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A Multi-Conceptual Approach  
with Dynamic Sequence Analysis  
and Fixed Effects Models**

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# **Rethinking Children's Family Complexity: A Multi-Conceptual Approach with Dynamic Sequence Analysis and Fixed Effects Models**

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## **Abstract**

*Objective:* The association between a wide range of family complexity indicators and children's educational outcomes was assessed.

*Background:* Previous research documented a negative impact of disadvantageous family transitions and family instability on children's educational outcomes. However, there is a theoretical and empirical debate surrounding the most appropriate measure of family complexity during childhood.

*Method:* Numerous theoretically conceptualized sequence-based complexity measures are applied to parents' life history data from the UK Household Longitudinal Study, which were linked to children's test scores in the National Pupils Dataset. Average within-child change in boys' and girls' math and English tests scores following change in mothers' and fathers' family complexity were estimated with fixed-effects regressions.

*Results:* Family complexity measures were largely found to be negatively associated with children's academic performance, however with differences across indicators. The number of transitions as well as the uncertainty and sum of disadvantage indicators were most tightly associated with children's test scores. In addition, results varied by parents' and children's gender. For example, family complexity for fathers was often positively associated with children's educational outcomes and associations were often stronger for boys compared to girls.

*Conclusion:* Findings highlight the importance of theoretically derived measures of family complexity. In this study, measures associated with family instability and parental absence were shown to be most strongly linked with children's educational outcomes.

**Keywords:** family complexity, family stability, family structure, children's outcomes, sequence analysis, life course, education, union dissolution, entropy

## 1 Introduction

As the second demographic transition has progressed (Lesthaeghe, 2014), social scientists have assessed the implications of changing family lives on children (e.g., McLanahan, 2004). Most studies have focused on the consequences of single family transitions on children's outcomes, such as union dissolution (Härkönen et al., 2017). However, the focus on the impact of single events stands in contrast to the contemporary family sociological notion that family stability is integral for children's life chances (e.g., Fomby and Cherlin, 2007; Waldfogel et al., 2010). In turn, research has shifted from individual transitions to broader measures of family dynamics, such as the number of family events (Cavanagh & Fomby, 2019). Typically, these studies quantify the number of transitions a child experiences, arguing that it is rather cumulative *family (in)stability* that affects children than single family changes (Cavanagh & Fomby, 2019; Wu & Martinson, 1993). Yet other studies argue that children's well-being depends not only on the quantity but the quality of family change, that is, the type of changes with regard to the *family structures* (e.g., Jarvis et al., 2021; Lee and McLanahan, 2015). As a result, there is a tension in the literature on which measures best reflect family life and which dimensions of family complexity are most relevant to children's outcomes. Indeed, recent review articles have called for a broader conceptualization and measurement of family complexity (Cavanagh & Fomby, 2019; Raley & Sweeney, 2020).

A parallel stream of research seeks to describe and explain differences in family life courses, such as the complexity of family life course patterns (Brückner & Mayer, 2005). For example, Van Winkle (2018) demonstrated that while the complexity of family life courses has increased across 20th-century cohorts, the differences between European countries remain considerably larger than the changes observed across cohorts. Recently, Rowold and Van Winkle (2023) integrated this stream

of literature with the literature on children's family lives by taking a children's rather than an adult's perspective to family life course complexity. They documented a stark increase in children's family complexity across cohorts as they grow older.

This study strengthens the link between these different streams of literature by introducing new concepts of family complexity to assess their consequences for children's outcomes. In line with Cavanagh's and Fomby's (2019) recommendation, we systematically test the impact of different measures of family complexity on children's educational outcomes. Our contribution is twofold.

First, we theoretically conceptualize different facets of family complexity. On the one hand, this entails broad and holistic sequence-based family complexity indices, which aim to capture family complexity more holistically. On the other hand, we introduce measures that incorporate different theoretical perspectives by weighting family states according to their associated levels of disadvantage.

The inherent flexibility of sequence complexity indices makes them exceptionally well suited to operationalize the broader and more specific notions of family stability and complexity, allowing for an in-depth emphasis on diverse aspects of the life course that generate complexity. The result is a multitude of family life course complexity measures that cover distinct facets of family complexity as well as different theoretical perspectives, contributing to the need for more comprehensive measures of children's family life over their childhood (Cavanagh & Fomby, 2019; Raley & Sweeney, 2020).

As second contribution, we estimate the consequences of family life course complexity for children's outcomes, applying a novel combination of methods. Although the family complexity concepts and measure we introduce are applicable to a wide range of outcomes, in this study we focus on educational outcomes, specifically math and English test scores, using data from the UK

Household Longitudinal Study (UKHLS) linked to the National Pupils Dataset for England. We are the first to combine dynamic sequence-based measures of complexity (Pelletier et al., 2020) with fixed effects regression models to estimate average within-child change in educational outcomes associated with changes in family life course complexity.

As a result, this study adopts a dynamic and holistic perspective on family life course complexity to children's outcomes. By comparing the magnitude of the various complexity measures' association with children's test scores, our exploratory approach assesses which specific facets of family complexity matter most for children's education. The results can guide future research on the consequences of family life on children's outcomes and provide insights on the underlying mechanisms linking family complexity and children's outcomes.

## **2 Theoretical Background and Previous Evidence**

### **2.1 Theoretical perspectives: family complexity and children's outcomes**

Explanations for the link between family life and child outcomes are commonly framed within the family investment and family stress models. *Family investment* frameworks are based on the intertwined relationship between resources and family structure (Fomby et al., 2015). Children benefit from economic and time resources that their families invest, which vary between family types. Two-adult families are likely to have more economic and time resources than single parent families, since two adults can contribute to the resources available in the household (Waldfogel et al., 2010). Apart from the number of adults in the household, the partnership status matters since married families tend to have better economic resources than families with cohabiting adults (Brown, 2004). In line with this perspective, there is evidence that single and cohabiting parents invest economically less in their children compared to their married peers (Hastings & Schneider,

2021).

*Family stress* perspectives for the impact of family lives on children's outcomes argue that family changes induce stress to children and adults, whereas family stability is beneficial (e.g. Lee and McLanahan, 2015). Particularly union dissolutions but also re-partnering might be linked to the disruption of family routines, as they can lead to changes in household membership and family roles (Brown, 2006). Family instability is related to maternal depression and mother's low mental health is linked to children's lower well-being (for an overview, see Fomby et al., 2015). However, the evidence for maternal stress mediating the association between family instability and children's well-being is mixed with stronger evidence for children's well-being at preschool-age (Fomby et al., 2015).

## **2.1 Previous measures and evidence**

In the following section, we briefly review research on family life and child outcomes focusing on different measurements of family complexity.

### **Single transitions**

The most common measure of family in relation to children's outcomes applied is whether children experienced a union dissolution of their parents (Härkönen et al., 2017). This includes the sole focus on one family transition but also studies that differentiate between different transition types. The latter include the dissolution versus the formation of unions or the dissolution of marriages versus cohabitations. For example, Kailaheimo-Lönnqvist et al. (2023) found for Finland that the negative effect of union dissolution is similar across union type (marriage and cohabitation). Usually, these measures are applied to educational outcomes (Bernardi & Radl, 2014; Grätz, 2015; Kailaheimo-Lönnqvist et al., 2023), and show negative relations with these outcomes. Commonly, these studies apply sibling or individual fixed-effects models to assess the relationship between family structure or stability and child

outcomes within individuals (Härkönen et al., 2017).

For the measures going beyond single transitions, there is a tension between whether the *quantity* of transitions matters most for children's outcomes (Wu, 1996; Wu & Martinson, 1993) or the *type* of transitions between more complex family status' (Lee & McLanahan, 2015) (for an overview see Cavanagh and Fomby, 2019). The two camps focus on different theoretical traditions: *family stability* and *family structure*.

### **Quantity of transitions (family stability)**

The number of transitions was applied as the first measures for *family instability* to test the family instability hypothesis (Wu, 1996; Wu & Martinson, 1993; Brown et al., 2016; Cooper et al., 2011; Fomby & Cherlin, 2007). Relying on social stress theory, the assumption is that any transition - even a 'positive' one - increases stress because the transition process itself is stressful (Fomby & Cherlin, 2007; Osborne & McLanahan, 2007). Overall, studies show that the more family transitions children experience, the greater the negative outcomes, such as increased behavior problems (Cooper et al., 2011; Fomby & Cherlin, 2007; Lee & McLanahan, 2015; Osborne & McLanahan, 2007), lower cognitive abilities (Cooper et al., 2011; Lee & McLanahan, 2015) and, at older ages, increasing risk of premarital birth (Wu, 1996; Wu & Martinson, 1993).

### **Type of transitions (family structure)**

A growing stream of literature argues that not merely the number but also the *type* of family transition matters and thereby highlights the need to consider the type of family transitions, also referred to as *family structure* (Hadfield et al., 2018; Jarvis et al., 2021; Lee & McLanahan, 2015). In contrast to studies focusing on the number of transitions, the argument is that not all transitions are equally disruptive and some might even be beneficial (Lee & McLanahan, 2015). The studies

differentiate between moves into or out of different qualitative family types such as two-parent families, single-parent families, or stepfamilies (Brown, 2006; Lee & McLanahan, 2015). Results show that children living in stable families tend to have more advantageous outcomes compared to almost all other types of families, such as fewer behavioral problems (Jarvis et al., 2021), higher economic well-being (Brown et al., 2015), as well as higher educational outcomes and mental health (Brown, 2006; for stable co-residential unions: Lee and McLanahan, 2015).

We argue that both theoretical perspectives and related measures have weaknesses. Family stability can be measured beyond the mere number of transitions as we show. However, in general, the assumption that any additional transitions increase family stability is very strong. Solely focusing on family structure and differentiating between different family types, on the other hand, risks simplifying family lives as well, as these types likely differ across time. We therefore suggest exploring different measures for family stability and combining both perspectives. The result is a conceptualisation of new family complexity measures along the lines of family stability and family structure which we introduce in the next section.

## **2.2 Family life course complexity**

A large body of literature that measures family lives more holistically evolved nearly independently of the literature on family lives and children's outcomes. The application of sequence complexity indices highlighted the change of family complexity across birth cohorts and countries for different subgroups. The literature is theoretically embedded in the life course paradigm, which measures family complexity in terms of differentiation. This is defined as the increasing number of family life course states experienced, as well as the unpredictability within individual life courses (Brückner & Mayer, 2005; Van Winkle, 2018). Sequence complexity

measures are commonly used to provide macro-level descriptions of how complexity develops across cohorts and countries and reveals for family life course complexity differs largely across countries and has increased across cohorts (Van Winkle, 2018). On individual level, family life course complexity measures have been used to study the link between childhood family structure and complexity of adult partnership life courses (Hiekel & Vidal, 2020). Rowold and Van Winkle (2023) have conceptually integrated both literature streams. For the UK, they documented that family complexity, measured based on partnership states, has not only increased for adults across cohorts, but particularly for children. The application of more comprehensive family life course complexity measures is likely not only helpful for describing how family complexity evolves throughout childhood but also to assess how it is related to children's outcomes.

### **3 Conceptualizing family complexity**

In this section we conceptualize such holistic family complexity measures that reflect different facets of family complexities, which we expect to be beneficial for understanding children's outcomes. Our approach is informed by the evolving literature on indices for measuring sequence complexity (Ritschard, 2021) as well as theoretical arguments and empirical evidence on family lives and children's outcomes. Essentially, we identify measures that are both theoretically grounded and conceptually robust, addressing the need for more comprehensive frameworks to conceptualize and measure the complexities of family lives (Cavanagh & Fomby, 2019; Raley & Sweeney, 2020).

