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Panel Data in Research on Mobility and Migration: A Review of Recent Advances*

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Abstract: Panel data has become the gold standard for causal assessments of complex human behaviour in quantitative social science. The objective of this review is to examine and discuss how panel data and related methods contribute to the identification of causal relationships in spatial mobility research. We illustrate this by providing a succinct overview of recent progress in spatial mobility research, drawing on panel data. The review outlines research from a number of scholarly disciplines that maps patterns, establishes determinants and assesses the impact of spatial mobility for a range of outcomes. Studies presented in this article are used to decipher complex interdependencies over the life course, scrutinise the selectivity of migrants, and shed light on the interplay between individual agency, social embeddedness and socio-structural contexts. The article concludes with a set of critical issues for future research.

Keywords: Panel data · Longitudinal methods · Residential mobility · Internal migration · Life course

1 Introduction

Spatial mobility is a major driving force underlying demographic and social change, and a fundamentally important experience for many people. In 2019, 272 million people (3.5 percent of the world's population) were international migrants living in a country other than their country of birth (*International Organization for Migration* 2019). Mobility within national borders is more common, but with significant variation

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across countries.[1] For instance, about 19 percent of the population in Iceland, around 9 percent in Germany, and roughly 3 percent in Spain changes residence each year (*Bell et al.* 2015). Changing the place of residence within countries, however, is becoming less common in many countries (*Bell/Charles-Edwards* 2013; *Champion et al.* 2017). Instead, recurrent mobility, such as commuting or circulating between multiple homes, is increasing with advances in transportation and communication technology, and with changes in the way work and families are organised (*Lück/Schneider* 2010). All of these types of spatial mobility can have a profound influence on individuals' wellbeing and life chances (*Aybek et al.* 2015).

Spatial mobility is studied by a multidisciplinary research community at the intersection of demography, economics, geography, psychology, sociology and other related disciplines. This community has made important advances in recent decades in our understanding of the patterns, determinants, and outcomes of spatial mobility. Many of these advances have been made possible through the increasing availability of panel data. This review aims to provide insights into the use of panel data and methods for the identification of causal relationships in spatial mobility research. This is illustrated through an overview of recent advances in selected research fields.

Panel data offers two key advantages for the study of spatial mobility through repeated observations of the same individuals. Firstly, panel data improves measurement. Observing individuals repeatedly is necessary if we are substantively interested in how changes occur within individuals, and to answer questions about long-term wage profiles of movers compared with non-movers. Importantly, panel data allows us to examine not only change but also persistence in mobility practices and immobility. Repeated observations are also necessary to track the various stages of the mobility process, from intentions and plans to the realisation of mobility (*Kley* 2011). Arguably, panel data is also superior in its accuracy of measuring mobility as prospective data collection is less likely to be subject to recall bias compared with retrospective data.

Secondly, panel data improves modelling. Repeated observations allow us to eliminate unobserved time-constant heterogeneity by analytically focusing on within-individual change. In addition, repeated observations allow us to longitudinally model individual-specific trajectories and other substantively relevant heterogeneity in multi-level models. However, panel data is not a panacea. Issues such as unobserved time-variant heterogeneity may still hinder causal inference based on panel data. These and other key advantages (and limitations) of panel data and methods are discussed in Section 2.

Building on these advantages, panel data has prompted major advances in spatial mobility research. Firstly, analyses of panel data enable the adoption of a temporal view on spatial mobility, which operationalises core concepts of the life course approach in empirical research, including individuals' practices, transitions,

[1] *Bell* and *Charles-Edwards* (2013) estimate that in 2005, about 12 percent of the world's population was living in its origin country but outside the region of birth.

and trajectories. This acknowledged the diversification and flexibility of individuals' lives, moving away from outdated life cycle views of spatial mobility. Diverse patterns of spatial mobility, repeated mobility practices and complex interdependencies with central life domains have thus become traceable. Secondly, analyses of panel data shed more light on inequalities and differences observed between movers and non-movers over time. In this context, the selectivity of mobile and migrant populations is not only a methodological issue to address when assessing the impacts of spatial mobility, but is also a central feature of the migration process itself that deserves further scrutiny. Thirdly, panel data with multi-actor designs (e.g. gathering information from several household members) deepens our knowledge as regards the relational dimension of spatial mobility, thereby acknowledging power relations and social resources from interpersonal relationships and the embeddedness in larger communities. Fourthly, panel data enables us to establish micro-macro links and address the interplay between individual agency and socio-structural conditions. These are the main themes around which our review of selected literature in Section 3 is organised.

We use the general term *spatial mobility* to refer to movements in geographic space that either involve a change of primary place of residence and place of daily activity or that are circular with a fixed primary (or several habitual) address(es), e.g. commuting (*Aybek et al*. 2015). Changes in place of residence can be across national borders (international migration) or within borders (internal migration, residential relocation). The latter type of mobility is most often covered in panel data. We include commuting and circular mobility around multiple homes as alternatives to relocation, but our working definition of spatial mobility does not include temporary, one-off mobility, such as travel for leisure, and daily routine mobility, such as shopping.

