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German Socio-Economic Panel (SOEP)
DIW Berlin
Mohrenstrasse 58
10117 Berlin, Germany

Contact: soeppapers@diw.de

How causal is separation? Lessons learnt from endogenous switching regression models for single mothers' economic strain in Germany

Antonia Birkeneder[a,*] **and Christina Boll**[a,b,c]

[a] *German Youth Institute (DJI), Munich (Germany)*

[b] *University of Munich (LMU), Munich (Germany)*

[c] *University of Applied Labour Studies (UALS), Schwerin (Germany)*

Abstract. Single mothers often experience precarious financial conditions. However, it is not fully understood to what extent separation is the cause of these conditions versus being their consequence. Estimating an endogenous switching regression model based on a sample of 626 separated and 5,525 non-separated mothers drawn from the German Socio-Economic Panel (SOEP) 1984-2018, we disentangle the roles of causation and selection for separated mothers' individual earnings as a measure of economic well-being. Our results indicate that separated mothers increase their working hours and sometimes adjust industry in anticipation of the separation event and afterwards. Adjusting for these processes that can be considered caused by the upcoming event, the positive selection into separation turns negative, while the non-separated are clearly positively selected. Thus, comparing average women with mean characteristics, the actually (non-)separated earn lower (higher) wages than women who are randomly assigned to a (non-)separation scenario. Additionally, the separated are more negatively selected into employment. Robustness checks largely confirm our results against changes in sample composition, eliminated group differences in period distribution, and model specification. Thus, our data support the notion that both chronic strain and crisis-caused factors diminish single mothers' economic well-being. Unobserved traits associated with lower labor market investments and productivity explain part of separated mothers' economic strain after separation.

JEL: J12, J22

Keywords: single mothers, earnings, selection, causation, endogenous switching regression model, Socio-economic Panel

*Corresponding author: German Youth Institute (DJI), Nockherstr. 2, D-81541 Munich (Germany). Tel. +49 89 62306-250. *E-mail address*: birkeneder@dji.de

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1 Introduction

Many studies have demonstrated that after union dissolution, women experience a decline in economic well-being (for Germany: Bayaz-Ozturk et al., 2018; Leopold & Kalmijn, 2016; Bröckel & Andreß, 2015), with women faring economically worse than men (e.g. Hao, 1996; Smock, 1993; Ross, 1995; Poortman, 2000; Andreß & Bröckel, 2007). In particular, this holds true for single mothers who face a strong need to provide. Unlike (re)partnered mothers, the former bear the full burden of breadwinning and caring. Hence, they can be expected to be the least driven by motherhood norms (Muller et al., 2020) and the least able to lower their employment intensity (Roman, 2017). Instead, they might be forced to accept low-paid jobs that offer the required compatibility with family duties. Thus, whereas one part of the negative separation effect on maternal earnings could stem from human capital depreciation during family leave prior to separation, another part could be due to employment necessity. The named effects are causal because they are less likely to materialize in the absence of a separation event – partnered mothers are more able to opt against employment in case of poor returns. However, it is not fully clear to what extent separation is a cause or a consequence of poor economic conditions. Women who eventually separate may have achieved a worse economic position even in the absence of separation, compared to women who do not separate.

The topic is salient for Germany because in 2019, almost 90% of 1.52 million single parents were mothers. Compared to mothers in couple families, single mothers have a lower average education, and although they are equally likely to be employed and work longer hours (Federal Statistical Office, 2018), they face higher poverty risks, which in the period 2007-2016 amounted to 27% for the formerly married, 45% for the formerly cohabiting and 61% for those who became single mothers by childbirth (Hübgen, 2020). For the former two groups, the question arises what the underlying forces of economic hardship are and to what extent the post-separation conditions are driven by factors evolving prior to separation. Hübgen (2020) posited that among mothers who later became single mothers income poverty and social transfer receipt were already more prevalent before the event, compared to mothers living in couple households. However, the bulk of studies addressing single mothers focused on their income dynamics *after* the event. Their preceding family and employment histories and related mechanisms of selection have been investigated much less extensively. Based on comprehensive longitudinal data from Germany, this study contributes to this scarce evidence, exploring the role of causation and selection for single mothers' labor earnings in an integrated model approach. We focus on earnings, since this economic well-being indicator is more suited than household income to reflect women's past biographical decisions and related preferences and abilities.

2 Theoretical underpinnings and empirical designs to address causality

Social scientists have employed a variety of theories to explain how union dissolution affects adults and children (cf. Amato, 2000; 2010). From the economic standpoint conveyed by the resource model (Soons & Liefbroer, 2008; Soons et al., 2009), separation is associated with economic costs for parents, encompassing lost economies of scale in the household and, in the presence of small children, foregone own earnings due to childcare obligations as well as reduced attractiveness on the partner market and associated limited access to partner resources. The situation is further aggravated for parents (mostly mothers) who have – in the context of traditional gender roles and economic rationales for an efficient labor division in the household (Becker, 1965) or preference-oriented self-selection (Hakim, 2000) – specialized in unpaid work during marriage. As a result, their human capital has depreciated during that time (Sørensen, 1994; Duncan & Hoffman 1985). The decline in individual resources post-separation is partly compensated via public and private transfer receipts that rely on social policies and spousal alimony obligations, respectively. However, alimony payments often do not suffice to fully cover child

maintenance, inducing a further decline in resources (Leopold & Kalmijn, 2016). Women who anticipate union dissolution may increase their employment intensity several years before the event takes place to protect themselves against material hardship (Johnson & Skinner, 1986; Poortman, 2005; Van Damme & Kalmijn, 2014).

In the context of the "selection vs. causation" question, the *crisis model* (Booth & Amato, 1991; Amato 2000) posits that separation and divorce have a causal effect on the well-being of former partners. It frames divorce as a process in which unhappiness and psychological distress begin to rise a few years prior to marital separation, peak around the event and rapidly decline in the years thereafter as soon as parents have adapted to the new situation. Individual resources act as moderators, determining the speed with which parents manage to adjust (Amato, 2000). In contrast, the *chronic strain model* **(**Amato, 2000) assumes that the association between union dissolution and well-being can be shaped by selection (Amato, 2010: 658). This may be the case if adjustment difficulties are rooted in unobserved individual traits (such as family and career orientations, physical and mental health) that jointly affect the separation event and its economic consequences. Parents may suffer from separation for a long time, and a return to the pre-separation level of well-being is not guaranteed. Further, chronic strain may emerge from a new social role (Johnson & Wu, 2002).