#### **3.1 Measures for family complexity**

Typically, life course complexity has been used as a static indicator, measured only at the end of an observed period. Recently, however, it has been proposed to measure complexity dynamically over the life course for each time point (Pelletier et al., 2020). This approach enables the

conceptualization of family complexity as a dynamic process evolving throughout one's life course, revealing when family complexity growth, when it peaks and when family lives stabilize (Rowold & Van Winkle, 2023). We apply dynamic sequence analysis as it allows us to analyze the relation of family complexity with outcomes longitudinally in panel regression such as fixed-effects models. This is in line with the literature studying the implications of family lives for children's outcomes.

A variety of sequence complexity measures have been developed and were empirically applied to different life-course dimensions (Ritschard, 2021), most often employment. The distinct complexity indices focus on different facets of complexity or weigh them differently. Their inherent flexibility not only ideally suits the task of conceptualizing broader family stability measurements (Cavanagh & Fomby, 2019; Raley & Sweeney, 2020) but also enables a targeted focus on various complexity facets. Crucially, applied as a dynamic measure, they contribute by incorporating the 'cumulative change' (Cavanagh & Fomby, 2019, p. 507) of distinct or combined complexity aspects. And lastly, the measures allow us to implement different theoretical perspectives, detail out different aspects of family stability and combine notions of family stability with family structure.

In the following we theoretically and conceptually introduce the different family complexity measures that we identify as particularly suitable for children's family lives and their outcomes. Details on their estimation and behavior are described in the Section 5. An overview of which theoretical perspectives the measures take, in which tradition they are embedded, and which complexity facets they cover is given in Table 1.

### **3.1.1 Objective measures**

The first set of indices we apply measures family complexity *objectively*, i.e., independently of the nature of the distinct family states individuals experience. They are thus largely in line with the

family stability tradition of previous research (Table 1).

**Uncertainty.** The uncertainty index measures the unpredictability of children's family life courses based on the distribution of different family states throughout childhood. It thus allows us to isolate the effect of pure uncertainty from other facets of complexity, such as the number of transitions or differentiating between the (dis)advantages of particular family states. This is consistent with the notion that it is important to study how children respond specifically to family “uncertainty” (Cavanagh & Fomby, 2019, p. 507). The assumption is that children might be more negatively affected by a childhood in which they experience all different family states equally often than by a life course in which they experience one family state (e.g., marriage) for 90% of the time and other states only for 2-4% of the time since the former induces more uncertainty.

**Complexity.** The life course complexity index (Gabadinho et al., 2010) combines the number of transitions with the overall unpredictability of family life courses. It thus integrates the notion of family stability based on the number of transitions (Wu, 1996) with the notion that family uncertainty matters (see above). Indeed, family stability may be better captured by a measure that considers overall uncertainty in addition to the number of transitions. The complexity index has been widely used to describe variations in family complexity across different cohorts, countries, and genders (Rowold & Van Winkle, 2023; Van Winkle, 2018).

### **3.1.2 Undesirability measures**

The second set measures family complexity more subjectively, considering the positive or negative nature of family states and the degree of disadvantage they may induce. It thus identifies transitions that either increase or decrease family complexity. By assigning ordinal rankings and undesirability weights to different family categories (Ritschard, 2021), this approach allows for the application of

differentiated levels of disadvantage according to different theoretical assumptions about the desirability of family states. This, in turn, allows the modeling of how the disadvantage of family trajectories evolves through childhood from different theoretical perspectives.

The distinction between the degree of disadvantage of different family states is consistent with the existing literature, which emphasizes the importance of transitions between different family *types* (Hadfield et al., 2018; Lee & McLanahan, 2015) and advocates taking into account “deviations from traditional, socially desirable partnership paths” (Hiekel & Vidal, 2020, p. 8). These complexity measures are thus conceptually close to the tradition of *family structure*. However, since some measures of undesirability include both the total number of transitions and their degree of disadvantage, they partly bridge the tensions between both theoretical traditions, addressing “the need to examine both the number and type of family structure transitions when assessing the effects of family instability” (Lee & McLanahan, 2015, p. 741).

**Weighted quantity of transitions ('Degradation').** The weighted quantity of transitions, operationalized by the degradation index, compares the frequency of positive transitions to that of negative transitions (Ritschard, 2021). In contrast to the notion that family stability increases with the mere number of any transitions, the degradation index assumes that some family transitions increase family stability (e.g., entering a new union), while others decrease it (e.g., union dissolution). It is thus a theoretically weighted version of the number of transitions while considering the notion that the type of family structure matters. Consequently, we locate it conceptually as an approach between the two classical approaches in the literature to measure family stability: the number of transitions and the type of family structure.

**Sum of disadvantage ('Badness').** The badness indicator sums the undesirability experienced at the different ages based on the disadvantage degrees assigned to each family state that the individual

has experienced (Ritschard, 2021). We conceptualize it as an indicator of the cumulative disadvantage in family life. Additionally, it gives particular emphasis to family states that were experienced more recently (close to the age at measurement). We argue that this is particularly useful for approaches that aim to assess the effects of life course complexity in fixed effects designs. In our application, children may be more affected by their recent family circumstances than by those experienced several years ago. This assumption is in line with the social stress theory, arguing that “negative effects of partnership changes should be most pronounced around the time of the change and should fade out over time” (Osborne & McLanahan, 2007, p. 1067).

**Weighted complexity I ('Precarity').** The precarity index is an advancement of the complexity index (Gabadinho et al., 2010) that considers different levels of undesirability of the distinct family states (Ritschard et al., 2018). It thus goes conceptually beyond the complexity index by incorporating the level of disadvantage assigned to every family life course state, as well as beyond the degradation and badness indices by considering the number of transitions and the uncertainty of the family life. Whereas the index has been originally conceptualized for employment precarity and “aims to provide a quantitative tool accounting for the cumulative process of precarity and its impact” (Ritschard et al., 2018, p. 281), it can be easily applied to family life courses. For example, the two trajectories cohabitation-cohabitation-marriage and cohabitation-cohabitation-separated would receive the same score for the measures number of transitions, uncertainty, and complexity. However, from theoretical standpoints, the former is more advantageous, as marriage likely implies stability, whereas union dissolution induces disruption. The precarity index can incorporate such differentiation in state disadvantage by assigning higher undesirability levels to the family state 'separation' compared to 'marriage' while still incorporating increasing complexity through increases in transitions experienced or uncertainty.

**Weighted complexity II ('Insecurity')**. The insecurity index is a more comprehensive version of the precarity index. It is based on the complexity index as well, but, other than the precarity index, only adjusted with the Degradation Index (Ritschard, 2021). It is both empirically and theoretically motivated, similar to the precarity index, but easier to interpret because it is simply the sum of the complexity index, the degradation index, and the degree of disadvantage of the first state. In summary, the precarity and insecurity indices are the most holistic measures considered, as they incorporate all facets of family complexity discussed, while the other indices focus on fewer or single aspects (see Table 1).

In total, we consider eight distinct family complexity measures (summarized in Table 1 and Table 3). The latter four of those indices consider the nature of the different family transitions or states by applying different levels of disadvantage. For these, we developed three distinct sets of weights to incorporate three different theoretical perspectives that we introduce in the next subsection.

### **Incorporating different theoretical perspectives in the undesirability levels**

By applying different weighting matrices to the disadvantage degrees of the distinct family states, we develop three different sets of undesirability degrees based on theoretical considerations. We thereby aim to incorporate the “need for researchers to carefully differentiate types of transitions and to theorize about them separately” (Hadfield et al., 2018, p. 106). Below we describe the three perspective of family lives based on the family states we consider empirically: union (or differentiation between married and cohabiting, nonmarried), single, separated, divorced, and widowed (Table A2).

**Table 1 Overview of family complexity concepts & link to theory**

<b>Concept</b>	<b>Theoretical Tradition</b>	<b>Theoretical Perspective</b>	<b>Complexity Facet</b>	<b>References</b>
<b>Union dissolution</b>	Family change/stability	Stress, Investment	Single transition	<i>Classic concept:</i> Amato, 1993
<b>Number of transitions</b>	Family Stability	Stress	Count of transitions	<i>Classic concept:</i> Osborne and McLanahan, 2007; Wu, 1996
<b>Uncertainty</b>	Family Uncertainty (subgroup of family stability)	Stress	Uncertainty of family life	<i>New concept,</i> discussed in Cavanagh and Fomby, 2019
<b>Complexity</b>	Complete Family Stability (integration of Stability and Uncertainty)	Stress	Uncertainty of family life, Count of transitions	<i>New concept,</i> discussed in Cavanagh and Fomby, 2019
<b>Weighted number of transitions</b>	Family Stability + Family Structure	A. Favourable family states: Investment, family dynamics, or B. Level of disruption: Stress, parental relationship, role ambiguity, or C. Parental absence: Investment	Level of disadvantage for each state, count of transitions	<i>New concept</i>
<b>Sum of disadvantage</b>	Cumulative family disadvantage, Family Structure		Level of disadvantage for each state, weighted for recency	<i>New concept</i>
<b>Weighted complexity I &amp; II</b>	Complete Family Stability + Family Structure		Uncertainty of family life, Count of transitions, Level of disadvantage per state	<i>New concept</i>

Note that the relations between disadvantage weights given to the different family states may differ across different contexts. However, the weighting matrices can be easily adjusted based on different theoretical perspectives or studied contexts. Similarly, they can be applied (in adjusted form) to other family states. In the following we discuss the levels of advantage or disadvantage we assign to the different family states based on the different theoretical perspectives (see Table 1 for the assigned values).

**A. Favorable family states.** As first perspective we implement the normative, institutional, and socio-economic *favorability* of the different family states. In most western countries marriage is still

the most favorable and normative acceptable family state. Additionally, some welfare states particularly protect and assign important rights and benefits to the status of being married, sometimes resulting in economic benefits (e.g., tax benefits in Germany and, to a lower extent, the UK). Thus, consistent with the investment argument, married adults likely provide better economic resources to their children. Married couples tend to be positively selected in terms of resources and generally experience higher relationship quality compared to cohabiting parents (Waldfogel et al., 2010).

As a results, from the *favorability* perspective, marriage promises the highest level of family advantage. Still, cohabiting adults provide dual time and financial resources and likely pool household resources, making cohabiting adults the second most favourable family state. For the same reasons single parents are less advantaged compared to cohabiting parents. Family states that induce a disruption in the family structure and roles, at least temporary, such as the loss of a second adult in the household through separation, divorce or widowhood are the least favourable family states from this perspective.

**B. Level of disruption.** The second perspective particularly focuses on the theoretical important notion of 'disruption' (Cavanagh & Fomby, 2019, p. 507). From this perspective, we argue that any union type, as well as singlehood without union experience, provide the most stability. In line with parental relationship theory (Waldfogel et al., 2010), these family states should also provide the lowest levels of conflict between adults in the household (and no conflict can occur for singles). In contrast, higher levels of conflict and role ambiguity are likely to occur when individuals experience union dissolution. This is consistent with stress theory, which argues that union dissolutions induce stress for both adults and children due to changes in family composition and potential ambiguity in the roles of family members (Brown, 2006; Lee & McLanahan, 2015). In addition, union dissolutions reduce family resources. Here we assume that the level of disruption is slightly lower for separation

than for divorce or widowhood. This is because both divorce and the death of a household member often involve legal proceedings that can be extremely disruptive and take several years.