Because the research area of spatial mobility is so vast, we necessarily have to limit ourselves in what we cover in this review. From our search of literature conducted on major databases,[2] we selected sets of topics and studies to exemplify the use of panel data in solving analytical problems and addressing new research questions. We only considered studies using panel data (including survey and register sources) which allow us to observe individuals before and after a move, or variation in recurrent mobility practices over time. This means that we excluded other important areas of research, such as those which followed immigrants after their migration over time. Notably, this excluded the bulk of studies on integration of migrants using panel data, which has become more relevant in recent decades.

[2] We conducted a literature search between March and June 2020 on Scopus and Google Scholar using the search terms "(panel | longitudinal | register) & (migration | mobility | move | residential)". We also searched the databases of the British Household Panel Survey (BHPS), Household, Income and Labour Dynamics in Australia (HILDA) Survey, Understanding Society – The UK Household Longitudinal Study (UKHLS), Panel Study of Income Dynamics (PSID), and the Socio-Economic Panel (SOEP) Study. We added further studies that we considered relevant but which were not covered by the search terms. The full database resulting from our literature search can be accessed at https://osf.io/nzbj8/.

Also note that although we covered studies from all over the world, relevant panel data is collected more often in developed countries.

2 Panel data in spatial mobility research

Panel data has become the gold standard for causal assessments of complex human behaviour in quantitative social science. There are several main advantages (and current issues) of panel data for *measuring* and *modelling* spatial mobility.

2.1 Measurement

A range of theories and conceptual frameworks of spatial mobility revolves around temporal processes, such as the dynamics of change among mobile populations, the dynamics of stability and persistence in place, and sequential processes of mobility decision-making. In the absence of longitudinal data, none of these processes can be empirically examined to an adequate extent. Compared with cross-sectional data, longitudinal measurement is also advantageous because it enables us to establish the time order of cause and effect, e.g. to address whether it is moving to a certain place (in the event of migration) or in being a migrant (thus a person with certain characteristics) that better explains employment outcomes.

Panel data presents several advantages over other sources of longitudinal data in terms of measurement quality, although researchers should also be aware of some problematic issues. Firstly, the longitudinal analysis of spatial mobility that is based on retrospective information collected as part of cross-sectional data designs is susceptible to left truncation bias (i.e. bias from omitting those who have previously moved), as samples are extracted from surviving populations that have not moved away from the study context at the time of data collection. With panel data, truncation bias in spatial mobility studies is minimised as the prospective design enables mobile individuals to be followed over time. However, left censoring, where the event of interest occurs before the observation period, can still be an issue.

The researcher should be aware, however, that prospective data collections are affected by attrition (i.e. the drop-out after a realised interview with unit non-response), which can lead to misleading results when respondents who drop out of the panel systematically differ from those who stay in the panel (*Frees* 2004: 11). Mobility (and even more so migration) increases the chances of attrition, partly because it is difficult to follow households if they change addresses. While prior research on spatial mobility finds little evidence that substantial conclusions are distorted by selective attrition (*Washbrook et al.* 2014), it is important that researchers think carefully about the potential implications of selective attrition for their research questions and adjust their empirical strategy accordingly.

Secondly, reports of spatial mobility practices and events are less likely to be subject to recall bias in panel data collections, particularly when time intervals between interviews are short. Recall bias in retrospective migration histories can be particularly harmful when it comes to events that occurred far in the past; that were

not paired with other salient life events (e.g. marriage, childbirth, or job change); for local moves; and for shorter residential episodes (*Smith*/*Thomas* 2003). Even with panel data, however, recall bias may occur, e.g. when respondents report events more than once. Also, the granularity of data on spatial mobility in extant panel data collections is limited. Since most panel data is not specifically designed for the study of spatial mobility (see Section 2.3), measurements are typically restricted to one change of residence since the last interview, and ignore repeated mobility between interviews. Since it is often the case that only annual data is collected, it is not always possible to clearly establish the time order of events such as mobility and their outcomes within a given yearly interval.

Thirdly, information that is collected retrospectively may be contaminated by more recent experiences, such as the outcomes of spatial mobility or immobility – what is also known as post-hoc rationalisation bias. This type of bias is particularly pernicious for subjective measures such as intentions, motivations, or attitudes, and should not be asked in reference to the past, particularly the distant past. While spatial mobility (and in particular subjective evaluations) is preferably collected prospectively, the extent to which learning effects and panel conditioning (i.e. response patterns influenced by prior interviews) compromise measurement deserves more attention in panel survey analysis.

While the prospective measurement of spatial mobility within countries is very common, panel data on international migration – with observations of individuals before (at origin) and after (at destination) a move – is limited. This is because most panel surveys focus on the representative nature of a dynamic population within national borders and do not re-interview original respondents after emigration even if they are traceable, considering them as a population that is not eligible for interview. A prominent exception is the Mexican Family Life Survey (as well as certain other projects in developing countries), which has made large efforts to track and re-interview migrants to the United States. In the absence of large migration flows, such as the case of Mexico-US migration, the investment in following individuals might be too great in relation to the small number of migrants to study (*Liu et al.* 2016). In this case, retrospective studies linking individuals across origins and destinations are more cost-effective sources of longitudinal data for the study of the international migration process. Nevertheless, information in panel studies on migrant networks, resources (e.g. remittances), intentions to move (abroad), migration histories, or survey metadata indicating whether respondents emigrated are all useful in addressing questions relating to the migration process. In addition, panel data in the receiving countries could be complemented with information from (non-migrant) populations in the origin countries to help us understand the extent to which migrants' outcomes are driven by migrant selectivity (*Feliciano* 2020).

