.

In the SA step, we detected three clusters of possible subsequences over five years after each starting status (education, OLF, education). Results from the estimation of the MM are presented in Table 3. First, we observe more stable trajectories in East before reunification (EB), where the hazard to follow the subsequence education breaks ("Edu–OLF–Edu–Empl" pattern, coef. "East", col. 3) and a prolonged transition to OLF (col. 2) are lower. We define as "prolonged transitions" those that spread over a longer time frame instead of consisting of instantaneous change from one state to another. In EB we additionally observe more prolonged transitions to employment after education (col. 4). Furthermore, the hazard of experiencing a prolonged transition to education (coef. "East", col. 5) or to employment (col. 6) after OLF spells is higher in EB than in West before reunification (WB). All significant coefficients have the same sign, implying shorter OLF spells in EB than in WB. Moreover, the chance to experience a prolonged transition from employment to OLF is significantly lower in EB than in WB (coef. "East, col. 9), meaning longer employment spell in EB compared to WB.

These results are consistent with previous findings on more straightforward school-to-work transition and employment trajectories in EB than in WB and shorter and less frequent OLF spells in EB. However the prolonged transition patterns and the multiple transitions pattern in and out of education would Before interpreting the effect of reunification in each context, it is worth looking at the general development—i.e., common to the East and the West—of the employment trajectories as captured by the "period" covariate. It mainly affects subsequences related to education. We observe less "Edu–OLF" (coef. "period", col. 2) and "Edu–Empl" (col. 4) subsequences and an increase of "Edu–OLF–Edu–Work" (col. 3), i.e., the start of a new education spell at the end of a previous education spell. Consistently, we also observe an increase of the hazard to follow the subsequences "OLF–Edu–Empl" (col. 5) or "Empl–Edu–Empl" (col. 8). Generally speaking, these trends reveal an increase in education length and in the hazard to restart education later on.

According to the "West:Reunif" coefficient in Table 3, the effect of reunification on the prolonged transitions was only limited in the West. We observe a significant increase only in prolonged transition from education to employment (col. 4). This evolution might capture a specific evolution of the education system in the West. On the contrary, the effect of reunification was much stronger in the East (coef. "East:Reunif"), where it seems to have triggered an increasing casualization of employment trajectories, especially compared to EB.

As in the West, we observe significantly more prolonged transitions to OLF after

	From education to			From OLF to			From employment to		
	OLF	OLF–Edu–Empl	Empl	Edu–Empl	Empl	Empl–OLF	Edu–Empl	OLF	OLF–Empl
East	$-0.54\ (0.21)^{**}$	$-0.22\ (0.10)^{*}$	$0.16\ (0.08)^{*}$	$0.41\ (0.12)^{***}$	$1.18\ (0.12)^{***}$	$-0.09\ (0.26)$	$-0.15\ (0.17)$	$-2.02\ (0.17)^{***}$	$-0.11\ (0.11)$
West:Reunif	$0.13\ (0.19)$	$-0.07\ (0.11)$	$0.38\ (0.08)^{***}$	$-0.13\ (0.12)$	$0.11\ (0.09)$	$-0.16\ (0.18)$	$0.12\ (0.16)$	$0.01\ (0.11)$	$-0.14\ (0.11)$
East:Reunif	$0.77\ (0.33)^{*}$	$-0.12\ (0.19)$	$0.36\ (0.15)^{*}$	$-0.49\ (0.20)^{*}$	$-0.50\ (0.15)^{**}$	$0.89\ (0.30)^{**}$	$0.34\ (0.26)$	$1.72\ (0.20)^{***}$	$0.35\ (0.15)^{*}$
Union	$1.33\ (0.14)^{***}$	$-0.71\ (0.16)^{***}$	$0.30\ (0.06)^{***}$	$-1.14\ (0.12)^{***}$	$-0.38\ (0.08)^{***}$	$0.14\ (0.15)$	$-0.63\ (0.12)^{***}$	$1.37\ (0.09)^{***}$	$0.04\ (0.08)$
Child	$1.16\ (0.19)^{***}$	$0.04\ (0.30)$	$-0.21\ (0.11)\dagger$	$-2.18\ (0.17)^{***}$	$-1.57\ (0.08)^{***}$	$-1.09\ (0.14)^{***}$	$-0.35\ (0.17)^{*}$	$0.78\ (0.08)^{***}$	$0.15\ (0.08)\dagger$
Period	$-0.25\ (0.09)^{**}$	$0.16\ (0.04)^{***}$	$-0.48\ (0.04)^{***}$	$0.27\ (0.05)^{***}$	$0.01\ (0.05)$	$0.11\ (0.09)$	$0.32\ (0.08)^{***}$	$-0.12\ (0.06)\dagger$	$0.09\ (0.06)$
Omitted output									
Maximum level of education of the parents									
Age (third degree polynomial)									
Month in the year dummies									
LogLik (NULL)	−4213.03	−11275.72	−28453.23	−11227.59	−16470.47	−3878.55	−4912.44	−12989.74	−10565.26
LogLik	−3699.03	−10185.50	−26688.88	−9104.69	−15888.96	−3718.34	−4532.83	−12217.23	−10389.36
AIC	984.00	2136.45	3484.70	4201.79	1119.02	276.42	715.22	1501.01	307.80
Num. events	532	1673	3777	1570	2141	469	705	1571	1259
Num. obs.	263292	263292	263292	141764	141764	141764	458124	458124	458124
Frailty (std dev)	1.66	0.77	1.16	0.73	1.05	0.85	1.11	1.45	0.77