**C. Parental absence.** The final theoretical perspective that we examine places particular emphasis on the importance of having parents present in the lives of their children. From this perspective family life course states that imply the absence of one or both parents are disadvantageous for children. The more and the longer parents are absent as well as the greater the distance between them and their children, the more disadvantageous this is for children.

Applied to our example of partnership states we weigh single as most disadvantageous as a single parent never had a cohabiting or married partner (as it is measured in our data). This is followed by widowhood as it means that one (step)parent was present but will be absent for the rest of the children's lives. We consider the dissolution of a union less disadvantageous, as it typically entails one parent residing separately but still maintaining some form of presence in the child's life. A union is regarded as the most advantageous status, either when both parents are involved or when new parental figures enter the child's life following a union dissolution.

The order and weights applied to different family states for the different perspectives based on these arguments are summarized in

Table 2. We apply these three theoretical family perspectives to the four undesirability indices described above which each emphasize different aspects of complexity. Methodological details on all complexity indices used are described in Section 5.

#### **4 Data**

We use data from the UK Household Longitudinal Study (UKHLS) to prepare family life course states for children based on their parents' partnership states (University of Essex 2024, 2025). We then

link the data to the Linked Education Administrative Datasets (National Pupil Database) for England (Department for Education 2019). The National Pupil Database is a register of all pupils in state schools in England, entailing exceptionally rich and reliable administrative records on educational characteristics, such as the attainment data recorded at the so-called key stage. Key stages are milestones at which tests are administered centrally. Pupils usually take five of these exams along their educational trajectories (see Table A1).

#### **4.1 Sample and data structure**

Our initial sample was derived from the UKHLS marital and cohabitational histories files, covering 11,447,377 person-months for mothers and 8,692,499 person-months for fathers. To focus specifically on relevant educational outcomes, we restricted our analysis to school years during which key stage tests were administered, reducing the sample size to 3,012,474 person-months for mothers and 2,246,978 person-months for fathers. For each school year, we calculated the family complexity measures and combined the data for mothers and fathers into a single dataset, resulting in a total sample size of 256,619 person-years. We then excluded person-years from key stages where test information for either mathematics or English was unavailable. Furthermore, we retained only individuals with at least two observations in key stages for each of the two outcome variables. After applying these criteria, our final analytical sample consisted of 20,035 person-years, including 8,437 person-years for fathers and 11,598 person-years for mothers.

#### **4.2 Dependent variables**

In our analysis, we examined two educational outcomes as dependent variables in separate models: Math and English test scores. Table A1 provides an overview of the expected performance levels across different Key Stages, school years, and age groups. We did not include

Key Stage 5 in our analysis, as its structure and assessment criteria vary significantly depending on the educational track which limits comparability. To ensure comparability across the Key Stages 1-4 that we use for our analysis, we classified student performance into three categories: below expected standard, expected standard, and above expected standard. This classification was based on the National Curriculum for England, as outlined by the UK government (2014). These categories allowed for a standardized evaluation of student achievement, facilitating meaningful comparisons between educational stages. We followed previous research in distinguishing the outcomes further into a 'negative' and a 'positive' educational outcome to uncover potential heterogeneities (Bernardi & Comolli, 2019). For this, we created two binary variables from the three categories: Not meeting the expected standard (below expected standard [1]; expected standard, and above [0]) and performing above the expected standard (above expected standard [1]; expected standard, and below [0]).

### **4.3 Independent variables**

We used a set of independent variables designed to capture family complexity (see the Methods section). These measures were derived from retrospective partnership parent-month spells and encompass various family statuses, including single, cohabiting, married, separated, divorced, and widowed (see Table A2). Individuals with missing partnership states were excluded. Data preparation followed the methodology outlined by Rowold and Van Winkle (2023). However, we measured the complexity indices for every relevant year just before the key stage exams in June, defining a school year as running from July to June of the following year.

## **5 Methods**

### **5.1 Family complexity measures**

We applied the family complexity measures that we introduce to the field of literature. For the

main analysis, we measured these based on the family lives of mothers. Table 3 gives an overview of the different measures we apply for studying children's family lives. In Appendix A1 we described how the different measures develop over time for example trajectories, highlighting differences and similarities across measures.

### **5.1.1 Basic sequence characteristics**

As reference points, we first replicated common measures applied for family stability in the previous literature referred to as basic sequence characteristics (Ritschard, 2021). We focused on union dissolution as well as the number of transitions.

**Single transition: union dissolution.** We tracked the years in which a union dissolution of the respective parent happened. This is the only complexity measure that is not cumulative since it only indicates whether a union dissolution happened in the last school year.

**Number of transitions.** Like in previous studies we counted the number of transitions that children experience during the observed period, i.e., in our case, their school career.

### **5.1.2 Objective sequence complexity measures**

**Uncertainty (Entropy).** Entropy measures the diversity of (family) life course states in the individual trajectories and is a measure for uncertainty or unpredictability in the lives of individuals (Ritschard et al., 2023). It was normalized and reached its minimum (0) if only one family state was experienced. The more distinct life course states individuals experienced and the more equally they were distributed over the life course, the higher the index. Entropy reached its maximum (1) if each state was experienced for the same fraction of time. Entropy decreased, i.e., life courses became more predictable, if the share of one life course state became much more frequent compared to the others.

**Complexity.** The complexity index (Gabadinho et al., 2010) is a composite measure that combines the

number of transitions with the uncertainty of a life course, measured by entropy. It ranged from 0-1. Complexity was 0 in cases where only one family life course state was experienced (= 0 entropy) and, therefore, no transitions across family life course states occurred. We would have measured maximum complexity if individuals had gone through a family transition for each school year and each family-life-course state had been experienced for the same amount of time (empirically not feasible with 6 family states and 13 time points).

### 5.1.3 Undesirability measures

We applied four different undesirability indices. For these measures, we assigned the degree of disadvantage to the different family states that we used. For each of the different indices, we applied the same three different sets of weights to the family states to implement and tested the relevance of different theoretical and empirical arguments as outlined in section 3. As a result, we had three versions of each undesirability index from different theoretical family perspectives, for a total of 12 measures (3x4).

For the *favorable family states* perspective, we weighed marriage as most favorable (1), followed by cohabitation (2), single (3) and, with some distance, any of separated, divorced, or widowed (5). For the *level of disruption* perspective, we did not differentiate between marriage and cohabitation and weighed both (union) as well as single as most favourable (1), followed with large distance by separated (4), and divorced, or widowed (5). For the *parental absence* perspective, we weighed both marriage and cohabitation as most favourable (1), followed with large distance by separated or divorced (4), widowed (5), and, finally, single (6). Table 2 summarises the weighting matrix for each family perspective.

**Table 2 Description of weighting data for different perspectives**

<b>Perspective</b>	<b>Description</b>	<b>Weights</b>
A. Favorable family states	0 married → 1 cohabitation → 2 single → 5 separated/divorced/widowed	0, 1, 2, 5
B. Level of disruption	0 union, single → 2 separated → 4 divorced/widowed	0, 2, 4
C. Parental absence	0 union → 2 separated/divorced → 4 widowed → 5 single	0, 2, 4, 5

**Weighted quantity of transitions ('Degradation').** The degradation index weighed the number of transitions by levels of negative or positive transitions, illustrating the proportion of negative to positive transitions. It ranged from -1 to 1 (Ritschard, 2021) and equaled -1 in the case of only positive transitions and 1 in the case of negative transitions only. 0 meant that there were no transitions or the same proportion of positive and negative transitions.

**Sum of disadvantage ('Badness').** The badness index is the sum of the undesirability weights of the family states individuals experience (Ritschard, 2021). The badness index differs from the other indices in that it assigns higher weights on states the closer they occur to the end of the observed period. We argue that this is particularly sensible for the dynamic Sequence Analysis approach in combination with the Fixed Effects framework, as recent family disruptions may have a stronger impact on children's outcomes than disadvantageous states experienced several years ago.

**Weighted Complexity I ('Precarity').** The precarity index is an advancement of the complexity index adjusting it by the proportion of negative and positive states, the level of undesirability of states and the starting state (Ritschard et al., 2018). It increased with the uncertainty (entropy) of the life course, but also with the transition to more disadvantageous family states, the level of disadvantage of the experienced states, as well as the level of disadvantage of the starting state. It ranged from 0 to a maximal score that depended on the parameters chosen (see Appendix A1).

**Table 3 Overview of family complexity measures used**

<b>Complexity concept</b>	<b>Formal index used</b>	<b>Complexity facets</b>	<b>Description</b>	<b>Type</b>	<b>Range</b>
<b>Union dissolution</b>	-	Single transition	Tracks when union dissolution happens	Basic/classic measure	0, 1
<b>n of transitions</b>	-	Count of transitions	Sum of the number of transitions happened until time t	Basic/classic measure	0, ..., $n_t$
<b>Uncertainty</b>	Entropy	Uncertainty/ unpredictability of family life	Measures the level of uncertainty within individual life courses based on the relative frequency of experienced life course states	Complexity	0–1
<b>Complexity</b>	Gabadinho's complexity	Uncertainty of family life, Count of transitions	Measures the overall complexity of family life courses based on uncertainty and the number of transitions	Complexity	0–1
<b>Weighted n of transitions</b>	Degradation	Level of disadvantage per state, Count of transitions	Proportion of negative to positive transitions	Undesirability	-1–1
<b>Sum of disadvantage</b>	Badness	Level of disadvantage per state	Sum of level of disadvantage per state experienced, with higher weights given to recent states experienced (i.e., close to time of measurement)	Undesirability	0–1
<b>Weighted complexity I</b>	Prearity	Uncertainty of family life, Count of transitions, Level of disadvantage per state	Measures family complexity by weighting it with the subjective levels of undesirability per family state	Undesirability and complexity	0–x
<b>Weighted complexity II</b>	Insecurity	Uncertainty of family life, Count of transitions, Level of disadvantage per state	Sum of complexity index, degradation index and disadvantage degree of first state	Undesirability and complexity	0–1

**Weighted Complexity II ('Insecurity')**. The insecurity index is a modification of the precarity index that aims to be more comprehensible given the lower number of tuning parameters (Ritschard, 2021). Like the precarity index, it builds on the complexity index but adjusts for the degradation index—the ratio of negative to positive transitions. Unlike the multiplicative precarity index, insecurity is additive.

While all measures effectively captured the accumulation of family change, two indicators—the *number of transitions* and the *sum of disadvantage*—were unidirectional by definition; they can only increase over time. These measures did not allow for the possibility of stabilization or reduction in family complexity. In contrast, the other indicators were designed to reflect not only increases but also decreases or periods of stability in family complexity.

#### **5.1.4 Dynamic Sequence Complexity**

We followed Pelletier et al. (2020) and measured all complexity indices for each school year cumulatively. At the end of each school year, complexity was measured from school entry up to that point, reflecting all family events within that period. All measures were therefore time-variant and cumulative, except for union dissolution, which is measured separately. The former is necessary for their application in panel regression designs, as we propose in this study.

## **5.2 Modelling approach: Combining Dynamic Sequence Analysis with Individual Fixed Effects Models**

To assess the impact of family complexity on children's education, we applied Individual fixed effects regression models, as commonly used in the literature. Measuring the sequence complexity indices dynamically over time, allowed us to apply them as covariates of interest in the fixed effects model, controlling for any time-constant confounders. The individual fixed effects model can be written as:

$$Y_{it} = \alpha + \beta X_{it} + \mu_i + \epsilon_{it}$$

Where  $Y_{it}$  was the educational outcome for individual  $i$  at school year  $t$ ,  $X_{it}$  was the family complexity measure that varies over time and across individuals,  $\mu_i$  represented the unobserved individual-specific fixed effect, and  $\epsilon_{it}$  was the error term.