2.2 Modelling

Theoretical and conceptual models of spatial mobility highlight a multiplicity of stressors, self-selective processes, and complex and recursive associations with the correlates of spatial mobility. Given this, and in the absence of (quasi-)experimental

research designs, methods for the analysis of cross-sectional data may lead to biased and inconsistent estimates of the antecedents and consequences of spatial mobility since key model assumptions are unlikely to hold. For example, spatial mobility is an intermediary variable for many other life course processes, and omitting these processes might lead to a misestimation of the impact of spatial mobility. With panel data and its associated methods, it is possible to identify causal effects under weaker assumptions. In particular, the fixed effects (FE) estimator – and related estimators that exploit within-individual variation in panel data – eliminates all individual-specific (time-constant) unobserved heterogeneity, thereby relaxing some strong assumptions in regression models, such as there being no correlation between explanatory variables and the stochastic error term. (See *Brüderl/Ludwig* 2014) for features and assumptions of major panel data estimators.) Accordingly, the FE estimator has become very popular in research that estimates spatial mobility and associated outcomes, such as employment status, income, and subjective wellbeing (*Cooke et al.* 2009; *Nowok et al.* 2013; *Scheffel/Zhang* 2019). Despite their advantages, most within estimators still assume no time-varying unobserved heterogeneity, but this assumption arguably does not hold true in many situations (see below). Also, among estimators that only exploit within-individual variation (and compared to random effects estimators that exploit between-variation and within-variation) efficiency is reduced, and inference (which cannot be made beyond the groups in the sample) is compromised when studying processes or contexts where spatial mobility is rare. Methods such as hybrid panel models aim to overcome issues of efficiency and inference (*Allison* 2009), but these introduce new model assumptions.

The main argument for the use of within estimators is that spatial mobility is a self-selective process. Mobile populations are often younger, healthier, and more qualified than the general population. Panel data is particularly helpful because it contains information on the populations of origin and destination, which enable us to study the selective nature of spatial mobility, how it has an impact on individuals' outcomes, and whether it leads to structural changes in the populations of origin and destination (see e.g. *Brimblecombe et al.* 2000; *Norman et al.* 2005). The fact that mobile individuals are also selected on unobservables (or factors that are difficult to measure, such as ability, personal traits, or motivation) is problematic because it induces individual unobserved heterogeneity in spatial mobility models and limits the ability of researchers to obtain unbiased estimates.

Within estimators and instrumental variable approaches can be used to obtain unbiased estimates under the presence of self-selection on unobservables. They are, however, not without problems. On the one hand, finding a valid instrument can be cumbersome; on the other hand, within-estimator approaches rely on the parallel trend assumption, i.e. the expectation of similar temporal trends in outcomes for the mobile and the non-mobile populations in the absence of spatial mobility. To relax the parallel trend assumption, fixed effects models with individual slopes can be used, but have rarely been deployed in mobility research (*Kratz/Brüderl* 2013), in part because data requirements are high.

Questions about causal relationships in spatial mobility research also concern temporality, including the timing of events, individual change and stability over time. The timing of mobility in relation to its trigger events is often addressed with event history analysis, which accounts for censoring and truncation biases relating to incomplete information on events and their timings as they occur outside the study observation window (*Blossfeld et al.* 2016). Growth curve models can be used to examine variability in outcome change rates across mobile and immobile populations (*Curran et al.* 2010). Dynamic panel models include lagged panel variables to account for "true" state dependence, by which prior experiences influence current experiences to explain processes such as persistence in place or neighbourhood disadvantage (*Baltagi et al.* 2015). Despite their usefulness in modelling temporality, most of these models are not immune to individual unobserved heterogeneity and so researchers need to be aware of potential issues relating to omitted variables, sample selection, or measurement error. Additionally, complex time dependencies between spatial mobility and its triggers/outcomes have been proposed (see Section 3.1), by which the time order of events does not necessarily reflect the causal order and brings up the issue of reverse causality. Recent advances allow us to address these issues more convincingly with panel data (*Allison et al.* 2017; *Steele* 2008). For instance, cross-lagged panel models with fixed effects or extensions of the event-history model to the simultaneous analysis of multiple correlated processes enable individual unobserved heterogeneity to be controlled for and reciprocal causation to be assessed. These models require the observation of repeated outcomes per individual, however, and are not immune to time-varying unobserved heterogeneity.