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$, $\dagger\ p < 0.1$

Table 3: Sequence-analysis multistate model (Main effects).

education (col. 2). However, more prolonged transitions to employment give hints on the resemblance between EB and West that can be explain either as a shortening of education spells or as convergence of the two systems.[12] Second, we observe a significant decrease in new spells of education (col. 5) and long-lasting employment spells after an OLF spell (col. 6). Finally, the hazard of following short-term employment subsequences before going back to OLF has increased in EA (col. 7). We therefore EA has been characterize by lower chances of prolonged employment spells counterbalanced by an increase of short employment episodes bridging to OLF. Consistently, such employment spells are more likely to lead to subsequences ending up in OLF at different paces (col. 9) and short OLF spells are more frequently followed by a new employment episode (col. 10).

While the changes related to reunification in the East are impressive when compared to EB, the picture is more nuanced when we compare East and West after reunification (EA and WA respectively).[13] Our findings partially support hypothesis 1b, since deregulation affected female employment trajectories in the West to some extent?probably also due to educational expansion–, and East converged to increasing casualization, but even more pronounced compared to its starting point, i.e. EB. This is clear especially looking at hazard of back-and-forth dynamics between states, such as short employment spells while in OLF or short OLF spells while in employment: these multiple transitions signify more volatile and casual trajectories and are significantly more common in EA than in WA. However, for women in WA restarting employment for a prolonged period after an OLF spell is still more difficult compare to EA, and the likelihood of prolonged transitions to OLF while in employment as well as the chances to go OLF for a longer spell are higher in WA than in EA.

These differences might result from a different effect of family status on employment trajectories between the two contexts. We can argue that having a family (both starting a cohabitation/get married and having a child) moves women out of the labor market in WA for longer periods while it lead to short breaks in EA (Beckmann and Kurtz, 2001). However, if the "fast patterns" only resulted from a family effect, we would not have expected a rise in these pattern, but rather a constant or declining trend. The rise of fast back-and-forth patterns in the East might reveal an actual casualization of employment trajectories in the EA. The persistence of a traditional labor market participation pattern in the West could signify a long-lasting legacy to the home-maker and home-caregiver roles, which would mirror the stronger attachment in the East due to the adoption of the breadwinner cultural model despite the higher risk of casualization?and its negative consequences. However, since in the new market economy female-dominated occupations were revaluated after reunification and due to the higher male unemployment rates in the East compared to the West, Eastern women might have been more attached to the labor market because of the household economic necessity rather than of individual preferences.

To highlight the benefit of the proposed methodology, we compared our results with

[12]The effect on the overall risk to end the spell is undetermined, because we have subsequence-specific hazard.