Researchers have aimed to extract causality of separation and/or divorce on economic well-being using different empirical approaches in order to reach a more precise estimate of the causal effect, e.g. fixed effects (Boertien & Lersch, 2021; Kapelle & Baxter, 2021; Leopold & Leopold 2016), instrumental variables (Ananat & Michaels, 2008) or matching procedures (Radenacker, 2016; Hübgen, 2020; Brüggmann, 2020; Brüggmann & Kreyenfeld, forthcoming). However, these methods fail to adequately address self-selection into treatment. Fixed effects estimations deliver biased results if the parallel trends assumption is violated (this is the case if the actually separated undergo different earnings dynamics before or after the (anticipated) separation than the unseparated would if they had experienced a separation (Brüderl & Ludwig, 2015)). Matching and weighting procedures aim to overcome this issue by producing statistical twins in pre-event characteristics, but they are confined to observables. Although sensitivity analyses can help to gauge the potential bias arising from unobserved confounders (see e.g. Brüggmann & Kreyenfeld, forthcoming, who employed the OVtool from the R library, referring to Pane et al., 2021), the named approaches do not allow for conclusions about selection and its quantitative importance relative to causation. To achieve this goal, selection and causation processes must be modelled in an integrated empirical framework.

This study

We apply an endogenous switching regression model that fulfils this requirement. As the model jointly determines the discrete variable (separation) and the continuous outcome (income) it affects, it allows us to test whether our data support the chronic strain or the crisis model, i.e. if selection is part of the explanation for single mothers' post-separation earnings evolution or not. Additionally and different from the formerly mentioned approaches, it gives a quantitative estimate of the underlying selection mechanisms.

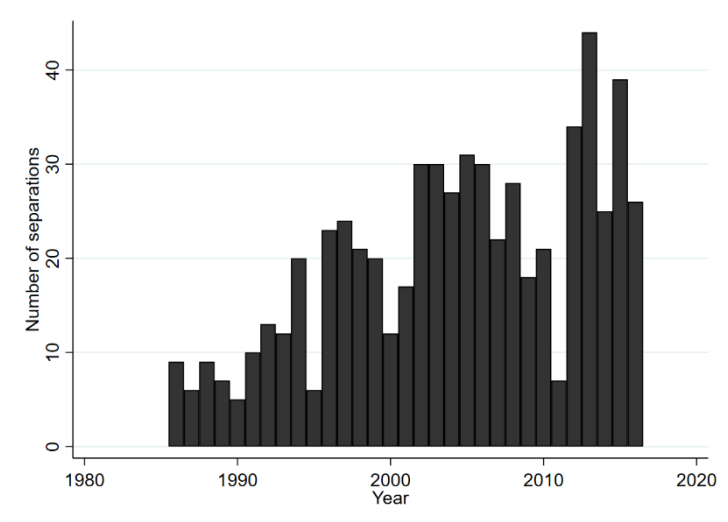
3 Data and sample

The empirical analysis was based on waves 1984-2018 of the German Socio-economic Panel (SOEP; Goebel et al., 2019; https://www.diw.de/), a yearly household panel survey which comprises a representative sample of the German population. The first step of data preparation aimed to identify mothers who lived (married or cohabiting) with their partners and at least one biological child of the mother, who then separated from their partners and henceforth lived as single mothers. The household

was required to be dissolved in the time between separation and the following interview. The respective change in household composition could be identified with the help of the partner identification number and the partnership and family status of the respondents. To exclude cases where the partner moved out but the relationship was still intact ('living apart together'), a second source of information was used to identify separation events. The individual questionnaire annually asks for changes in the family situation, including the separation from a spouse/partner. Additional to household dissolution, a separation event had to be self-recorded via this variable. The former couple was not allowed to be observed living together again. For respondents who registered more than one separation with minor children in the household, only the first separation was considered. The separated mothers were required to have fully answered the five interviews from two years before (t-2) up to two years after (t+2) t0. Year t0 refers to the first interview the woman gave after separation, which took place between one and 19 months after separation. Thus, the year "t+2" may in fact lie up to 42 (19+12+12) months after the separation event. This will have to be kept in mind when we henceforth simply refer to two years before and after separation. The sample was restricted to women between 18 and 60 at the time of separation who separated from male partners, who were not in training or education two years before and after separation and who continued to live with at least one minor biological child in the household after separation, at least up to year t+2. After setting these restrictions, we were left with 626 women who experienced a separation during the years 1986-2016. Further, women only entered the analysis as long as they were single mothers, i.e. no new partner lived with them (and their biological children) in the household. In the group of separated mothers, 5% (30 women), 16% (102 women) and 23% (147 women) repartnered in t0, t+1 and t+2, respectively. Hence, the final sample of separated mothers amounted to 596 in t0, 524 in t+1 and 479 in t+2.

Separation events occurred in the time span between 1986 and 2016 (**Figure 1**). They became tendentially more frequent over the years, which can be attributed both to an increasing number of interviewees in the SOEP and to an increasing number of separations in the population over time.

Figure 1: Distribution of separation events over years



Source: SOEP v.35, own calculations.

The group of non-separated mothers consists of women in co-residential relationships (again married or cohabiting) which did not end as long as the respondents were observed in the panel. Additionally, the partners were required to live together with at least one minor child (thereof at least one biological child of the mother) for at least five years. However, although the non-separation group aimed to represent mothers in stable relationships, it might include women planning a separation near-term. This might

cause a selection bias if mothers leaving the panel in the course of the event systematically differed from the ones remaining. Trappmann et al. (2015) showed that usual techniques correcting for panel attrition bias, making use of variables measured at the wave before dropout, were not able to reduce the bias when attrition was due to events occurring after an interview, including changes in partnership status. Hence, propensity models or weighting class techniques are not suitable to address this problem. Requiring mothers to live at least five years in a couple household with minor children, as we did, should mitigate the bias to some extent. Next, the points in time where non-separated are to be compared with separated mothers had to be specified. This was the year of separation for separated women, but for non-separated women, no such benchmark exists. We solved this problem by using an event-centered approach (for a similar procedure cf. Hübgen, 2020; Radenacker, 2016). Specifically, the non-separated mothers' observed years of cohabitation with their partner and minor children were split into consecutive sequences of five years, supposing that these sequences represent years t-2 to t+2 around a "non-separation event" in t0. The women entered the non-separation group with all their t0 events. Hence, one non-separated person could contribute more than one episode of being non-separated to the group, which has led to a total of 34,316 sequences.