Spatial mobility can be considered as a process that is wider than an event or practice observed at one discrete point in time. Adopting a holistic view to spatial mobility, trajectories consisting of multiple mobility events and immobility episodes have been examined using descriptive sequence analysis methods. Related studies established typical long-term mobility pathways, often in interplay with occupational and family trajectories (e.g. *Stovel/Bolan* 2004; *Vidal/Lutz* 2018; *Impicciatore/Panichella* 2019). With panel data, it is also possible to address more explanatory questions within holistic approaches, although these have not yet been considered in spatial mobility research. For example, researchers can use mixture hidden Markov models to predict transition probabilities between life stages in trajectories combining spatial mobility with events in employment, family and other life domains (*Helske et al.* 2018). Additionally, machine learning methods for variable selection, such as Boruta or LASSO, can be used to identify the most relevant properties (i.e. sequencing, timing and duration) of migration trajectories associated with a life outcome (*Bolano/Studer* 2020). Also, *Brüderl et al.* (2019) propose the triangulation of statistical tools, including descriptions of long-term trajectories and panel methods to shed light on underlying causal processes.

Many theoretical approaches highlight social relations and structural factors influencing spatial mobility behaviour and outcomes. Although panel data is largely used in empirical analyses informed by these approaches, a relatively small number of these applications use appropriate modelling strategies that deal

with heterogeneity at supra-individual levels. Multi-level modelling frameworks acknowledge complicated clusters of individuals in social relationships or structures, which enable us to explicitly address the influence of the spatial areas where individuals are nested in their mobility behaviour and outcomes. Dyadic models, a sub-type of multi-level models, have been used recently in the study of family migration in order to address the joint influence of couple members on mobility decisions and associated outcomes (see Section 3.2).

2.3 Types of panel data

There are increasing numbers of panel datasets which are regularly used for the study of spatial mobility. These data collections are diverse but rarely are they specifically designed to study spatial mobility. As a result, extant types of panel data display different strengths and limitations for the study of spatial mobility in relation to key aspects, such as sample size and attrition, length of observation, quality of measurement, or availability of key study variables to address intermediate or spurious relations.

Recent research often used *household panel surveys* such as the UK Household Longitudinal Study, the Socio-Economic Panel in Germany, or the Panel Study of Income Dynamics in the USA. These data collections follow nationally representative samples of households, where all (adult) household members have been interviewed on a regular basis (often annually). These data sources are particularly advantageous in that their multi-actor designs enable the collection of a wealth of information in a household context, and their broader target populations enable us to study heterogeneity in a society, in terms of age groups, mobile/non-mobile populations, etc. Many of these surveys follow individuals over long periods of time, even those that abandon or join original sample households. This not only helps to maintain the representativeness of the population in the sample but also enables the examination of a rich set of household dynamics, such as changes in family arrangements or the role of power relations within households for spatial mobility (see Section 3.2).

Cohort studies such as the UK Millennial cohort study, the German Family Panel, or the Survey of Health Ageing and Retirement in Europe (SHARE) follow individuals from a given cohort defined by age or an event such as birth, leaving school, or entering retirement. Since samples are drawn for homogeneous groups (cohorts), the data design already controls for a great deal of context heterogeneity and allows for better causal assessments than general population surveys. The ability to make inferences to other groups of society, however, is rather limited. Given the focus on the stages of childhood (and early adulthood), birth cohort studies have become particularly popular when studying the role of spatial mobility for childhood developmental processes and (later) outcomes (e.g. *Vidal/Baxter* 2018).

Rotating panel surveys such as the European Living Conditions Survey or the European Labour Force Survey follow different sets of individuals for shorter periods of time. For example, the longitudinal part of the Labour Force Survey interviews the same individuals in each quarter of a year, but only for six consecutive quarters.

This is advantageous as far as the quality of the responses is concerned. Panel conditioning is restricted here because respondents are less likely to grow tired or be susceptible to learning effects if they are not to be interviewed too many times. Furthermore, since samples are refreshed frequently so as to enable new participants to be followed, sample representativeness remains high as it is less likely to be affected by panel attrition. The obvious drawback is that individuals can only be followed for a short observation window which limits within-individual analyses.

Mobility-specific panel studies, such as Migration Decisions in the Course of Life in two German cities (*Huinink/Kley* 2011) or Job Mobilities and Family Lives in Europe (*Schneider et al.* 2011), are advantageous in that they collect more and very detailed measurements to analyse the migration process. In addition, these studies often over-sample mobile populations, which provides sufficient statistical power for analysis. Despite their advantages, mobility-focused studies generally contain fewer observations (in many cases only two) and some leave aside the non-mobile population, which limits options to exploit within-individual change.

The use of *longitudinal population registers* (often linked with data from other administrative registers, censuses or surveys) for research purposes is advantageous in that they enable (virtually) whole registered populations to be followed. This limits typical issues relating to the representativeness of the sample and allows us to focus on specific populations and mobility processes for which survey samples are not sufficiently large. The possibility of deepening the study associations is often limited by the restricted availability of key study variables to address intermediate or spurious relations, including the absence of subjective measures. To date, this type of data has only been used in a few countries where it is available for research purposes (mostly in Northern Europe) but other countries are starting to grant access. In Spain, access to the entire collection of social security records meant that the impact of inter-city migration on occupational achievement could be studied (*La Roca/Puga* 2017).

Less common is panel data deriving from *experimental designs*. Although the random assignment of treatments provides the best context for causal inference, such designs are costly and complex to set up for spatial mobility. An example of a randomised social experiment is the Moving to Opportunity (MTO) project that addresses impacts on life outcomes of sponsored moves to low-poverty areas for children in low-income families in five US American metropolitan areas (*Chetty et al.* 2016).