We estimated separate models for each of the family complexity measures introduced, without adjusting for time-varying covariates, in order to capture the unadjusted (or "raw") associations between complexity and educational outcomes. We deliberately refrained from including time-varying controls to avoid over-specifying the models and to ensure that the full effect of the complexity measures is observed. Controlling for such variables could potentially obscure meaningful variation, especially if they mediated rather than confounded the relationship between family complexity and educational performance. In additional analyses, we also estimate our models separately by parents' and children's gender to capture potential heterogeneous effects.

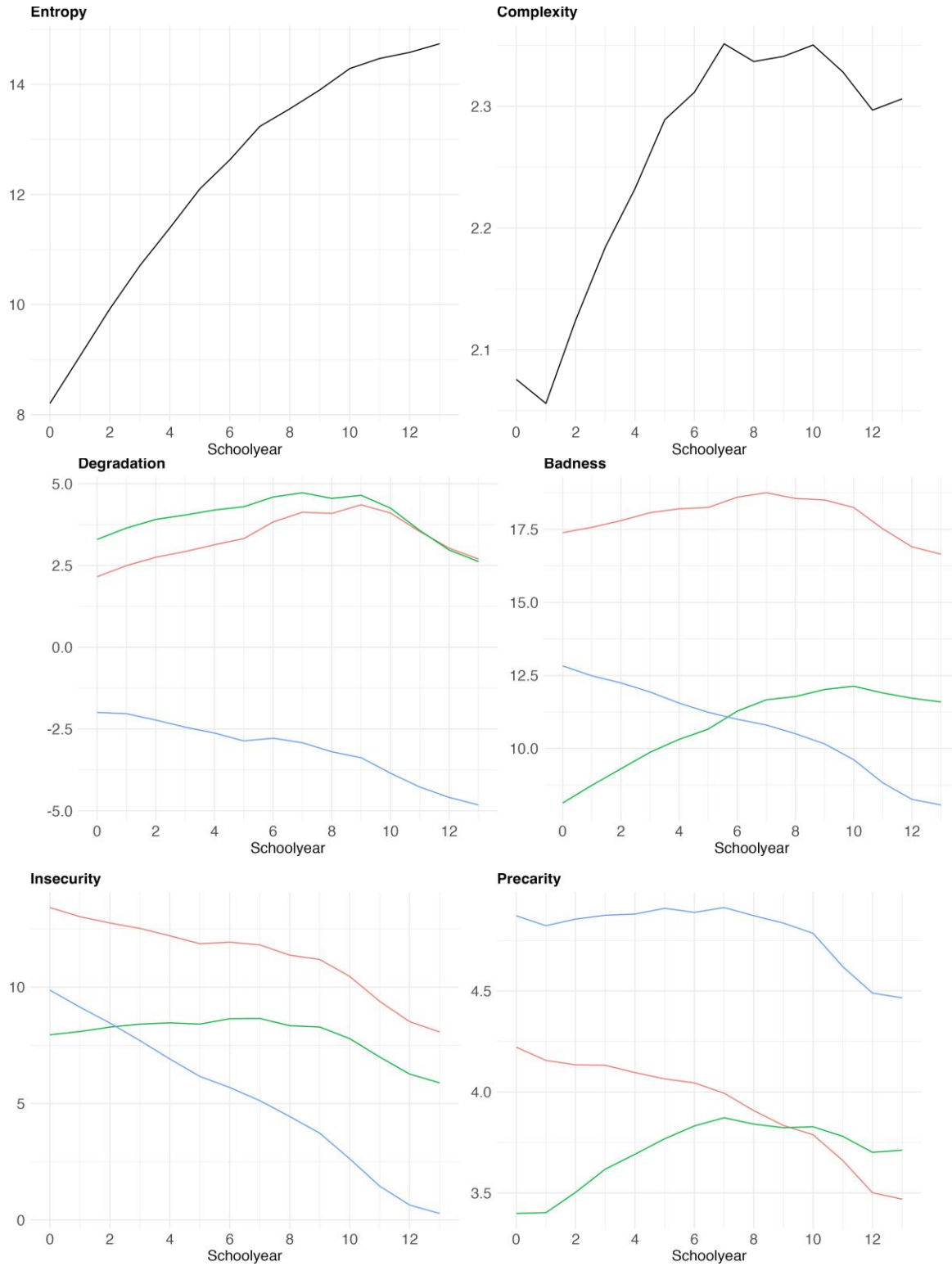
## 6 Results

### 6.1 Descriptive evidence

First, we briefly described how family complexity, measured based on mothers' partnership life, evolved over children's school age on average (Figure 1).

*Uncertainty* and *complexity* increased strongly from school years 2-5 of children (Figure 1, top panel). While *uncertainty* continued to increase, its growth rate declined over time, with only a slight rise during school years 10–12 (Figure 1, top left panel). In contrast, *complexity* stabilized by school year 7 and gradually declines thereafter (Figure 1, top right panel).

**Figure 1: Average family complexity measures over school years for mothers.**



Perspective — A: Favourable Family States — B: Level of Disruption — C: Parental Absence

Note: Values multiplied by 100.

The center and bottom panel of Figure 1 reveal how family complexity evolves over children's school careers considering the degree of disadvantage from different family states and transitions. For the *weighted number of transitions* and the *sum of disadvantages*, patterns differed partly depending on the theoretical perspective applied (Figure 1, center panel). Adopting the favorable family states perspective (A), we observed a slight increase in family complexity from school start until school years 7-9, before it started to decrease for both indices. However, the dynamic changed significantly when parental absences (C) were identified as the most disadvantageous factor. For both indices, family complexity decreased across school years at similar rates. When weighed by the level of disruption (B), complexity increased until years 7-10 for both indices, followed by a subsequent decrease that is more pronounced for the degradation index. When the *weighted number of transitions* (degradation) was considered, the level of disruption (B) perspective resulted in the highest levels of complexity. In contrast, the favorable family states (A) perspective reached the highest complexity for the *sum of disadvantage* (badness) index. This demonstrates that the interaction between different facets of complexity and different theoretically derived disadvantages can lead to markedly different complexity dynamics over time.

The patterns identified by our two most holistic measures, which incorporated all three facets of family complexity (uncertainty of family life, count of transitions, level of disadvantage), exhibited slight discrepancies when compared to those presented above (Figure 1, bottom panel). In contrast to the other two desirability measures, family complexity decreased over all school years when considering the favorability of family states (perspective A). With regard to the level of disruption perspective (B), *weighted complexity II* (insecurity) exhibited a relatively stable trend until it began to decline from school year 9 onwards. However, *weighted complexity I* (precarity)

increased slightly until year 7. Family complexity as measured by *weighted complexity I* was highest when based on parental absence (C) when across all school years, despite a decrease over time. Applying the parental absence (C) perspective with *weighted complexity II* resulted in lower complexity levels compared to the other two theoretical perspectives and a steeper decrease over time.

In conclusion, the findings indicate that the dynamics of family complexity during children's school years vary considerably depending on the different statistical measures and theoretical family perspectives employed. This underscores the necessity of employing a multi-faceted approach to avoid the limitations of relying on a single measure. The subsequent step involves testing the relationship between the measures and children's educational outcomes, thereby identifying the most fruitful theoretical perspectives for explaining the educational disparities observed among children based on their family lives.

## 6.2 Fixed effects

We investigated whether the observed changes in family complexity across childhood are linked to shifts in children's educational outcomes starting with measures based on mothers' partnership states. In line with existing evidence on negative consequences of family instability, we found mostly significant negative relationships of the various family complexity concepts with children's educational outcomes (Figure 1, Table A3). However, the significances and effect sizes varied overall across complexity concepts, educational underachievement and overachievement and subject.

For English, we found overall stronger effects on the likelihood of not performing above the expected standard (ES) in the key stage tests (right graphs in **Error! Reference source not found.**) compared to whether pupils reach ES in the first place (left graphs in **Error! Reference source not found.**). For example, a one standard deviation increase in the number of family transitions

decreased the probability of overperforming in English by 7 percentage points, while it increased the likelihood of not meeting the ES by only 3 percentage points (Table A3). The contrary was the case for math: family complexity prevented pupils stronger from meeting the ES in math than overperforming (i.e., reaching grades higher than the ES). The same pattern prevails when using father's family life courses to measure family complexity (Figure 3).

**Figure 2: Coefficient plots of complexity measures on English and Math outcomes of children based on the mother's family life course.**



Overall, the negative impact of the classical measure of family stability, i.e., the *number of transitions*, was the most robust finding across models (most often significant), even all heterogeneities considered (see also Figures 3 and A5-A8 and Tables A3 and A4 in the Appendix). However, two new measures, family *uncertainty* and the *sum of disadvantage*, were almost as robust and often matched the effect size of the *number of transitions*. For example, increases in the *number of transitions*, *uncertainty*, and the *sum of disadvantage* (here for all

theoretical perspectives) by one standard deviation increased the probability of not reaching the ES in Math roughly by 5 percentage points.

When it comes to the different theoretical perspectives applied, we did not observe strong differences across measures by theoretical perspective using mothers' partnership lives.

### **6.2.1 Heterogeneities**

Our findings indicated significant variation by both child and parent gender (Figures 3 and A5-A8, Tables A3 and A4). First, we found differences in the importance of different family complexity concepts and theoretical perspectives across children's gender. While the different theoretical family disadvantage perspectives did not matter much for overall results, results showed large differences by theoretical perspective across the gender of children when considering mother's family lives. For girls, objective measures of family stability (*number of transitions* and *uncertainty*) still had the strongest negative impact on educational outcomes, for example decreasing the probability of performing above expected standard in English by 8-9 percentage points (Figures A5 & A6, Table A3). However, for boys, the *sum of disadvantage* taking the parental absence perspective (C) had the strongest impact in terms of both effect sizes and quantity of significant effects. In fact, measures implementing the parental absence (C) perspective were exclusively negatively associated with educational outcomes for boys when considering their mothers' partnership lives. This indicates that, for girls, their educational performance does not seem to be affected by their mothers' life course developing in the direction of having no partner (parental absence perspective C). However, for boys, being alone with their mother has particularly negative educational implications for both subjects, especially strongly preventing them from performing above ES (Figures A5 & A6, Table A3).

Second, we observe differences across outcome heterogeneity by children’s gender. While increases in mothers’ family complexity decreased the likelihood of boys for both, reaching ES and performing above ES in English, it only decreased girls’ chances to achieve grades above ES in English, with stronger effects compared to boys (Figure A5). For math, boys and girls were similarly negatively affected by mothers’ family complexity for reaching ES (Figure A6, upper panel). However, while family complexity did not matter for girls' likelihood of overperforming, it reduced boys' chances to do so (Figure A6, lower panel).

**Figure 3 Coefficient plots of complexity measures on English and math outcomes of children based on the fathers family life course.**



Third, we observed markedly different patterns when examining fathers’ partnership histories as a measure of family complexity. Notably, the direction of the effects varied depending on the specific conceptualization of family complexity employed (see Figures 3, A7-A8, Table A4). A clear pattern among all models emerged: increases in objective complexity measures (*union dissolution, number*

*of transitions, entropy*) as well as *weighted complexity 2* tended to worsen children's education outcomes (higher likelihood of not reaching ES, lower likelihood of achieving higher grades than ES), while increases in most theoretically weighted measures led to positive educational performances.