The correct modelling of causation and selection through the empirical approach applied in this study required that the sample proportion of separated and non-separated mothers matched the general probability to separate in the German population. As data on the separation probability of mothers was not available, the general divorce probability specific to marriage duration was used. Based on partnership duration at the time of separation, each separated woman was assigned an individual separation probability, which was calculated from marriage duration-specific divorce rates (as separation rates were not available) obtained from microcensus data (Federal Statistical Office, 2021). Then, the average separation probability of all women in the sample (the total of the separated and the non-separated) was calculated. The derived proportion amounted to 14.9%, which is similar to the sample proportion of separated women in the analysis of Smock et al. (1999) with 14.7%. Hence, from the 34,316 non-separation sequences, 3,575 were randomly drawn, representing the other 85.1% of the total sample. In this final sample, women could still contribute several of their non-separation sequences, which is why standard errors were clustered on the individual level in the multivariate analysis.

Table 1. Analytic sample with exclusion restrictions

1 - General sample selection		2 - Sample selection separated (supplementary restrictions to 1)		3 - Sample selection non-separated (supplementary restrictions to 1)	
SOEP samples A-O:	142 308	Separation event:	1 247	No separation event:	38 616
Only full interviews:	96 461	Interviews from t-2 to t+2:	749	At least five years in not ending relation-ship with children:	5 525
Only private households:	94 491	Children in household:	626		
Only women:	48 565	Not repartnered in t0:	596		
Age 18 – 60:	40 902	Not repartnered in t+1:	524	All five year sequences:	34 316
No same sex partnerships:	40 810	Not repartnered in t+2:	479		
Not in education/training:	39 616			Random sample	3 575

Source: SOEP v.35, own calculations.

4 Methodology

4.1 Model

As aforementioned, we apply an endogenous switching regression model to disentangle selection and causation in the explanation of post-separation maternal earnings. The model description follows Mare and Winship (1988). Consider Y_{1i} as the economic situation of mother i after she separated from her partner and Y_{2i} as her economic situation if she did not separate. The economic situation is affected by a vector of k-individual characteristics, X_{ki},, which could also have an impact on the likelihood to separate. Thus, the two equations

$$Y_{1i} = \sum_k \beta_{1k} X_{ki} + \varepsilon_{1i} \tag{1}$$

$$Y_{2i} = \sum_k \beta_{2k} X_{ki} + \varepsilon_{2i} \tag{2}$$

estimate the effect of characteristics X_{ki} on the mothers' economic situation and, indirectly, the effect of separation on the economic situation, with parameters β_{1k} and β_{2k} and disturbances ε_{1i} and ε_{2i}. The parameters will only be estimated consistently if there are no unmeasured variables affecting both the economic outcome as well as the likelihood of separation. To take this unobservable selection into account, equations (1) and (2) need to be estimated jointly with an equation predicting the likelihood of separation, which has the following form:

$$Z_i = \sum_k \gamma_k X_{ki} + \eta_1 Y_{1i} + \eta_2 Y_{2i} + \zeta_i \tag{3}$$

The latent scores Z_i represent mothers' individual probability to separate from their partners. They depend on individual characteristics X_{ki} as well as on the economic outcomes expected in both separation categories. γ_k, η_1 and η_2 are parameters to be estimated and ζ is an error term, which is uncorrelated with ε_1 and ε_2.

Equations (1), (2) and (3) describe the structural form of the model. However, as for each woman only one economic outcome is observed, equation (3) can only be estimated indirectly through its reduced form:

$$Z_i = \sum_k \pi_k X_{ki} + \varepsilon_{3i}, \text{ where}$$

$$\pi_k = \eta_1 \beta_{1k} + \eta_2 \beta_{2k} + \gamma_k, \text{ and} \tag{4}$$

$$\varepsilon_{3i} = \eta_1 \varepsilon_{1i} + \eta_2 \varepsilon_{2i} + \zeta_i$$

Equations (1), (2) and (4) describe the reduced form of the model. The disturbances ε_{1i}, ε_{2i} and ε_{3i} are assumed to follow a trivariate normal distribution with mean zero and covariance matrix

$$\Omega = \begin{bmatrix} \sigma_1^2 & \sigma_{12} & \sigma_{13} \\ \sigma_{21} & \sigma_2^2 & \sigma_{23} \\ \sigma_{31} & \sigma_{32} & \sigma_3^2 \end{bmatrix}$$

Hence, ε_3 is allowed to be correlated with ε_1 and ε_2. This way, the model incorporates the effects of unmeasured non-random selection of mothers in the two separation categories. The respective

covariances, σ_{13} and σ_{23}, show the degree and direction of this selection. A positive sign of σ_{13} indicates a positive selection (in terms of economic consequences) of separated mothers into the state of separation, whereas a positive sign of σ_{23} indicates a negative selection of non-separated mothers into the state of non-separation.

The model can be estimated by the maximum likelihood method or, as applied here, by a multi-step procedure. First, the probability of separation is estimated by a Probit model. Second, predicted values for $\hat{Z}_i$ and the following ratios are calculated:

$$\frac{\phi(\hat{Z}_i)}{\Phi(\hat{Z}_i)} \text{ and } \frac{\phi(\hat{Z}_i)}{[1-\Phi(\hat{Z}_i)]},$$

with ϕ being the normal probability density function and Φ being the complementary cumulative distribution function. The ratios are functions of the probability of assignment to position 1 (separation) or 2 (non-separation). The first (second) ratio is included as a regressor when predicting the economic outcome of separated (non-separated) mothers by OLS. The respective coefficients give an estimate of σ_{13} and σ_{23}. As a result, the parameters β_{1k} and β_{2k} are free from selection bias.