3 Advances in spatial mobility research using panel data: An overview

3.1 Micro-level perspectives on spatial mobility over the life course

One major advantage of panel data is its greater capacity to model complex human behaviour. Below, we illustrate how panel data has been instrumental to improving our knowledge of spatial mobility in relation to life course dynamics, decision-making processes, and labour market outcomes.

Pioneering longitudinal research with panel data has studied spatial mobility as discrete events, often using event history analysis or discrete choice models, and redirecting the attention from frequencies to the timing of moves. The comparison of results from (pooled) cross-sectional and longitudinal models using PSID data from the United States by *Davies* and *Pickles* (1985) and *Clark* (1992) acknowledges the adequacy of longitudinal data analyses to examine spatial mobility.[3] This adequacy stems from the ability to approach spatial mobility as a time-dependent process, and to include time-varying variables in the analysis to partly address issues of the right time order of events, and omitted variables in the analysis of cross-sectional data. Importantly, these papers recognise the contribution of the longitudinal analysis of panel data in moving from the evidence that is contingent in a particular period, based on life cycle views dominating prior micro-level research, to the *impacts* associated with change and transitions over the life course.

Over recent decades, research that has adopted a life course approach and longitudinal models has examined the proximate determinants of spatial mobility, often stemming from (expected) changes in occupational, family, and other relevant life domains – including in relation to social conditions (e.g. *Cooke et al*. 2016; *Clark/Lisowski* 2017; *Kulu et al.* 2021; *Melzer/Hinz* 2019; *Warner/Sharp* 2016). Even with panel data, establishing causal associations is often a daunting task given the concatenation of mobility events over short periods of time and the multiplicity of underlying time-varying stressors, particularly among young adults in the context of high diversity and the complexity of individuals' life courses. Capitalising on large panel data collections, recent research has deployed more sophisticated models that enable multiple, complex, and conditional life course events to be assessed in relation to spatial mobility.

For instance, *Pelikh* and *Kulu* (2018) used BHPS data and multi-state event history models to examine cohort and gender differences in series of short-distance and

[3] Although earlier research used panel data to assess aspects associated with mobility, these early studies did not adopt longitudinal methods and did not exploit the panel structure of the data. Using retrospective data, *Sandefur* and *Scott* (1981) were among the first to deploy longitudinal models and to pay more attention to the life course *triggers* of spatial mobility. They found that *time-varying* statuses in the family and work careers not only emerged as important predictors of intercounty and interstate mobility in the United States, but these statuses also largely explained the well-established inverse relationship between age and frequency of mobility from early to mid-adulthood.

long-distance moves among young adults from age 16. Their analytical approach extends the traditional event history model of a single event to assess several moves for the same individuals (i.e. first, second, and third/higher-order moves, also disaggregated by distance). This way, the authors do not assume homogeneity in the antecedents of initial and repeated moves over short and long distances. Results showed significant differences across cohorts, with more recent cohorts having a lower risk of first move and a higher risk of third move, which the authors attribute to increasing polarisation between movers and stayers. Group differences were not fully explained by typical family-related triggers (of short-distance moves) or employment-related triggers (of long-distance moves). However, the analytical design does not enable the authors to completely discard the fact that group differences can be due to omitted variables in the analysis.

With increasing recognition of interdependence across life course domains, empirical research has addressed complex time dynamics of spatial mobility before (in anticipation of) or after (as adaptations to) transitions in other life domains (*Clark*/*Withers* 2009). While temporal synchronicity suggests important interdependences across life course events, the direction of causality and the size of the effect remain unclear if the empirical strategy does not explicitly consider whether life events are endogenous or jointly determined.[4] Multi-level, multi-process modelling, which consists of simultaneous equations with correlated random terms, accounting for individual level unobserved heterogeneity that commonly affect spatial mobility and other life course processes, is increasingly applied to solve these issues (*Steele* 2008). Along these lines, *Kulu* and *Steele* (2013) use partnership and housing histories and annual measurements of key covariates between 1987 and 2000 from the Finnish Longitudinal Fertility Register to jointly estimate relocations among women to specific housing types (single-family house, terraced house, and apartment) and fertility progression (first, second, and third conceptions). Results showed a higher propensity to moving when a child is born, a higher likelihood of moving to single-family housing when the number of children increases, and an elevated level of fertility after residential mobility, particularly when moving to single-family housing. Results also revealed a substantive degree of correlation among equation-specific random terms, which indicates that long-term family plans and housing aspirations were closely related – with women who wished for a large family more prone to moving (several times) to achieve adequate or desired housing. Not accounting for the cross-process correlations would have led to bias on the causal effects, overstating the role of fertility for housing transitions and fertility differences by housing types (see also *Lersch* and *Vidal* (2014) for an application focusing on separation).

[4] Also, *Hoem* and *Nedoluzhko* (2016) warn that some practices of anticipatory analysis in spatial mobility research (e.g. using negative durations of independent variables, and other forms of conditioning on future outcomes) might produce biased estimates, and propose alternatives to adequately assess anticipation.