The positive effects of fathers' family complexity were especially robust and high for measures that weighed parental absence (C) higher, indicating that children, especially girls, would rather benefit if their fathers have no partner. For example, an increase by one standard deviation in the *sum of disadvantage* applying the parental absence perspective based on fathers' family lives increases girls' probability to overperform in English by 16 percentage points (Table A4, model 6). This is striking given that not a single measure taking the parental absence perspective was significant for girls based on their mother's family lives. Furthermore, while only a very small number of the most complete complexity measures, *weighted complexity I* and *II*, were significant for mother's family life, they were about as often significant as other measures for fathers' family life, with *weighted complexity I*, taking the parental absence perspective (C), being most often significant.

## **7 Discussion**

In this study, we adopt a dynamic and holistic family life course complexity perspective to assess its consequences for children's educational outcomes. We build on Cavanagh's and Fomby's (2019) call to conceptualize and systematically test the impact of various measures of family complexity on the educational outcomes of children. To that end, we used linked UKHLS data to estimate the consequences of different measures of family life course complexity for children's maths and english test scores, applying sequence-based complexity measures to fixed effects regression models for the first time. The family complexity measures we develop incorporate multiple dimensions of family

complexity, as well as different theoretical perspectives on the degree of disadvantage associated with various family states. These measures capture the cumulative family complexity over the course of children's academic careers, drawing upon a range of theoretical concepts.

Using dynamic sequence analysis measures (Pelletier et al., 2020) allows us to measure how family complexity develops over children's childhood. The description of the distinct concepts of complexity reveals that average family complexity dynamics differ significantly across i) facets of complexity and ii) theoretical family perspectives on the disadvantage associated with different family states. This underscores that family complexity can manifest in varying degrees and exhibit contrasting trajectories (increase or decrease) over time, depending on the underlying measures or concepts employed. It highlights the need to expand the scope of measurements for family complexity, as previously proposed (Cavanagh & Fomby, 2019; Raley & Sweeney, 2020), and to conduct comprehensive testing of these measures in relation to children's outcomes. Thus, the second part of this study helps to ascertain whether the existing, relatively limited set of measures is adequate for capturing the most important relationships between children's family life and their outcomes.

Our results indicated that a majority of family complexity measures were negatively associated with children's academic performance, both in Math and English. While this was a very robust finding when measuring family complexity based on mothers' life courses, most effects of theory-weighted family complexity measures turned positive when using fathers' life courses. Thus, for some subgroups it might not only matter for the effect size which measure to use, but also for the direction of the effect. Furthermore, we find that family complexity more strongly prevents children to reach the expected standard in Math compared to English, while it more strongly prevents them

to overperforming in English.

Furthermore, consistent with prior research, we find substantial differences across subgroups. Notably, these heterogeneous effects vary considerably depending on the complexity measures applied, highlighting the potential bias introduced by measure selection. Measures that integrate levels of disadvantage associated with specific family states and theoretical perspectives show greater variability in relevance across subgroups and outcomes (e.g., boys vs. girls, mothers vs. fathers). In contrast, conventional family stability indicators—such as the number of transitions or overall family uncertainty—tend to exhibit more general associations and are less sensitive to subgroup heterogeneity.

Our findings suggest that measures aligned with the parental absence perspective are more strongly associated with boys' academic performance, while girls' outcomes appear to be more affected by broader patterns of family disruption—though this pattern emerges primarily when mothers' partnership histories are considered. When complexity is assessed based on fathers' family lives, parental absence proves equally relevant for both boys and girls. Thus, boys' educational performance suffers if there is a lack of a (male) partner of the mother, while both girls and boys rather benefit if the father has not partner.

Across all models we found that the *number of transitions*, the classic measure for family stability, most often measured a significant impact on children's educational performance, followed by the new concepts *uncertainty* and the *sum of disadvantage* (taking the parental absence perspective). Effect sizes were most often largest for *number of transitions*, but often also for more granular measures such as the *sum of disadvantage* and those measures given most weight to the parental absence perspective. The *sum of disadvantage* is also the only measure that puts

more weight on the most recently experienced family states, which might be an explanation for its strong performance, suggesting a benefit of applying such measures in Fixed-Effects designs. The most complete measures combining the number of transitions, uncertainty, and partly also the level of disadvantage (*complexity, weighted complexity I and II*) showed overall most often insignificant effects. However, this differed again across heterogeneities, most importantly across the gender of the parent. Thus, when it comes to how to measure family complexity based on *mother's* life courses it seems to be more relevant to focus on certain aspects of complexity than mingling many different ones into single measures, whereas for disentangling the effect of fathers' family lives, considering a larger range of measure might be meaningful.

We conclude that while overall stability measures, such as the *number of transitions*, seem to apply broadly and capture most relations to children's educational performance, measures that consider different family structures should be considered at least additional to better understand heterogeneities in the consequences of family lives on children's well-being. Otherwise, important effect heterogeneities or even reverse effects might be concealed. Especially measures that cover single or few complexity concepts and can consider different theoretical perspectives (*sum of disadvantage, weighted transitions*) can help measuring how distinct definitions of cumulative family (dis)advantage relate to children's outcomes across subgroups differently.

Our study has several limitations, which may also highlight important avenues of future research. Due to data constraints, we had to rely on four time points for children's outcomes throughout their school trajectories. However, research has shown that family stability is of greater importance during preschool compared to later ages (see Cavanagh and Fomby, 2019). Thus, future research would benefit from testing the measurements developed in this study to children's outcomes at younger

ages. Additionally, to measure family complexity, we focused solely on the partnership states of mothers and fathers due to data feasibility constraints. However, there is a need to consider more dimensions of family complexity, such as fertility, household size (e.g., number and type of siblings, grandparents), or residential moves (Cavanagh & Fomby, 2019; Raley & Sweeney, 2020). These family dimensions and states could easily be incorporated into the family complexity measures introduced here and explored in future research. This is especially important for further integrating the family structure perspective into the family complexity measures we develop, as family structure is often measured solely on parents' partnership states and the household structure of children (Brown et al., 2015; Jarvis et al., 2021). Furthermore, other aspects of family life may also influence children's outcomes, but were not included in our analysis. First, the quality of relationships between family members may matter and mediate the impact of family structure and stability (Wagner et al., 2024). Second, the level of conflict within the family, especially between parents, is likely to be important for children's well-being as well. Lastly, a common limitation of holistic measures of family stability is that their interpretations can be challenging. Additionally, deriving concrete social policy implications can be difficult since the specific family features driving the complexity remain obscured. However, we aim to turn this limitation into a strength by considering various theoretically derived measures. Future research could go even further by decomposing these measures into their individual components. Moreover, by conceptually linking distinct theoretical streams and facets of complexity with different measures, a substantive and socially relevant interpretation becomes more feasible.

Our conceptual measures of family complexity, along with the empirical implementation of different theoretical family perspectives along the lines of family structure and family stability, are

easily transferable to other outcomes and research questions. They can also be adapted and extended to other theoretical perspectives, family states, and contexts. Most importantly, given the pronounced heterogeneities revealed across both children's and parents' gender, future research should engage more deeply with these findings. More broadly, prior research has documented various other dimensions of heterogeneity, including race and socioeconomic background. Applying our family complexity measures to these dimensions may contribute to a better understanding of the mechanisms underlying persistent social inequalities.

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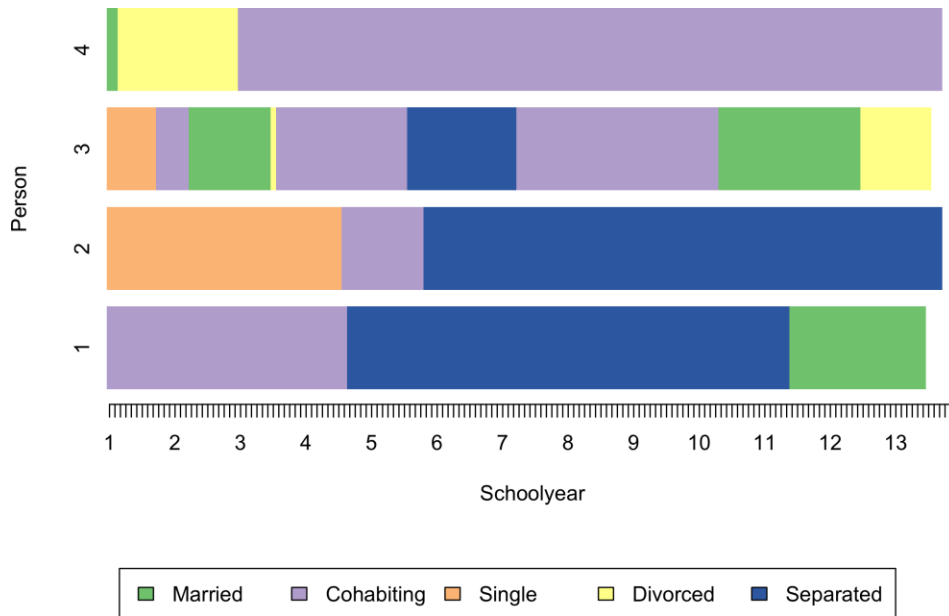
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## Appendix

### A1 Description of complexity measures

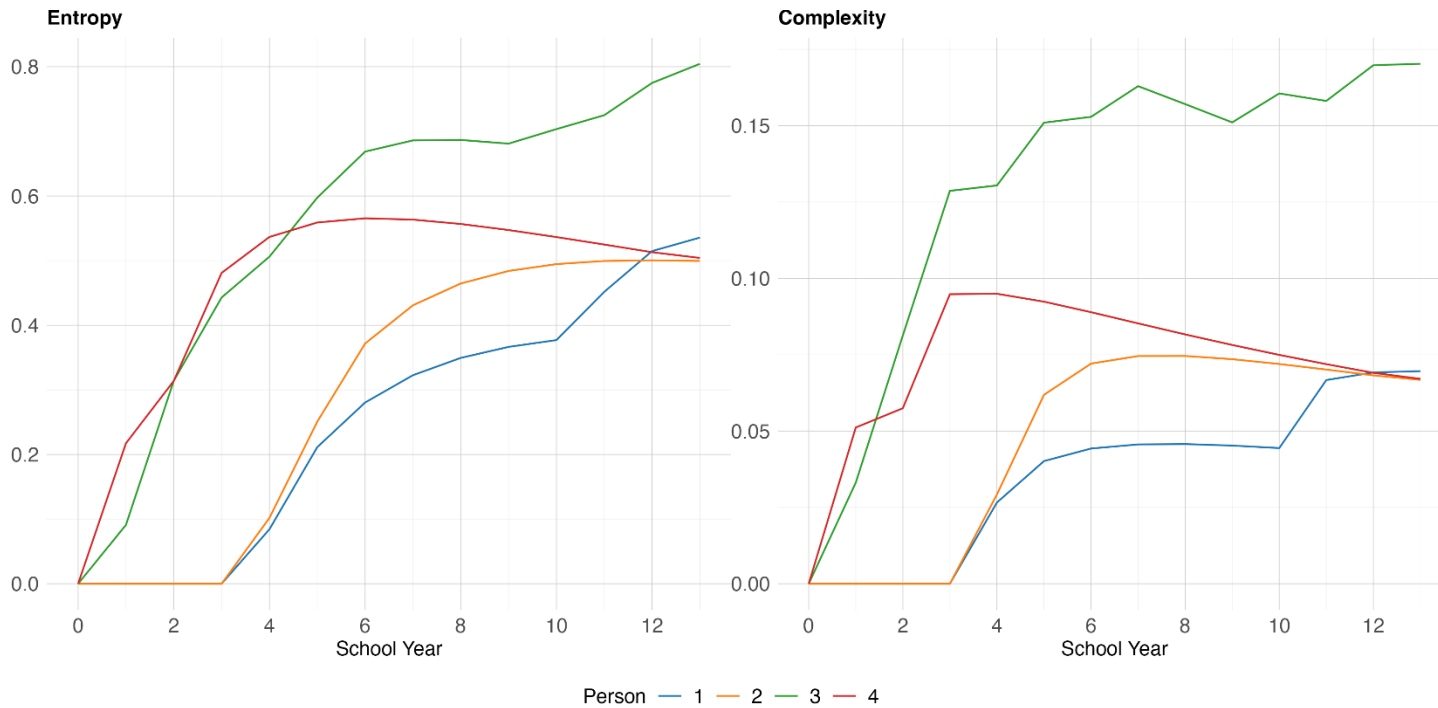
**Figure A1: Sequence example trajectories of 4 children (based on their mother's partnership states)**



We describe the complexity and undesirability indices based on example trajectories for four children from our data in the Appendix (Figure A1). Figure A2 show how family entropy and complexity behave over time for the four different children. Entropy is 0 until after school year 3 for children 1 and 2 because they experience only one state (cohabiting or single) until the end of school year 3 (Figure A2, right panel). Entropy reaches its maximum (1) if each state is experienced for the same fraction of time. In our example, it is highest for child 3 who experiences all five distinct family states that are also distributed relatively equal. Entropy decreases, i.e., life courses become more predictable, if the share of one life course state becomes much more frequent compared to the others, for example for children 2 and 4 after school years 3 and 4 (Figure A1).