4.2 Variables

Target Variable – Economic Outcome Equations

The economic well-being of separated and non-separated mothers was measured by the logarithm of individual labor earnings. We used the variable I11110 from the $PEQUIV dataset provided by the SOEP which consists of gross monthly wages and salaries from all employment contracts of an individual, i.e. primary and secondary jobs and self-employment, including bonuses, overtime, and profit-sharing (Grabka 2020). When investigating selection effects, individual earnings are a more appropriate measure of economic well-being than household (equivalence) income. Gross labor earnings quantify a person's degree of economic independence, because they reflect her earnings capacity irrespective of her family constellation in terms of taxes, social contributions, and transfers. Earnings were inflation-adjusted using 2010 as the base year. To monitor earnings evolution after separation, the earnings equations were estimated in two consecutive years, t+1 and t+2.

Explanatory Variables – Economic Outcome Equations

Both outcome equations – for separated and non-separated mothers, respectively – used the same set of explanatory variables. Following Smock et al. (1999), they were measured at pre-event time points in order to model the correct causal ordering of (selective) individual characteristics, separation and subsequent economic well-being. Variables that could be subject to anticipatory behavior before separation (employment status, employment experience, earnings) and subjective evaluations that are potentially influenced by the foreseen event (satisfaction, worries) were measured two years (t-2) before the event, the remaining variables were measured in year t-1.

Women's human capital investments earlier in life shape their labor market attachment and earnings and should thus be decisive for economic well-being after separation. We used the ISCED 97 classification to measure women's educational level (in t-2) as low, medium or high. Training-on-the-job is considered a second pillar of human capital (Becker, 1964; Mincer, 1974) and should be particularly important to women re-entering the labor market after family leave (Poortman, 2000). We measured women's years of part-time and full-time experience (accumulated in t-2) and their employment status (in t-2). Individual earnings measured in year t-2 were included in the income regressions since they are a predictor of both separation probability (Killewald, 2016) and post-separation income. Further, we

incorporated a range of demographic characteristics at the individual and at the family level, i.e. the woman's age (<30/30-39/40-49/>=50 years), migration background (yes/no), residence in East Germany (yes/no, t-1), own property (yes/no, t-1), cohabiting vs. married before the event (t-1), number of children (1, 2, 3 or more; t-1). Finally, we incorporated subjective evaluations of economic well-being (in terms of financial worries (no/some/many; measured in t-2)) and general life satisfaction (measured in t-2 and ranging from 0 to 10, with higher values representing higher satisfaction) to explore any systematic differences between the separated and the non-separated before the event.

Explanatory Variables – Separation Probability Equation

The Probit estimation of the separation equation employed the explanatory variables used in the economic outcome equations plus a set of instrument variables. The latter are assumed to directly impact the probability to separate. At the same time, they are allowed to influence individual earnings in an indirect way only, through their effect on separation probability and/or through their effect on the explanatory variables included in the economic outcome equations (Mare & Winship, 1988). Partnership characteristics arguably meet these requirements. We used the following four instruments: Age at beginning of the partnership, partnership duration at the time of the event and its squared term, and a categorical variable that indicates if the woman was in her first or higher order marriage or unmarried before the event. Additionally, a categorical variable representing the cohort (<1960, 1960-1969, 1970-1979, >=1980) was used, arguing that this variable is highly important for the separation probability but does not influence earnings beyond its indirect effect channelled through other explanatory variables (e.g. age).

Table A1 in the Annex shows the descriptive statistics. Compared to separated mothers, the non-separated recorded a higher educational level one year before the event. Whereas the share of mothers with low education was virtually the same for both groups, non-separated women were more often highly educated (25.81% versus 20.77%). Compared to the non-separated, separated mothers were more likely to have only one biological child in the year before the event, were younger and therefore more frequently represented in younger cohorts, were less likely to be in their first marriage (despite their younger age), had significantly lower levels of work experience, were less likely to have a migration background, were less often homeowners and resided more often in eastern Germany. Two years before the event, they recorded a lower general satisfaction and more financial worries and were more prone to cohabitation (instead of being married). No significant difference was shown regarding weekly work volume (full-time vs. part-time) two years before the event. Additionally, the separated were older when their relationship started and, in the year before the event, relationship duration was lower. Note that the separated had higher average earnings. This was the case two years before separation and to an even higher extent thereafter. This stands in stark contrast to this group's socio-economic disadvantage in terms of human capital endowment, which is in line with previous findings (Smock et al., 1999). Separate analyses (results available on request) referring to an even earlier point in time, i.e. two years before the start of the partnership, showed the same pattern. Hence, the disadvantages manifest themselves early in life. It became evident at this point that separated mothers' behavioral adjustments to cope with their new situation had to be addressed in our further investigations.

5 Results

5.1 General results

In what follows, we report the results from the endogenous switching regression model. The full results can be found in **Table A2** (separation equation) and **Table A3** (earnings equation for the separated and

non-separated) in the Appendix. Note that the results for the earnings equation are the final ones, including working hours and industry.

Concerning selectivity of separation, **Table 2a** denotes the estimated disturbance covariances σ_{13} and σ_{23} for t+1 and t+2, respectively. The estimates of σ_{13} had a positive sign for both time points, although not significant. This indicates a positive selection of separated mothers based on their unobserved attributes. Consider a woman who was randomly drawn from the total population and then placed in the first group, thus undergoing a separation event. In comparison to this woman, an actually separated mother who had the same observable characteristics is expected to record a higher individual labor income in the years after the event. At a first glance, this is somehow at odds with the former finding that separated women exhibited lower socio-economic status. However, when controlling for socio-economic background, a separated woman seemed to have characteristics that led to higher earnings compared to a randomly drawn woman in the event of separation.

Non-separated mothers had estimates of σ_{23} near zero, which indicates that this group of women was not substantially selected with regard to their unmeasured attributes. Comparing a random mother who did not undergo a separation with an actually non-separated mother with the same observable characteristics, the latter is expected to have about the same level of labor earnings after the event (which is non-separation in this case). The results for both groups suggest that mothers select into those positions that maximize their earnings. Conversely, had an actually non-separated mother been placed in a separation scenario, she would have done worse than a mother who in fact separated, and vice versa (Mare & Winship, 1988).