Further research has improved our understanding of spatial mobility in anticipation of *triggering* life events by examining spatial mobility behaviour as a function of reported intentions in other life domains. An example of this is the study by *Vidal/Huinink/Feldhaus* (2017) which uses data from the German Family Panel and event history models. This study finds that the intention to have a child in the near future impacts subsequent mobility, even though the direction of the effect varies depending on the life course phase. When intending to have a child, younger and childless individuals relocate at a lower rate while older individuals with children relocate at a higher rate. These associations are largely due to different opportunities and rationales for adjusting housing and other living conditions in anticipation of fertility behaviour. The authors also deploy multi-level multi-process modelling to show that results are consistent after accounting for unobserved factors that commonly determine fertility and spatial mobility decisions.

With regard to spatial mobility as an intentional behaviour, panel data – with observations of subjective evaluations before and after the behaviour – has been instrumental in unveiling the mechanisms underlying mobility desires, concrete plans, and ultimately behaviour. It has also helped to explain how life course experiences motivate voluntary and involuntary (im)mobility. *Kley* (2017) addresses the question as to why individuals who intend to leave their current town in the near future often do not realise their intention, and examine moving facilitators and constraints across different stages of the decision-making process. The analysis relies on a panel study conducted in two German cities that was designed around a three-step decision-making model consisting of pre-decisional (considerations), post-decisional (plans), and behavioural (realisation) stages (see *Kley* 2011). Results from several sets of (bivariate and seemingly unrelated) probit regressions show that the role of typical constraints (i.e. home ownership, place of work, and friendships in town) are significantly underestimated if the pre-decisional stage is not included in the analysis. *Kley* argues that those who are strongly rooted to their place of residence are not at risk of migrating because they do not consider migration a possibility. *Coulter* and *Scott* (2015) use data from the BHPS, one of the few panel studies that has collected annual information on desires to move and their associated motivations, to examine the reasons that trigger mobility desires and behaviour. Beyond the findings that such motivations vary over a life course, results from fixed effects models show that targeted motivations related to life course transitions, particularly employment, are better predictors of mobility than more diffuse or unspecific reasons (see also *Groot et al.* (2011) for the role of unanticipated life course events in terms of unintended mobility).

Studying the dynamics in employment and other outcomes where panel data is uniquely suited to tracing changes before and after migration has been a subject of interest. A common finding is that wage gains after migration are not instantaneous but delayed. For instance, *Lehmer* and *Ludsteck* (2011) use German employment register data to compare the wage changes for workers moving between places of work within regions and for those migrating between regions within a fixed effects regression framework. The study finds clear wage gains of migration beyond changing workplaces, which are established about three to

four years after migration. They use a fixed effects approach to estimating panel data in order to limit bias due to unaccounted heterogeneity that is constant across individuals and establishments. The authors discuss that the time-varying unobserved heterogeneity might have been less of a problem in their application because workers often have longer rather than shorter decision horizons. Similarly, *Rowe et al.* (2017), drawing on Australian panel data, find that movers from rural into metropolitan areas receive a delayed wage premium. It is noteworthy that the study uses sequence analysis to gain a better understanding of the employment pathways leading to these wage premiums and find that rural-metropolitan movers are more likely to experience rapid transitions into employment after school (and university). Their analytical strategy considered decomposing differences in wage distributions between migrants and stayers, using an extension of the Oaxaca-Blinder approach to quantile regression to account for unobserved features that explain wage differences across groups. Going beyond wages, *Perales* (2017) deploys fixed effects panel models on the same Australian dataset and finds long-term increases in job satisfaction (at least five years) after long-distance relocations with decreases before migration. Effects are less pronounced for job-related moves and quickly fade after job-related moves.

As referred to above, conventional fixed effects regression assumes parallel trends in outcome variables (*Brüderl/Ludwig* 2014), which is seldom acknowledged as a problem in applied research. *Kratz* and *Brüderl* (2013) use fixed effects models with individual slopes to examine the effect of internal migration (for job reasons) on wages in Germany, relaxing the parallel trend assumption. When comparing results from pooled Ordinary Least Squares (OLS), conventional fixed effects and fixed effects individual slope models, they find that conventional fixed effects models overestimate the effect of migration (almost 7 percent) compared with fixed effects individual slope models (about 3 percent), which indicates that migrants may be selected on wage growth. However, in this application, pooled OLS estimates are very similar to fixed effects individual slope estimates (see also *Jolly* (2015)).

A common concern in the study of labour market migration outcomes is selection. One type of selection is state dependence, where past labour market states determine current states. For example, previously unemployed individuals are more likely to become unemployed again (*Arulampalam et al.* 2000) and they may also be more likely to migrate. Panel data can help to address this problem but simplistic approaches may create more problems than they solve. For instance, it is common to include lagged dependent variables (e.g. *Cooke* 2003; *Blackburn* 2009, 2010). A naïve lagged dependent variable approach is problematic, however, because true and spurious state dependence cannot be separated. Furthermore, it is very likely that the typical assumption of no correlation between the stochastic error and the lagged dependent variable in the regression equation has been violated; if unobserved factors affected the lagged outcome, they are also likely to affect the current outcome.