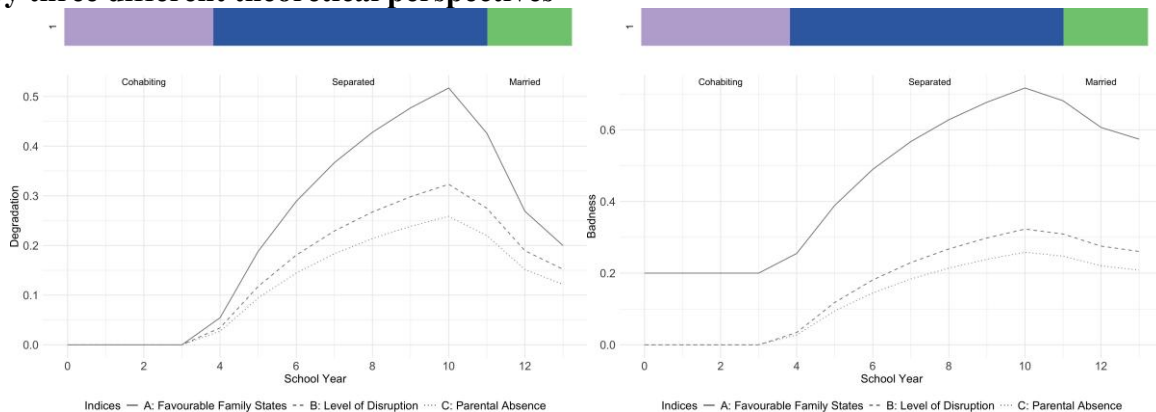
Figure A2 demonstrates that child 3 exhibits the highest sequence *complexity* (left panel). Compared to pure uncertainty (entropy) family complexity is much higher and grows steeper for child 3 compared to the other individuals. This is because child 3 not only encounters the highest number of different states but also experiences by far the most transitions between states (see Figure 1). Since the latter component is not captured by pure uncertainty, family complexity growth is steeper compared to entropy for child 3 and is relatively higher for child 3 compared to the other children.

**Figure A2: Family uncertainty (left) and complexity (right) for four examples**



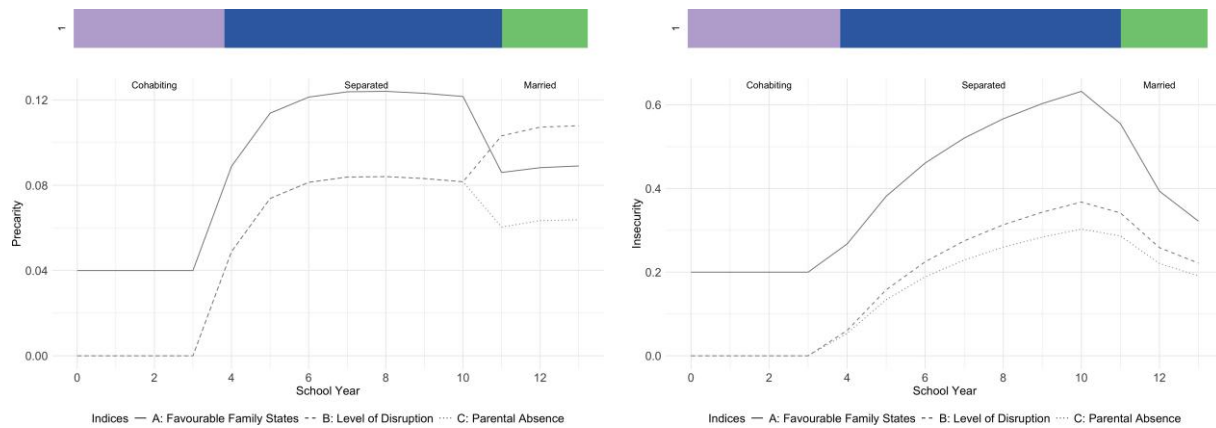
Figures A4 and A5 show for each undesirability index how it behaves over time across the three perspectives for the school career of child 1. Comparing Figures 3 and 4 highlights the different nuances of family complexity that the degradation and badness indicators emphasize. First, for Perspective A (favourable family states), the 'badness' score is 0.2 for the first three years, as it reflects the summation of disadvantage degrees, with cohabitation being assigned a low level of disadvantage in this perspective. The 'degradation' score remains 0 during this period because no transitions occur before the third school year. On the other hand, for family perspectives B and C, both the 'badness' and 'degradation' scores remain at 0 for the same time frame, as we have assigned a disadvantage weight of 0 to cohabitation in these scenarios.

**Figure A3. Weighted number of transitions (left) and sum of disadvantage (right) for person 1 by three different theoretical perspectives**



For the example trajectory, the precarity index reaches the maximum family complexity earlier compared to all other indices across all three theoretical perspectives (at school year seven) and the growth of complexity is steeper between school years three and seven (Figure A5). During stable periods of family states (i.e., in periods where no transitions happen), independently of the degree of disadvantage, it also stabilises much quicker compared to any of the other measures. It is thus more sensitive to changes in the life course pattern than the other measures. The dynamic of the insecurity measure over the school years is smoother than that one of the precarity measure and resembles the one of the degradation index most (Figure A6).

**Figure A4. Weighted complexity I (left) and weighted complexity II (right) for person 1 by three different theoretical perspectives**



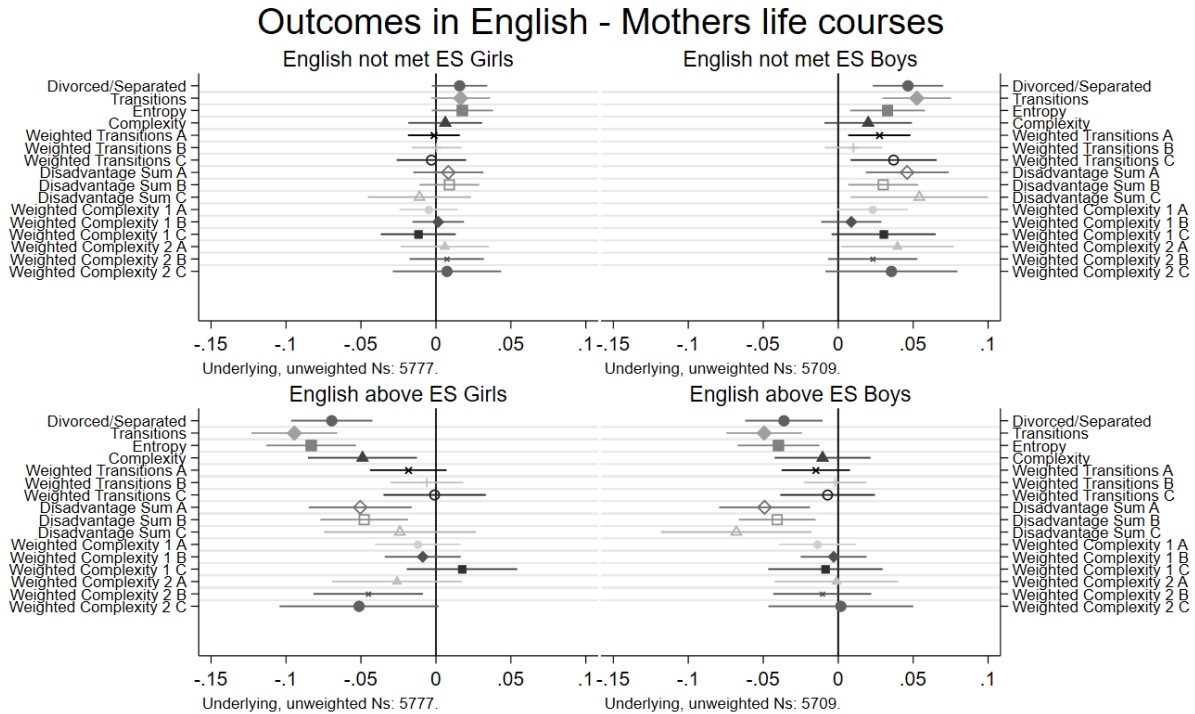
### Precarity

Three parameters have to be adjusted for the precarity parameter. We follow the suggestions of Ritschard (2021) and apply .2 for  $\lambda$ , 1 for  $\alpha$  and 1.2 for  $\beta$ .

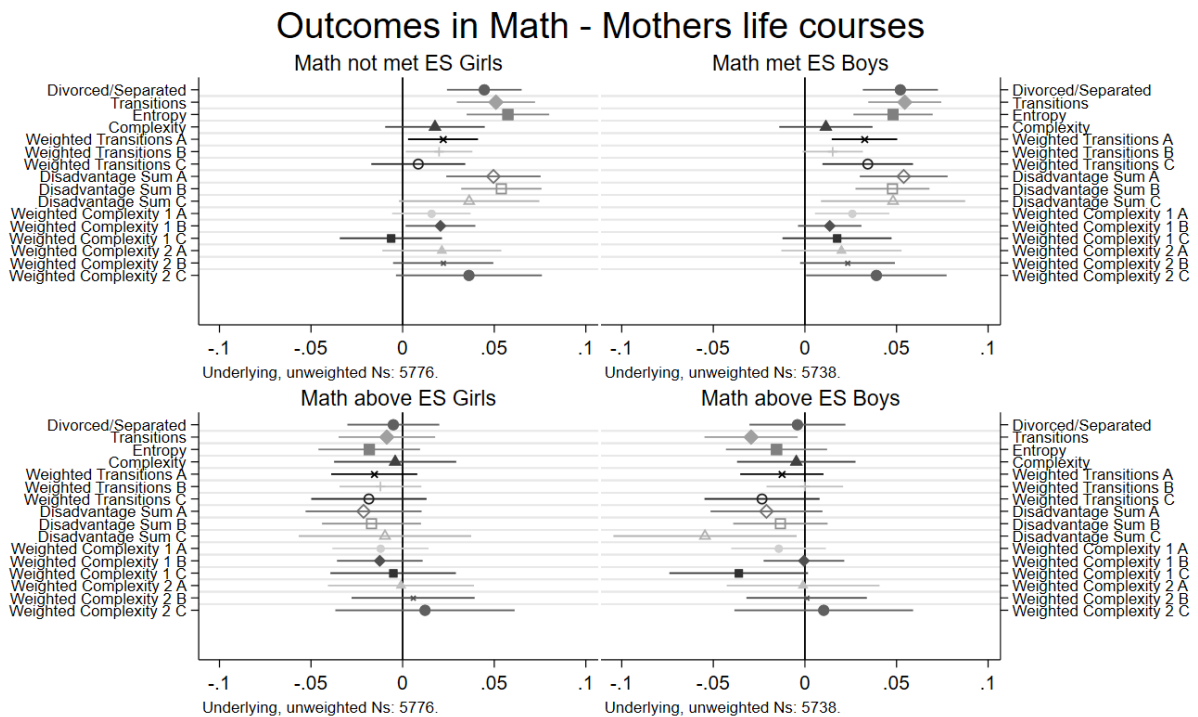
- $\lambda$  sets the relation of the precarity degree of the starting state.
- We set  $\lambda$  as 0.2 which means that 20% is assigned to the starting state and 80%.
- Assigning a sufficient weight to the precarity of the starting state considers the evidence of the family type perspective that the starting point of transitions matter (Lee & McLanahan, 2015).