Table 2a. Disturbance covariances σ_{13} and σ_{23}, measuring the direction and magnitude of selection

	Unmeasured selection into separation (σ_{13})	**Unmeasured selection into non-separation** (σ_{23})
t+1	0.37	0.02
t+2	0.20	-0.10

Source: SOEP v.35, own calculations.
*p < .05.**p< .01.***p< .001.

To identify the causal effect of separation, expected earnings were calculated for women who have mean values of observable variables of the total sample, assuming that they stemmed from different populations (the separated, the non-separated, all) and were placed in different scenarios (separation, non-separation). The results are summarized in **Table 2b**. The row "All" describes a hypothetical setting in which the separation event was randomly distributed over the whole population. Hence, earnings differences in the two scenarios "Separation" and "Non-separation" describe the causal effect of separation for the average woman. For period t+1, for example, this causal effect was negative, as the average woman's expected earnings amounted to 15,362 € if non-separated and to 10,008€ if separated. By contrast, under the *actual* allocation of separation events, separated mothers exhibited far higher expected earnings which can be attributed to their positive selection based on unmeasured characteristics, which in this case was accounted for in the estimates. Their positive selection effect was strong, resulting in actually expected earnings amounting to 17,651€ instead of 10,008€. As non-separated mothers recorded a selection effect near zero, their earnings hardly differed between the two allocations. Although the causal effect of separation was negative, unmeasured factors of the separated led to a higher expected labor income of separated versus non-separated mothers (17,651€ versus 15,266€). As noted before, both groups of mothers were allocated in the optimal position in terms of

earnings. A separated mother was actually expected to gain 17,651€, but only 15,885€ in the hypothetical scenario that she did not separate. Conversely, a non-separated mother was expected to earn 15,266€, but only 9,006€ when hypothetically being separated. The patterns of these findings were the same for t+2.

Table 2b. Expected earnings of mothers in different scenarios

		Scenario	
	Population	**Separation**	**Non-separation**
t+1	**Separation**	17,651	15,885
	Non-separation	9,006	15,266
	All	10,008	15,362
t+2	**Separation**	18,483	13,284
	Non-separation	12,785	15,970
	All	13,557	15,509

Source: SOEP v.35, own calculations.
Notes: Numbers are calculated for a woman with mean values for all observable characteristics, referring to the total population. The separation probability equals the sample proportion of separations (14.9 %).

5.2 Selection into observables: The role of hours of work and industry

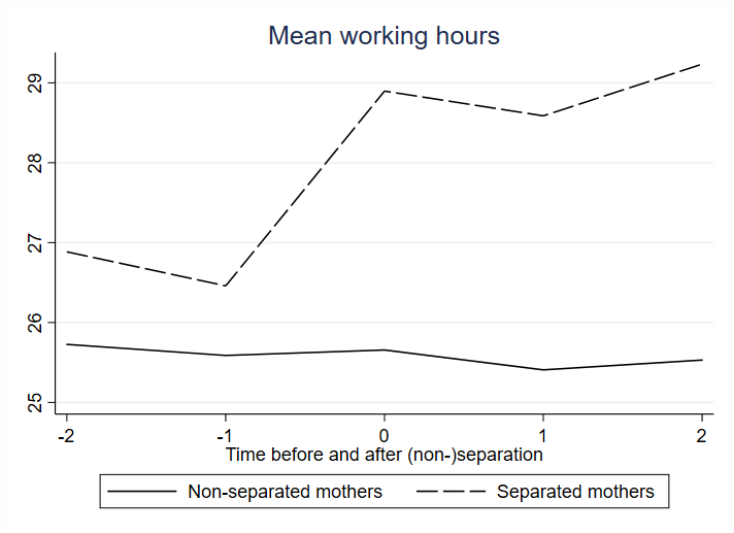
Unmeasured selection effects of separated mothers seem to have a strong influence on post-separation earnings. In the current setting of the model, explanatory variables were measured before the separation event in order to correctly model the causal ordering of the event and post-event income. A disadvantage of this procedure is that behavioral adaptations, which occur only shortly before the event and thereafter, remained unmeasured and thus were captured in the estimated selection effect. Anticipatory adjustment of employment behavior has been evidenced by the literature, in particular for women (Van Damme & Kalmijn, 2014; Brüggmann et al., 2018; Brüggmann, 2020 with a more nuanced pattern for different types of employment). We therefore took a closer look at developments of work-related variables in our sample around the time of the event.

Figure 2 illustrates the evolution of working hours of separated and non-separated mothers from t-2 to t+2. Non-separated women's hours hardly rose, while separated women exhibited a strong increase post-separation. Arguably, separated mothers adapted to the new circumstances after separation by extending their working hours. This behavioral adaptation was not controlled for in the former results of the endogenous switching regression model and therefore, the effect of increased working hours on labor income was part of the selection effect based on unobserved variables. As higher working hours imply higher earnings, the estimated selection term of separated mothers is expected to decrease when post-separation working hours are controlled for. As further analyses (available upon request) indicate, hourly wages did not structurally differ between the two groups.

A second kind of behavioral adaptation relates to the industries the mothers are affiliated to. As Christopher (2005) and Nieuwenhuis and Maldonado (2018) stated, single mothers might be forced to take on precarious jobs with low quality or intensity. Own descriptive analyses (not shown here) revealed that separated women changed industries more often after the event than non-separated women and that mothers who changed industries recorded lower average hourly wages in the pre- and even more so in the post-event industry. The sectoral adjustment might counteract the working hours

adjustment, which is why we expect the estimated selection term of separated mothers to increase when controlling for sectoral changes.

Figure 2: Evolution of agreed working hours



Source: SOEP v.35; own calculations.

To measure the selection effect of separated mothers corrected for behavioral adjustments, we re-ran our endogenous switching regression model, this time including hours of work as well as a categorical variable representing mothers' post-separation 1-digit industry as additional regressors in the earnings equations. These variables were the only ones measured at post-separation time points. The estimated selection terms when controlling for both kinds of behavioral adaptation are summarized in **Table 3a** and show a pattern that is clearly different from the baseline results in Table 2a. The positive selection of separated mothers turned negative, albeit insignificant. This holds true for both time points t+1 and t+2 and means that an actually separated woman was expected to earn less than a woman with similar characteristics who was randomly drawn from the population and placed in the separation scenario. This can be attributed to selection on unobservables with disadvantageous income associations. For the group of non-separated mothers, results also changed. Their selection term based on unobservable characteristics became clearly positive (indicated by its negative sign, as explained before) and significant on the 5% level (t+1) and the 1% level (t+2), respectively. Letting the two variables enter the estimation separately showed that the change in results was mostly driven by the inclusion of working hours (see **Table A4** in the Annex). When solely including industry dummies, the selection terms hardly changed compared to the baseline results (the only exception is σ_{13} in t+2.). This could be due to the rather broad specification of industries on the 1-digit level, which made sector changes rather unlikely.