[13]To make this comparison from the provided results, one needs to compare the "West:Reunif" with the sum of "East" and "East:Reunif" coefficients. Additional analyses were ran to assess the statistical significance of the EA-WA differences by changing the reference categories (results available upon request).

the one of a "standard" MM, where competing risks are transitions between states. The results of these "standard" models are presented in Table 4 in the appendix A. The "standard" MM fails to identify the increase of prolonged transitions to OLF after education in the East. This is probably due to the fact that, in the subsequence-based model, we distinguish between short education interruptions (which are in fact continuation of education) and prolonged transition to OLF. In the "standard" models, both subsequences are aggregated. For the same reason, the "standard" model measures a trend (period covariate) of increasing education to OLF transitions, which in fact reveal an increase in education interruptions as our subsequence-based model showed. More importantly from a substantive point of view, using the "standard" MM, we cannot observe the increase of back-and-forth moves between OLF and employment in the East, as—for instance—transition to short or prolonged employment are not distinguished. Finally, we can notice that statistical significance of the "East:Reunif" covariates are somewhat smaller in the "standard" model, showing that the distinction made with the subsequences are relevant for our topic.

7 Concluding remarks (to be completed)

In this paper we contribute to the existing literature on the consequences of changes in the institutional context on the unfolding of individual life course both substantively and methodologically. Focusing on the two German sub-societies before and after reunification, we consider whether changes in the institutional system and labor market structure fostered convergence or divergence of Western and Eastern female employment trajectories for women born between 1944 and 1990.

Consistently with previous research, we found more straightforward school-to-work transition in EB than in WB. We also found longer employment and shorter OLF spells in EB than WB. After reunification, our findings highlight some convergence to the Western labor market participation model. We observed an increasing casualization of the labor market experience in East Germany. As a consequence, Eastern women were more likely to be engaged in unstable and volatile trajectories characterized by multiple transitions in and out of the labor force, and the timing of the school-to-work transition extended as well as the spell spent OLF. These changes affected employment trajectories in the West to a lesser extent, so that core differences of the division period persist, even though more nuanced. In fact, the probability of being in employment for a prolonged period after OLF spells is still significantly higher in the East than in West. This can be interpreted as a signal of a persistent necessity to work for Eastern women compare to those in the West. Second, short and long unemployment during employment are more common for Western women, probably due to the fact that they do not manage to go back to work after parental leave as successfully as their Eastern peers (Beckmann and Kurtz, 2001).

Overall, this evidence supports to the convergence hypothesis of the East towards increasing casualization, revealing the difficult transition from a centrally planned economy to market capitalism. However, because our research design does not include a comparison

to men, we cannot argue, as suggested by Kurz et al. (2005); Berger et al. (1993), that in Germany changes in labor market experience triggered by globalization were channeled to women, but our results support what proposed by (Buchholz and Grunow, 2006) that the charge of increasingly de-standardized employment trajectories (difficult school-to-work transition, more volatile patterns made out of higher number of transitions in and out of the labor forces) followed on the Eastern women shoulders.

Some limitations should be acknowledged. Our restricted definition of the states did not make it possible to distinguish between parental leave, unemployment and inactivity, as well as between part-time and full-time work. As discussed above, this choice was taken in the interest of the presentation of the SAMM technique since the modelling and the set of results become increasingly complex when additional states are considered. Furthermore, we excluded individuals who migrated between the two contexts from our analysis. The small sample size for this subgroup did not allow us to test for the existence of different degrees of convergence/divergence according to the internal-migration status. Finally, the socioeconomic changes in the life course occur differently according to age and labor market position Mayer (2006). A comparisons across cohorts was beyond the aim of this paper, but further research on is needed to detect different investment in education and re-training by younger cohorts having less experience but longer working life in front invested differently and older cohorts.

Our substantive contribution results from the implementation of the newly proposed sequence-analysis multistate model, SAMM, a combination SA and MM. SAMM offers several advantages for the study of the life course taking into account the interdependencies between the states and transitions occurring along individual trajectories as well as the effects of time-varying covariates on subsequences of transitions and states. First it allows to study states and transitions as lasting over prolonged periods and not only at specific points in time. Second, changes in typical subsequences can be put in direct connection with contextual/structural transformation happening during the unfolding of individuals' life courses. Third, SAMM incorporate the analysis of the time spent within each spell, which is a crucial dimension when studying trajectories. Finally, thanks to the extraction of subsequences from sequences of different initial lengths, censored observations can be included to the benefit–in our case–of the incorporation in the comparison of younger cohorts of individuals whose life course is only partially observable by definition.

Further extensions The proposed methodology relies on two kinds of information: a sequence of spells S that defines the spells to be analyzed with the multistate model, and, on the other hand, the subsequences or sub-trajectory T that follow each of these spells. In our analysis of employment trajectories, we use the same alphabet—i.e., the set of possible states—Σ_{S} and Σ_{T} to describe S and T respectively. However, we could very well have choose two different alphabets.