## A2. Results for heterogeneities

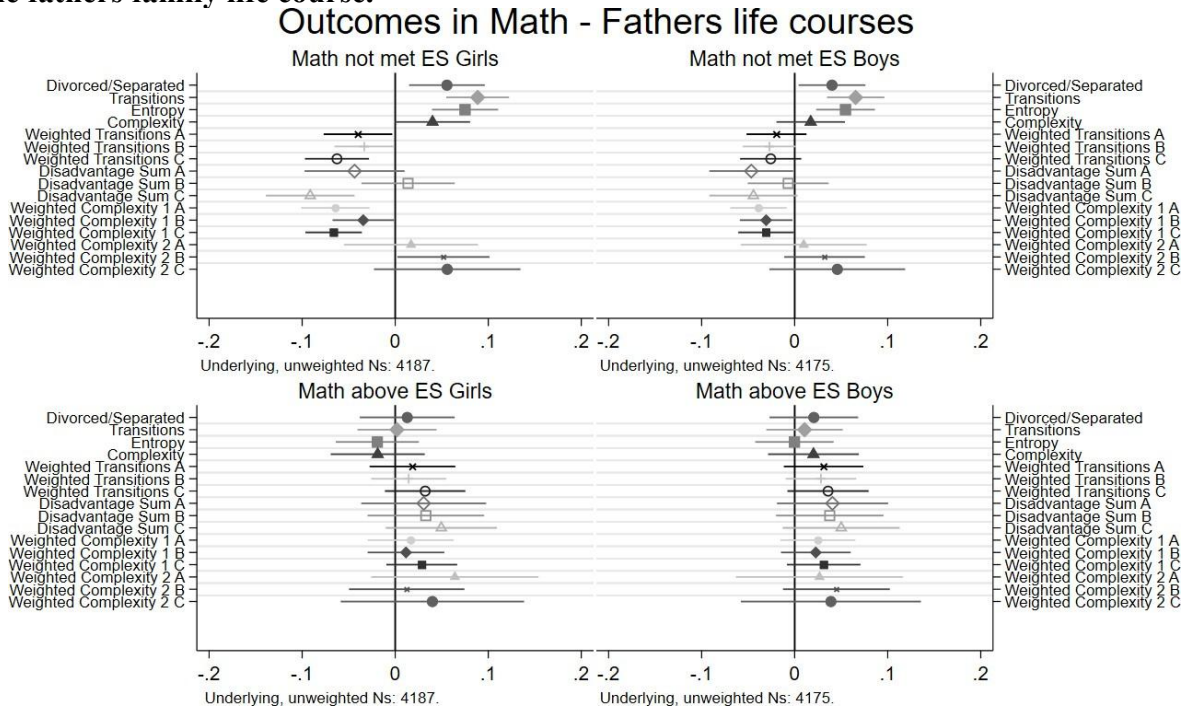
**Figure A5 Coefficient plots of complexity measures on English outcomes by gender based on the mothers family life course.**



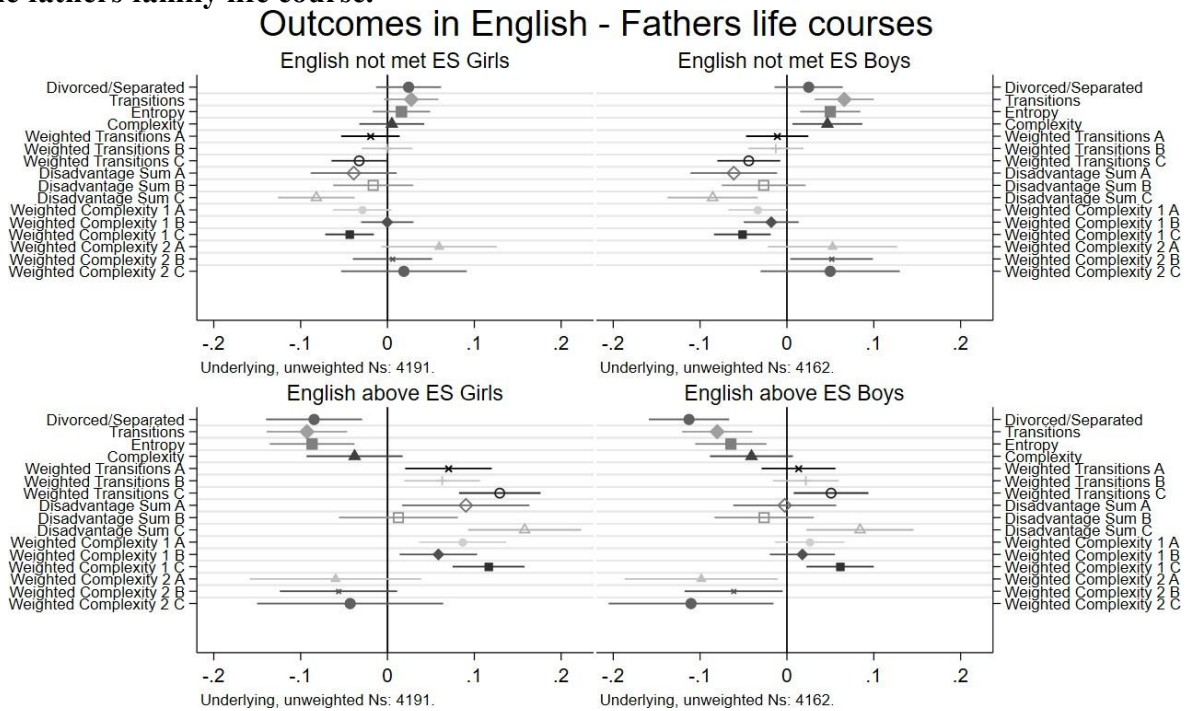
**Figure A6: Coefficient plots of complexity measures on Math outcomes by gender based on the mothers family life course.**



**Figure A7: Coefficient plots of complexity measures on Math outcomes by gender based on the fathers family life course.**



**Figure A8: Coefficient plots of complexity measures on Math outcomes by gender based on the fathers family life course.**



### A3. Additional tables

**Table A1. Overview of Key Stages tests in English and Math, School Years and Age of Children**

Key Stage	School Year	Age of Children	Below Standard	Expected Standard	Above Standard
1	1	5–6	1	2C, 2B, 2A	3, 4
2	6	10–11	1,2,3	4	5,6
3	9	13–14	1,2,3,4	5,6	7,8
4	11	15–16	D, E, F, G	C, B	A*, A
5	12	16–17	-	-	-

**Table A2. Partnership Status and Spell Information**

<b>Partnership Status</b>	<b>Start of Spell</b>	<b>End of Spell</b>
<b>Single</b>	Age 16, if no partnership reported yet	Start of first partnership spell or last observed date
<b>Union</b>	Start of marriage, civil partnership, or cohabitation	End of marriage, civil partnership, cohabitation, or last observed date
<b>Divorced</b>	End of marriage or civil partnership through divorce	Start of any subsequent partnership spell or last observed date
<b>Widowed</b>	End of marriage or civil partnership through widowhood	
<b>Separated</b>	End of cohabitation spell through break-up	
<b>Missing</b>	Start of a spell with missing start or end date, or period between partnership spells with unknown union dissolution	Start of any subsequent partnership spell or last observed date