Boyle et al. (2009) is one of the few studies which aim to adequately address the issue of state dependence by estimating dynamic panel models. They find that moving for men's jobs (but also moving for non-employment-related reasons)

diminishes women's subsequent employment in Britain. Without a dynamic panel model, the effect of state dependence is overstated but the overall conclusions remain unchanged. The estimation of dynamic panel models crucially rests on the inclusion of instrumental variables for the initial condition – in *Boyle et al.* (2009) one instrument is occupational gender diversity in the region – which comes with the usual problems of finding adequate instruments.

3.2 Linked lives

Spatial mobility does not occur in a social vacuum since mobility decisions and outcomes are influenced by and affect the lives of other individuals. Panel surveys that adopt multi-actor designs are particularly well-suited to examining relationships between household members and the underlying inequalities and power relations in terms of spatial mobility. In addition, the regular collection of information on wider social relations and resources in some panel studies has enabled the influence and impact of spatial mobility beyond the household to be studied.

The consequences of family migration, i.e. couples' long-distance relocations within national borders for women's labour market outcomes, have received considerable scholarly attention (*Vidal et al.* 2017). Here, household panel data helps to address individual unobserved heterogeneity while enabling us to study individuals within their household context. In a seminal study, *Cooke et al.* (2009) use PSID and BHPS in a fixed effects approach to study the changes in earnings for women related to family migration and also compare effect sizes for the consequences of childbirth. Differentiating current moves, the number of past moves, and the number of years since the last move (thereby allowing a study of changes over time), the study finds that the overall negative earning effects for women are smaller than those for childbirth in both countries. The negative effect of migration on women's earnings is more persistent in Britain. Using a comparative approach, *Lersch* (2014: 202ff) finds long-distance relocations reduce employment chances for women and men (only marginally statistically greater effect for women), but these effects are short-lived (only in the first year after migration). The negative effects for women are greater in England and West Germany compared with East Germany. This study shows that without accounting for individual-level heterogeneity using random effects migration effects for women are overestimated (4 percent vs 3 percent), while for men the estimated effects are similar in both model specifications.

Further studies suggest that parental status and childbearing transitions underlie gender inequalities in couple migration outcomes. For instance, studying the interrelatedness of parental status, migration, and labour market outcomes, *Cooke* (2001) finds that the negative effect of migration on married women's employment is mostly concentrated among mothers of young children in the United States. The author stresses that panel data and methods enable him to address changes before and after migration and parenthood, rather than to simply observe differences between migrants and non-migrants (see also related research in *Kley* and *Drobnič* 2019 and *Vidal et al.* 2016).

Household panel studies usually include interviews with all household members, thus allowing us to directly model the couple level, which is particularly relevant in the study of family migration. Against this backdrop, sophisticated models that exploit both temporal and multi-actor components of panel household data have been deployed to address the joint influence of couple members on mobility decisions and associated outcomes. Using a dyadic approach (actor-partner interdependence model) which also capitalises on the household panel structure, *Lersch* (2016) shows that in Britain, women with more egalitarian partners are less likely to leave employment after family migration. However, even adjusting for egalitarian gender ideology, family migration still has different outcomes among men and women. The model contains partner-specific random variables which are allowed to correlate to account for non-independence within couples and to limit bias due to couple-level heterogeneity.

Recently, dyadic models specific to residential mobility have been proposed. *Kern* and *Stein* (2018) put forward a dyadic modelling framework that specifies actor and partner effects on the mobility dispositions of each couple member, which in turn have an impact on joint couple mobility decisions. They empirically illustrate the model using a multi-level structural equation model set-up (also accounting for regional context heterogeneity) and SOEP geo-coded data. Results show strong similarities in couple members' conditional mobility disposition, and that couple members influence household moving behaviour through their partner's dispositions. This supports the notion of family migration as a by-product of couple bargaining. *Steele et al.* (2013) propose panel data models that acknowledge the influence of both partners in couple decisions and are flexible enough to address partnership dynamics, i.e. that individuals can change partners and incur periods of singlehood. Compared to previously used panel data models, the proposed new models were found to improve the residual structure of an application to residential mobility as they capture unaccounted partnership dynamics.[5] Although the authors find differences in estimated effects across models, these were not large enough to affect the substantive conclusions. We note that despite their usefulness, the level of sophistication and the high data requirements of these modelling approaches might hamper their wider application.

Although the number of panel studies following international migrants before and after migration is small, the consequences of migration for sending households can be examined in panel studies for countries with high emigration rates. Migration and mobility do not only affect those who are mobile, but also those left behind, and it is important to account for selectivity in migration. Most studies along these lines have deployed cross-sectional data, which does not enable us to assess whether study outcomes are due to differences between households (with members abroad or not), or changes before and after a member moved abroad that better reflect the

[5] These are "multiple-membership-consensus" models that include a weighted combination of the random effects for each partner, and a "head-of-household-joint" model that specifies distinct but correlated random terms for single and partnered individuals.

causal effect of migration. In this regard, novel collections of panel data in developing countries have been instrumental in obtaining more accurate estimates of the impact of emigration. For instance, in contrast to earlier cross-sectional analyses, *Acosta* (2020) finds no effects of remittances or international migration on labour supply in origin households when using fixed effects and controlling for agricultural income shocks as important sources of time-varying heterogeneity in rural areas of El Salvador for men. For women, remittances and migration increase their participation in agricultural activities while reducing non-agricultural and domestic labour, but the effect sizes are small (see also *Arouri* and *Nguyen* (2018) and also *Murard* (2020)). Using a similar analytical strategy, *Cuong* and *Linh* (2018) find that in Vietnam, remittances increase both household earnings and consumption and reduce poverty, while also reducing labour supply. The overall effect of migration on these outcomes is minor, most likely because migrants already contributed substantially to households' economic resources before migration. Similar results have been found for the Philippines (*Ducanes* 2015).