Conceptually, in the sequence-analysis multistate model, Σ_{S} describes the different starting conditions to experiences the competing risks (Steele et al., 2004), i.e., the following subsequences T. As noted by Steele et al. (2004), one of the main limit of multistate models is related to the usually high number of hazard functions to estimate.

To limit this number, it is recommend to consider only very broad differences and therefore limit the size of Σ_S (Steele et al., 2004). More subtle differences in the starting conditions can be taken into account by including additional covariate to the spell-specific models.[14] For instance, the employment rate could be added to the model to distinguish between full- and part-time employment.

In the sequence-analysis multistate model, the subsequences T define the studied dynamics of the trajectories. In some cases, one may benefit from a more precise description of these dynamics. This can be achieved by considering a more detailed alphabet for T. For instance, distinguishing between the different reasons to be OLF, such as unemployment, parental leaves or gap within trajectories, one might be able to better describe the dynamics of casual employment. As another example, distinguishing between part- and full-time employments might better describe how women restart an employment spell after stopping working.

As stated by Steele et al. (2004), the competing events under analysis are not necessarily the transitions between the states. The framework is much more general. It is therefore not required to use the same alphabet to describe the spells' sequence S and the subsequences T. A small alphabet is recommended for the spells' sequence in order to limit the number of hazard function to be estimated. However, a more detailed alphabet for the subsequence could be of interest to have a more precise view on the dynamics of the trajectories. Nevertheless, a too detailed alphabet would also result in a high number of hazard function to be estimated.

In order to make the presentation simpler, we used here the same alphabet for the sequences of spell and the subsequences.

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[14] Indeed, As Putter et al. (2007) points out, it is possible to include a different set of covariates for each spell.

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A Transition-based multistate models

In order to highlight the benefit of the proposed methodology, we also ran the corresponding multistate model. Table 4 present the coefficient of the "main effect model". The results can be compared with the one presented in Table 3. In order to have more comparable results, the transition based multistate models were estimated on the same dataset. This implies that we used the same censoring time limit.

	From education to		From OLF to		From employment to	
	OLF	Empl	Edu	Empl	Edu	OLF
East	$-0.41\ (0.09)^{***}$	$0.22\ (0.07)^{**}$	$0.39\ (0.11)^{***}$	$0.94\ (0.10)^{***}$	$-0.08\ (0.15)$	$-0.97\ (0.09)^{***}$
West:Reunif	$-0.18\ (0.09)^{*}$	$0.43\ (0.08)^{***}$	$-0.18\ (0.11)$	$0.12\ (0.08)$	$0.15\ (0.15)$	$-0.10\ (0.08)$
East:Reunif	$0.26\ (0.16)\dagger$	$0.22\ (0.14)$	$-0.38\ (0.18)^{*}$	$-0.26\ (0.13)^{*}$	$0.35\ (0.24)$	$0.95\ (0.12)^{***}$
Union	$0.38\ (0.09)^{***}$	$0.24\ (0.06)^{***}$	$-1.07\ (0.11)^{***}$	$-0.29\ (0.07)^{***}$	$-0.82\ (0.11)^{***}$	$0.76\ (0.06)^{***}$
Child	$1.13\ (0.13)^{***}$	$-0.29\ (0.11)^{*}$	$-1.95\ (0.14)^{***}$	$-1.39\ (0.07)^{***}$	$-0.33\ (0.15)^{*}$	$0.46\ (0.06)^{***}$
Period	$0.16\ (0.04)^{***}$	$-0.47\ (0.03)^{***}$	$0.25\ (0.05)^{***}$	$0.04\ (0.04)$	$0.20\ (0.07)^{**}$	$0.05\ (0.04)$
Omitted output	Maximum level of education of the parents Age (third degree polynomial) Month in the year dummies					
LogLik (NULL)	−16778.27	−27161.32	−12036.80	−19525.61	−5519.54	−22943.53
LogLik (Integrated)	−15460.10	−25573.75	−9864.16	−19014.75	−5143.16	−22384.47
AIC (Integrated)	2592.35	3131.15	4301.29	977.72	708.76	1074.11
Num. events	2346	3636	1641	2539	759	2776
Num. obs.	263292	263292	141764	141764	458124	458124
Frailty (std dev)	0.90	0.89	0.56	0.74	1.05	0.89

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$, $\dagger p < 0.1$

Table 4: Transition-based multistate model (Main effects).