**Table A3 Fixed Effects Regression Results for Mothers Family Life Courses**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	M-ENG1	M-ENG2	M-MAT1	M-MAT2	M-ENG-G1	M-ENG-G2	M-ENG-B1	M-ENG-B2	M-MAT-G1	M-MAT-G2	M-MAT-B1	M-MAT-B2
Union dissolution	0.0289*** (0.000)	-0.0531*** (0.000)	0.0478*** (0.000)	-0.00326 (0.724)	0.0158 (0.094)	-0.0695*** (0.000)	0.0466*** (0.000)	-0.0362** (0.006)	0.0446*** (0.000)	-0.00509 (0.690)	0.0521*** (0.000)	-0.00408 (0.760)
Number of transitions	0.0342*** (0.000)	-0.0713*** (0.000)	0.0523*** (0.000)	-0.0187* (0.045)	0.0165 (0.099)	-0.0944*** (0.000)	0.0524*** (0.000)	-0.0494*** (0.000)	0.0509*** (0.000)	-0.00864 (0.520)	0.0545*** (0.000)	-0.0294* (0.024)
Uncertainty	0.0245** (0.003)	-0.0617*** (0.000)	0.0525*** (0.000)	-0.0161 (0.107)	0.0176 (0.091)	-0.0832*** (0.000)	0.0329** (0.010)	-0.0399** (0.004)	0.0575*** (0.000)	-0.0182 (0.198)	0.0481*** (0.000)	-0.0155 (0.271)
Complexity	0.0131 (0.176)	-0.0290* (0.019)	0.0144 (0.128)	-0.00446 (0.706)	0.00623 (0.621)	-0.0490** (0.008)	0.0200 (0.179)	-0.0104 (0.523)	0.0176 (0.203)	-0.00409 (0.810)	0.0114 (0.378)	-0.00470 (0.776)
Weighted n of transitions A	0.0132 (0.053)	-0.0155 (0.073)	0.0271*** (0.000)	-0.0129 (0.121)	-0.00138 (0.876)	-0.0184 (0.158)	0.0274** (0.010)	-0.0150 (0.197)	0.0220* (0.024)	-0.0155 (0.196)	0.0325*** (0.000)	-0.0126 (0.278)
Weighted n of transitions B	0.00546 (0.392)	-0.00264 (0.745)	0.0171** (0.005)	-0.00430 (0.579)	0.000406 (0.961)	-0.00610 (0.622)	0.0102 (0.295)	-0.00198 (0.853)	0.0199* (0.032)	-0.0121 (0.287)	0.0152 (0.071)	-0.0000483 (0.996)
Weighted n of transitions C	0.0169 (0.070)	-0.00305 (0.797)	0.0214* (0.018)	-0.0200 (0.077)	-0.00303 (0.798)	-0.000875 (0.960)	0.0369* (0.012)	-0.00708 (0.660)	0.00853 (0.515)	-0.0184 (0.251)	0.0343** (0.006)	-0.0234 (0.144)
Sum of disadvantage A	0.0271** (0.003)	-0.0484*** (0.000)	0.0511*** (0.000)	-0.0190 (0.089)	0.00827 (0.487)	-0.0505** (0.004)	0.0460** (0.001)	-0.0491** (0.001)	0.0496*** (0.000)	-0.0213 (0.187)	0.0539*** (0.000)	-0.0210 (0.178)
Sum of disadvantage B	0.0191* (0.013)	-0.0423*** (0.000)	0.0498*** (0.000)	-0.0129 (0.174)	0.00895 (0.377)	-0.0478** (0.001)	0.0300* (0.012)	-0.0407** (0.002)	0.0539*** (0.000)	-0.0170 (0.218)	0.0478*** (0.000)	-0.0134 (0.309)
Sum of disadvantage C	0.0185 (0.196)	-0.0428* (0.019)	0.0415** (0.003)	-0.0287 (0.100)	-0.0110 (0.530)	-0.0241 (0.352)	0.0542* (0.020)	-0.0680** (0.008)	0.0363 (0.063)	-0.00965 (0.688)	0.0481* (0.017)	-0.0546* (0.032)
Weighted Complexity 1 A	0.00909 (0.238)	-0.0119 (0.224)	0.0205** (0.006)	-0.0121 (0.196)	-0.00493 (0.619)	-0.0121 (0.406)	0.0229 (0.056)	-0.0139 (0.291)	0.0157 (0.151)	-0.0121 (0.366)	0.0258* (0.013)	-0.0144 (0.275)
Weighted Complexity 1 B	0.00520 (0.437)	-0.00441 (0.604)	0.0166* (0.010)	-0.00472 (0.561)	0.00153 (0.862)	-0.00878 (0.498)	0.00873 (0.393)	-0.00302 (0.788)	0.0206* (0.033)	-0.0125 (0.295)	0.0136 (0.124)	-0.000537 (0.962)
Weighted Complexity 1 C	0.00689 (0.516)	0.00685 (0.611)	0.00443 (0.667)	-0.0185 (0.154)	-0.0118 (0.357)	0.0174 (0.355)	0.0303 (0.087)	-0.00856 (0.660)	-0.00640 (0.653)	-0.00519 (0.766)	0.0175 (0.249)	-0.0362 (0.061)
Weighted Complexity 2 A	0.0215 (0.074)	-0.0154 (0.314)	0.0205 (0.079)	-0.00229 (0.876)	0.00588 (0.695)	-0.0260 (0.241)	0.0395* (0.039)	-0.00116 (0.956)	0.0214 (0.197)	-0.000924 (0.964)	0.0199 (0.233)	-0.00100 (0.962)
Weighted Complexity 2 B	0.0139 (0.157)	-0.0275* (0.028)	0.0225* (0.018)	0.00396 (0.741)	0.00720 (0.570)	-0.0451* (0.015)	0.0230 (0.129)	-0.0106 (0.524)	0.0222 (0.112)	0.00570 (0.739)	0.0232 (0.078)	0.000942 (0.955)
Weighted Complexity 2 C	0.0185 (0.198)	-0.0256 (0.161)	0.0372** (0.008)	0.0124 (0.481)	0.00735 (0.690)	-0.0513 (0.058)	0.0355 (0.114)	0.00175 (0.943)	0.0362 (0.075)	0.0122 (0.625)	0.0390* (0.046)	0.0103 (0.680)
Constant	0.160*** (0.000)	0.284*** (0.000)	0.116*** (0.000)	0.304*** (0.000)	0.117*** (0.000)	0.331*** (0.000)	0.204*** (0.000)	0.232*** (0.000)	0.112*** (0.000)	0.288*** (0.000)	0.122*** (0.000)	0.316*** (0.000)
Observations	11598	11598	11623	11623	5777	5777	5709	5709	5776	5776	5738	5738

Notes: Standard errors in parentheses. All models estimated using fixed effects regression. Model abbreviations: M-ENG1: Not achieving the expected standard in English; M-ENG2: Achieving a level above the expected standard in English. M-MAT1: Not achieving the expected standard in Mathematics. M-MAT2: Achieving a level above the expected standard in Mathematics. M-ENG-G1 and M-ENG-G2: Same as above for English, for girls only (columns 5–6). M-ENG-B1 and M-ENG-B2 (columns 7–8): Same as above, for boys only. M-MAT-G1 and M-MAT-G2 (columns 9–10): Same as above, for girls only. M-MAT-B1 and M-MAT-B2 (columns 11–12): Same as above, for boys only.

\* p < 0.05, \*\* p < 0.01, \*\*\* p < 0.001.

**Table A4. Fixed Effects Regression Results for Fathers Family Life Courses**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	F-ENG1	F-ENG2	F-MAT1	F-MAT2	F-ENG-G1	F-ENG-G2	F-ENG-B1	F-ENG-B2	F-MAT-G1	F-MAT-G2	F-MAT-B1	F-MAT-B2
Union dissolution	0.0247 (0.073)	-0.0998*** (0.000)	0.0472*** (0.001)	0.0171 (0.336)	0.0243 (0.202)	-0.0845** (0.003)	0.0249 (0.213)	-0.113*** (0.000)	0.0556** (0.007)	0.0129 (0.619)	0.0401* (0.028)	0.0206 (0.396)
Number of transitions	0.0470*** (0.000)	-0.0846*** (0.000)	0.0757*** (0.000)	0.00714 (0.635)	0.0274 (0.087)	-0.0927*** (0.000)	0.0660*** (0.000)	-0.0803*** (0.000)	0.0886*** (0.000)	0.00190 (0.930)	0.0656*** (0.000)	0.0106 (0.612)
Uncertainty	0.0342** (0.005)	-0.0744*** (0.000)	0.0638*** (0.000)	-0.00984 (0.528)	0.0161 (0.340)	-0.0868*** (0.000)	0.0499** (0.005)	-0.0645** (0.002)	0.0751*** (0.000)	-0.0192 (0.400)	0.0547*** (0.001)	-0.000226 (0.992)
Complexity	0.0268 (0.054)	-0.0375* (0.043)	0.0279* (0.044)	0.00160 (0.929)	0.00502 (0.792)	-0.0379 (0.180)	0.0466* (0.023)	-0.0409 (0.093)	0.0401 (0.052)	-0.0188 (0.465)	0.0172 (0.358)	0.0202 (0.417)
Weighted n of transitions A	-0.0151 (0.226)	0.0408* (0.014)	-0.0288* (0.020)	0.0264 (0.100)	-0.0196 (0.254)	0.0702** (0.006)	-0.0112 (0.539)	0.0133 (0.538)	-0.0400* (0.033)	0.0185 (0.431)	-0.0195 (0.235)	0.0311 (0.153)
Weighted n of transitions B	-0.00698 (0.526)	0.0422** (0.004)	-0.0298** (0.006)	0.0227 (0.108)	-0.000543 (0.971)	0.0630** (0.005)	-0.0128 (0.431)	0.0218 (0.259)	-0.0332* (0.043)	0.0145 (0.481)	-0.0270 (0.065)	0.0283 (0.145)
Weighted n of transitions C	-0.0382** (0.002)	0.0909*** (0.000)	-0.0439*** (0.000)	0.0350* (0.026)	-0.0326* (0.045)	0.129*** (0.000)	-0.0440* (0.017)	0.0508* (0.020)	-0.0626*** (0.000)	0.0322 (0.144)	-0.0258 (0.125)	0.0358 (0.108)
Sum of disadvantage A	-0.0512** (0.004)	0.0404 (0.089)	-0.0452* (0.010)	0.0383 (0.093)	-0.0389 (0.123)	0.0902* (0.016)	-0.0612* (0.016)	-0.00258 (0.932)	-0.0437 (0.111)	0.0306 (0.372)	-0.0466* (0.043)	0.0407 (0.183)
Sum of disadvantage B	-0.0220 (0.194)	-0.00734 (0.745)	0.00239 (0.887)	0.0367 (0.091)	-0.0164 (0.485)	0.0126 (0.718)	-0.0267 (0.278)	-0.0263 (0.367)	0.0138 (0.588)	0.0329 (0.303)	-0.00696 (0.754)	0.0377 (0.201)
Sum of disadvantage C	-0.0836*** (0.000)	0.123*** (0.000)	-0.0685*** (0.000)	0.0506* (0.022)	-0.0819*** (0.000)	0.158*** (0.000)	-0.0855** (0.001)	0.0841** (0.008)	-0.0913*** (0.000)	0.0495 (0.104)	-0.0443 (0.067)	0.0500 (0.119)
Weighted Complexity 1 A	-0.0317** (0.009)	0.0533*** (0.001)	-0.0496*** (0.000)	0.0223 (0.151)	-0.0291 (0.092)	0.0864*** (0.001)	-0.0337 (0.050)	0.0262 (0.201)	-0.0643*** (0.001)	0.0166 (0.479)	-0.0389* (0.012)	0.0250 (0.223)
Weighted Complexity 1 B	-0.00987 (0.373)	0.0374* (0.011)	-0.0323** (0.003)	0.0186 (0.190)	-0.000254 (0.987)	0.0587** (0.010)	-0.0180 (0.263)	0.0178 (0.352)	-0.0344* (0.041)	0.0116 (0.581)	-0.0306* (0.033)	0.0227 (0.235)
Weighted Complexity 1 C	-0.0474*** (0.000)	0.0901*** (0.000)	-0.0488*** (0.000)	0.0304* (0.030)	-0.0437** (0.002)	0.116*** (0.000)	-0.0514** (0.002)	0.0613** (0.002)	-0.0662*** (0.000)	0.0286 (0.141)	-0.0308* (0.043)	0.0312 (0.122)
Weighted Complexity 2 A	0.0559* (0.027)	-0.0782* (0.020)	0.0133 (0.597)	0.0462 (0.155)	0.0595 (0.079)	-0.0598 (0.234)	0.0525 (0.167)	-0.0986* (0.028)	0.0170 (0.644)	0.0641 (0.163)	0.00976 (0.777)	0.0267 (0.560)
Weighted Complexity 2 B	0.0305 (0.068)	-0.0578** (0.009)	0.0409* (0.014)	0.0299 (0.164)	0.00572 (0.806)	-0.0564 (0.102)	0.0514* (0.034)	-0.0614* (0.033)	0.0518* (0.040)	0.0124 (0.695)	0.0321 (0.146)	0.0449 (0.125)
Weighted Complexity 2 C	0.0347 (0.205)	-0.0778* (0.033)	0.0505 (0.063)	0.0390 (0.269)	0.0189 (0.609)	-0.0430 (0.432)	0.0498 (0.223)	-0.110* (0.023)	0.0559 (0.164)	0.0400 (0.426)	0.0458 (0.218)	0.0389 (0.430)
Constant	0.158*** (0.000)	0.269*** (0.000)	0.132*** (0.000)	0.330*** (0.000)	0.124*** (0.000)	0.319*** (0.000)	0.194*** (0.000)	0.214*** (0.000)	0.133*** (0.000)	0.312*** (0.000)	0.133*** (0.000)	0.344*** (0.000)
Observations	8437	8437	8443	8443	4191	4191	4162	4162	4187	4187	4175	4175

Notes: Standard errors in parentheses. All models estimated using fixed effects regression. Model abbreviations: M-ENG1: Not achieving the expected standard in English; M-ENG2: Achieving a level above the expected standard in English. M-MAT1: Not achieving the expected standard in Mathematics. M-MAT2: Achieving a level above the expected standard in Mathematics. M-ENG-G1 and M-ENG-G2: Same as above for English, for girls only (columns 5–6). M-ENG-B1 and M-ENG-B2 (columns 7–8): Same as above, for boys only. M-MAT-G1 and M-MAT-G2 (columns 9–10): Same as above, for girls only. M-MAT-B1 and M-MAT-B2 (columns 11–12): Same as above, for boys only.

\* p < 0.05, \*\* p < 0.01, \*\*\* p < 0.00