Table 3a. Disturbance covariances σ_{13} and σ_{23}, measuring the direction and magnitude of selection, accounting for behavioral adaptation (working hours and industry)

	Unmeasured selection into separation (σ_{13})	**Unmeasured selection into non-separation** (σ_{23})
t+1	-0.07	-0.50*
t+2	-0.19	-0.56**

Source: SOEP v.35, own calculations.
*p < .05.**p< .01.***p< .001.

The changes in the estimated selection terms of separated and non-separated women influenced expected earnings in different scenarios (**Table 3b**). The average woman exhibited mean values of pre-separation characteristics and – new in this scenario – mean values of post-separation working hours and industry affiliation. It turns out that unlike before, the causal effect of separation on earnings was positive in the new setting. In a hypothetical world, where separation is randomly allocated, a separated mother earned more than a non-separated mother (20,805€ versus 14,816€). However, under the actual allocation of separation events, the individual earnings of an average mother who is separated were only slightly higher than those of a non-separated mother (18,561€ versus 17,093€). This difference between random and actual allocation of separation events was mainly driven by the positive selection based on unmeasured characteristics of non-separated mothers, but in parts also by the, now negative, selection of separated mothers. Again, these findings followed the same pattern in the earnings estimation for t+2.

Table 3b. Expected earnings of mothers in different scenarios, accounting for behavioral adaptation (working hours and industry)

		Scenario	
	Population	**Separation**	**Non-separation**
t+1	**Separation**	18,561	6,866
	Non-separation	21,251	17,093
	All	20,805	14,816
t+2	**Separation**	18,317	6,492
	Non-separation	25,720	17,879
	All	24,367	15,217

Source: SOEP v.35, own calculations.
Notes: Numbers are calculated for a woman with mean values (total population) of all observable characteristics; Separation probability equals the sample proportion of separation (14.9 %)

Additional insights into the roots of differential wage returns for separated and non-separated mothers were gained from an exploration of the household context. The results revealed a differential selection into employment (**Tables A5 and A6** in the Appendix). Both mother groups were negatively selected, meaning that a higher (lower) earnings capacity was associated to a lower (higher) employment probability, but selection was more pronounced for the separated. Apparently, their employment was driven by necessity rather than opportunity. As discussed earlier, they had fewer years of training-on-the job and lower education, compared to non-separated mothers. While the necessity to provide and further causal factors of separation such as lost economies of scale in the household, costs associated with moving out of the family home etc. incentivized separated mothers' employment and hours, their human capital disadvantage and related skills and preferences triggered both separation and lower earnings trajectories.

5.3 Robustness checks

We ran four robustness checks to test the sensitivity of our results against (1) a modification in sample composition, (2) the inclusion of period fixed effects, (3) a modification of the 'standard woman' and (4) modifications of the applied instruments.

From 2011 onwards, the sample included mothers who were interviewed in the framework of the FiD survey ("Familien in Deutschland"), which was subsequently integrated into the SOEP data. The FiD sample is selective in terms of family composition and socio-economic background. Single parents, parents with three or more minor children, families with children below three years of age and low income-families are overrepresented (Schröder et al., 2013). In a first check, we tested the robustness of our results against this selectivity. To this end, the extended model was repeated without women from the FiD subsample. This led to the exclusion of 95 separated mothers and 170 non-separated mothers. **Table 4** depicts the results. For the group of non-separated women, the positive selection became somewhat smaller and insignificant in t+1 but greater in t+2. The negative selection of separated mothers was slightly stronger in t+1 and had about the same size in t+2. Overall, the former pattern of unmeasured selection did not change.

Table 4. Disturbance covariances σ_{13} and σ_{23}, measuring the direction and magnitude of selection, without FID interviews

	Unmeasured selection separation (σ_{13})	**Unmeasured selection non-separation** (σ_{23})
t+1	-0.17	-0.41
t+2	-0.20	-0.62**

Source: SOEP v.35, own calculations.
*p < .05.**p< .01.***p< .001.

The *second* robustness check addressed group differences in the distribution of separation events over years. Following Hübgen (2020), we constructed a categorical variable differentiating between two periods (1998-2006, 2007-2016) and a reference category (1984-1997). During the period 1998-2006, major labor market reforms with a further strengthening of work incentives were introduced and between 2007 and 2016, family policies boosting the work-family-compatibility and stimulating paternal childcare engagement came into effect. The question was whether the results would stay the same when the observation period were included as an additional regressor in the earnings equation. Results are summarized in **Table 5**. Again, non-separated mothers exhibited a positive selection. As before, separated mothers were negatively selected in t+1, but this changed in period t+2, though the result was still not significantly different from zero. Thus, if group differences in period distribution were accounted for, separated mothers showed a quicker recovery from the economic struggles during separation, and both groups of mothers were positively selected in t+2, that is, they were optimally allocated in economic terms.

Table 5. Disturbance covariances σ_{13} and σ_{23}, measuring the direction and magnitude of selection, including time effects

	Unmeasured selection into separation (σ_{13})	**Unmeasured selection into non-separation** (σ_{23})
t+1	-0.19	-0.45
t+2	0.09	-0.63*

Source: SOEP v.35, own calculations.
*p < .05.**p< .01.***p< .001.

In a *third* robustness check, we modified the construction of the 'average woman'. The idea behind is that as non-separated women represented 85.1% of the total sample, the woman with average characteristics based on the whole sample was more similar to a non-separated than to a separated mother. Thus, instead of referring to the total sample when computing mean values of observables, we used group-specific means. Results are shown in **Table 6**. It depicts in its upper (lower) half the individual labor income of the separated (non-separated) woman. Compared to the overall average woman (Table 3b), earnings for a mean separated woman were slightly higher in all scenarios, whereas for a mean non-separated woman, values were slightly lower. However, the general interpretation of the results was not affected. This also applied to results for t+2.

Table 6. Expected earnings of mothers in different scenarios, accounting for behavioral adaptation, for an average separated and an average non-separated woman, respectively, in t+1

		Scenario	
	Population	**Separation**	**Non-separation**
Mean separated women	**Separation**	18,830	6,881
	Non-separation	21,559	17,129
	All	21,107	14,847
Mean non-separated women	**Separation**	18,495	6,856
	Non-separation	21,176	17,066
	All	20,731	14,793

Source: SOEP v.35, own calculations.
Notes: Separation probability equals the sample proportion of separation (14.9 %).

Fourth, we checked whether our instruments fulfilled the necessary requirements and whether our results from the endogenous switching regression model were sensitive to a change in instruments (results are available on request). Regarding the requirements, we tested the relevance and exogeneity of our indicators in Probit and OLS model specifications. The instruments showed the required (in)significance in the majority of specifications of the separation and earnings equations. Running the estimation of the endogenous switching regression model separately with all possible combinations of the four instruments showed that the results were largely robust to the different specifications.

6 Conclusion

This study analyzed the earnings trajectories of single mothers up to two years after separation and investigated their relationships to pre-separation characteristics and anticipatory strategies around separation. As pre-separation individual traits and behavior may both channel selection into separation and impact its economic consequences, we opted for an integrated empirical approach that allowed us to disentangle selection from causation. We found that mothers indeed increased their employment intensity prior to the event. These adjustments presumably arose from the need to provide and were thus part of the causal effect of separation. Further, we found that separated mothers were negatively selected into separation, meaning that unobserved individual traits triggered both separation and large earnings disadvantages after the event. Conversely, non-separated mothers were positively selected into non-separation. Robustness checks largely confirmed that our results are not substantially affected by changes in sample composition, eliminating group differences in period distribution, and changes in model specification.

In all, our data support the notion that both chronic strain and crisis-caused factors hamper single mothers' economic well-being after separation. On the one hand, unobserved traits associated with lower labor market investments and productivity should answer for part of their economic strain. The fact that the separated exhibit a severely negative selection into employment supports the notion of high economic pressure combined with limited human capital resources. On the other hand, the full burden of caring duties decrease the time and energy budget for maternal career investments and the need to provide are crisis-driven factors that aggravate mothers' financial struggles. We conclude that policies should focus on institutional frameworks and monetary policies that enable and incentivize mothers' solid labor market integration and economic independence from early on and throughout their lives, irrespective of partner and family constellation.

Limitations

The limitations of this study mostly concern the small sample size, which precludes more fine-grained differentiations with respect to the target group, major confounders and the study's longitudinal scope. To give some examples, it would have been intriguing to analyze cohort effects and the role of changing social norms and institutional settings. Although the large time frame from which the events are gathered (1986-2016) is principally suited for such endeavors, sample sizes were too small to pursue them. Specifically, addressing the behavioral effects of the maintenance law reform ("Unterhaltsrechtsänderungsgesetz"), which has come into effect in 2008 and which increased the work incentives of formerly married women after their child's third birthday (Deutscher Bundestag, 2007) would have been a worthwhile investigation. The same holds true for the legal custody reform ("Kindschaftsrechtsreformgesetz") enacted in 1998, which strengthened the rights of separated formerly unmarried fathers towards their children (Dethloff, 2015). Relatedly, a differentiation of single mothers by practiced physical custody arrangements and a widening of the observation window post-separation would have been desirable. Hopefully, data that meets the named requirements, i.e. combining high observation numbers with rich household context and valid income information, will be available in the near future.

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Appendix

Table A1. Socio-economic group differences

	Separated mothers	Non-separated mothers	Significance
Education l1 (%)			
Low	17.09	16.60	
Moderate	61.02	56.78	*
High	20.77	25.81	**
Number of children l1 (%)			
One	44.57	35.16	***
Two	39.30	48.20	***
More	16.13	16.64	
Full time experience l2 (years)	6.04	7.06	***
Part time experience l2 (years)	2.39	2.97	***
Age l1 (%)			
18 – 29	23.64	13.34	***
30 – 39	50.32	49.85	
40 – 49	25.08	33.68	***
50 and above	0.96	3.13	**
Migration background (%)	15.50	25.48	***
East Germany l1 (%)	27.80	19.48	***
General satisfaction l2	6.84	7.33	***
Financial worries l2 (%)			
None	15.97	25.90	***
Some	51.28	54.12	
Many	32.59	19.51	***
Cohabitation l1 (%)	25.72	4.90	***
Working l2 (%)	47.44	45.97	
Homeowner l1 (%)	31.95	52.66	***
Cohort (%)			
Before 1960	15.97	33.12	***
1960 – 1969	37.86	40.45	
1970 – 1979	33.87	22.38	***
1980 and later	12.30	4.06	***
Age at begin of partnership (years)	26.10	25.00	***
Time in partnership l1 (years)	8.56	12.12	***
Number of marriage l1 (%)			
Cohabitation or missing	29.55	6.94	***
First	61.98	86.99	***
Second or more	8.47	6.07	*
Yearly labour income (€)			
t-2	13,297	11,535	**
t+1	16,784	14,127	***
t+2	18,147	14,576	***
Period			
1984-1997	23.00	35.41	***
1998-2006	34.82	32.67	
2007-2016	42.17	31.92	***
Total	626	3,575	

Source: SOEP v.35, own calculations. l1=measured at the last survey before the event (t-1), l2=measured at the second-last survey before the event (t-2); variables without a time-specification are time-invariant.
Notes: Significance levels of one-sided t-tests: *p < .05.**p< .01.***p< .001.

Table A2. Regression results (Probit) for the separation equation

	π
Education l1	
Low	(Reference)
Moderate	0.03
High	-0.12
Number of children l1	
One	(Reference)
Two	0.02
More	0.17
Full time experience l2	-0.01
Part time experience l2	-0.01
Age l1	
18 – 29	(Reference)
30 – 39	-0.05
40 – 49	0.00
50 and above	-0.13
Migration background	-0.31**
East Germany l1	-0.09
General satisfaction l2	-0.07**
Financial worries l2	
None	(Reference)
Some	0.02
Many	0.20*
Cohabitation l1	0.64***
Working l2	-0.10
Homeowner l1	-0.27***
Pre-event individual labor income	0.08*
Cohort	
Before 1960	(Reference)
1960 – 1969	0.17
1970 – 1979	0.31**
1980 and later	0.30
Age at begin of partnership	0.00
Time in partnership l1	-0.00
Time in partnership squared l1	-0.00
Number of marriage l1	
First	(Reference)
Second or more	-0.11
Constant	-1.05
Total	2,565

Source: SOEP v.35, own calculations.
*p < .05.**p< .01.***p< .001.

Table A3. Regression results (OLS) for the earnings equations in t+1 and t+2, by mother group

	t+1		t+2	
	Separated	**Non-separated**	**Separated**	**Non-separated**
Education l1				
Low	(Reference)	(Reference)	(Reference)	(Reference)
Moderate	0.42**	0.12*	0.20	0.13*
High	0.72***	0.40***	0.66***	0.39***
Number of children l1				
One	(Reference)	(Reference)	(Reference)	(Reference)
Two	-0.03	0.03	0.08	0.04
More	-0.08	0.00	-0.11	-0.03
Full time experience l2	0.01	0.01**	0.00	0.01*
Part time experience l2	0.00	0.01*	-0.01	0.00
Age l1				
18 – 29	(Reference)	(Reference)	(Reference)	(Reference)
30 – 39	-0.16	0.14	-0.01	-0.00
40 – 49	-0.02	0.11	0.22	-0.01
50 and above	-0.23	0.12	-0.36	0.10
Migration background	0.01	-0.04	0.02	-0.06
East Germany l1	-0.26**	-0.23***	-0.51***	-0.22***
General satisfaction l2	-0.04	0.01	0.01	0.02*
Financial worries l2				
None	(Reference)	(Reference)	(Reference)	(Reference)
Some	-0.14	-0.09**	0.07	-0.11**
Many	-0.32**	-0.17***	-0.07	-0.22***
Cohabitation l1	0.02	-0.16	-0.02	-0.24*
Working l2	-0.03	-0.08	0.13	-0.02
Homeowner l1	0.10	0.04	0.13	0.05
Pre-event individual labor income	0.28***	0.33***	0.21***	0.28***
Controls for current industry	Yes	Yes	Yes	Yes
Current working hours (agreed)	0.03***	0.03***	0.04***	0.03***
Constant	6.70***	5.31***	6.61***	5.84***
$\boldsymbol{\sigma_{13}}$	-0.07	-0.50*	-0.19	-0.56**
Total	240	1,549	194	1,378

Source: SOEP v.35, own calculations.

*p < .05.**p< .01.***p< .001.

Table A4. Disturbance covariances σ_{13} and σ_{23}, measuring the direction and magnitude of selection, accounting for behavioral adaptation (industry and working hours separately)

	Unmeasured selection separation (σ_{13})	**Unmeasured selection non-separation** (σ_{23})
Only industry		
t+1	0.36	-0.02
t+2	0.13	-0.10
Only working hours		
t+1	-0.09	-0.49*
t+2	-0.19	-0.58**

Source: SOEP v.35, own calculations.
*p < .05.**p< .01.***p< .001.

Table A5. Regression results (Probit) for the employment equation in t+1 and t+2

	t+1	t+2
Education		
Low	(Reference)	(Reference)
Moderate	0.09	0.18**
High	0.72***	0.46***
Number of children		
One	(Reference)	(Reference)
Two	-0.04	0.07
More	-0.23**	-0.06
Full time experience	0.08***	0.06***
Part time experience	0.23***	0.11***
Age		
18 – 29	(Reference)	(Reference)
30 – 39	-0.32**	-0.01
40 – 49	-0.94***	-0.51***
50 and above	1.80***	-1.37***
Migration background	-0.03	-0.17**
East Germany	0.31***	0.18**
General satisfaction	0.02	0.03*
Financial worries		
None	(Reference)	(Reference)
Some	0.12	0.13*
Many	0.13	0.13
Cohabitation	0.58**	0.04
Homeowner	0.03	-0.01
Youngest child	0.06***	0.04***
Controls for last industry	Yes	Yes
Constant	-1.03***	-1.07***
Total	4,059	4,035

Source: SOEP v.35, own calculations.

*p < .05.**p< .01.***p< .001.

Table A6. Regression results (OLS) for the earnings equations in t+1 and t+2, by mother group, with employment selection correction

	t+1		t+2	
	Separated	**Non-separated**	**Separated**	**Non-separated**
Education				
Low	(Reference)	(Reference)	(Reference)	(Reference)
Moderate	0.14	-0.01	-0.02	-0.13
High	0.33	0.40***	0.38	0.30**
Number of children				
One	(Reference)	(Reference)	(Reference)	(Reference)
Two	-0.09	-0.10*	0.01	-0.13**
More	-0.09	-0.16*	-0.23	-0.21**
Full time experience	0.01	0.05***	-0.02	0.04***
Part time experience	-0.05	0.01	-0.09*	-0.01
Age				
18 – 29	(Reference)	(Reference)	(Reference)	(Reference)
30 – 39	-0.08	0.12	-0.38	0.07
40 – 49	0.02	0.06	-0.12	0.08
50 and above	0.09	-0.06	0.16	0.06
Migration background	0.11	0.13*	0.10	0.03
East Germany	-0.16	0.20***	-0.29*	0.08
General satisfaction	-0.01	0.04**	0.01	0.04**
Financial worries				
None	(Reference)	(Reference)	(Reference)	(Reference)
Some	-0.30*	-0.23***	-0.41**	-0.15**
Many	-0.77***	-0.24***	-0.57**	-0.19**
Cohabitation	(Omitted)	0.04	(Omitted)	0.12
Homeowner	0.24*	-0.01	0.24*	0.03
Controls for last industry	Yes	Yes	Yes	Yes
Constant	10.71***	8.87***	11.74***	9.42***
Employment selection term	-1.58***	-0.56***	-2.14**	-0.77**
Total	405	2,569	343	2,327

Source: SOEP v.35, own calculations.

*p < .05.**p< .01.***p< .001.