In a related manner, the consequences of migration on left-behind children have received growing attention over recent years. *Binci* and *Giannelli* (2018) use Vietnam Living Standards Surveys and fixed effects regression to show that remittances after domestic migration reduce child labour and increase school attendance for origin households in the country. In contrast, applying cross-sectional methods remittances from international migration seem to be more important than remittances from domestic migration. The authors argue that unobserved migration networks of families may drive these differences across methods. *Lu* (2015) examines the consequences of internal and international migration on the physical growth (height and BMI) of left-behind children in Indonesia (Indonesian Family Life Survey) and Mexico (Mexican Family Life Survey) using fixed effects regression. While there is no effect on BMI, the study finds that internal migration impacts positively on height in Indonesia while the effect of international migration is negative in Mexico (other effects are not statistically significant). These cross-country differences were attributable to the different developmental status and nutritional profiles of both countries. *Yue et al.* (2020) study maternal, internal out-migration for children below the age of 2 in China with a two-way fixed effects regression, i.e. a difference-in-difference approach. Maternal out-migration leads to worse mental development and cognitive delay. There is no association of out-migration with social-emotional delay, anaemia, weight, or frequency of illness. Earlier out-migration has particularly negative effects. Results for pooled OLS would lead to substantially different conclusions, sometimes with opposite signs. Intermediate variables that can explain the association between out-migration and children's outcomes are reduced activity with children and a reduction in the quality of food.

3.3 Context-level conditions and outcomes

Spatial mobility allows individuals and households to change their economic, social, environmental, and geographical context, e.g. by moving into a different neighbourhood or labour market region. At the same time, dynamic contexts

have an impact on the probability of spatial mobility. Because individuals (partly) select their contexts, it is often difficult to examine the causal consequences of contexts in terms of behaviour and outcomes. The aggregation of individual decisions also shapes population compositions and can lead to social change. Panel data has several major advantages when studying the relationship between spatial mobility and context. Firstly, panel data allows us to observe and model selection in context. Secondly, because place is not static (*Baker et al.* 2016), panel data is also particularly suited to investigating how changing contextual conditions influence spatial mobility and how spatial mobility creates changes in context. Thirdly, panel data allows us to study the persistence in contextual exposure, e.g. the exposure to poor neighbourhoods. In addition, deploying multi-level models on repeated observations of individuals clustered in different contexts enables correct inferences to be drawn where there is context-level heterogeneity, and allows us to estimate context-level effects on individuals' mobility behaviour and outcomes.

A central context for spatial mobility at the macro level is the housing market, which is often conceptualised at the regional level. As theorised in the institutional approach of spatial mobility (*Flowerdew* 1982), aspects such as tenure structure (where more rental accommodation facilitates mobility), housing demand, transaction costs, and housing costs can all have important implications for mobility. Panel data is particularly suited to understanding the consequences of changing housing markets for spatial mobility. In considering changes in supply and demand in regional housing markets by drawing on panel data, *Lersch* (2014: 156f) shows that population growth is positively associated with increases in crowding in Britain and Germany, but regional tenure structure is not associated. The author deploys fixed effects regression, and replicates the analyses using multi-level models with random intercepts at the individual and housing market level to yield unbiased standard errors for the housing market variables. Results from the application are broadly similar across both models, but standard errors are greater for the fixed effects models.

The bulk of micro-level research on the role of context characteristics for individual migration decisions has focused on those of origin context only. Such models implicitly assume that the characteristics of potential destinations do not play any role in migration decisions, and is inconsistent with theory and empirical evidence from macro-level research that considers that such destinations do matter. Incorporating information about potential destinations for movers in Britain, *Rabe* and *Taylor* (2012) find that differentials in house prices between origin and potential destinations matter for migration decisions; in particular, these deter migration for homeowners. The study innovatively combines BHPS with the British Labour Force Survey, register data on regional mobility, and regional house price data to estimate random effects regression models predicting mobility. Several sources of migrant selectivity were modelled additionally, since random effects models are not immune to individual unobserved heterogeneity. The choice of the random effects model is in response to the interest in examining differences in opportunities across individuals rather than within-individual variation over time. Overall, the origin-destination comparison approach enriches our understanding of context-

level migration incentives. *Thomas et al.* (2015) also consider origin and destination contexts in a study of the distance moved by residential movers in England and Wales. They assess the relative importance of individual and place-based variations, employing a multi-level cross-classified statistical framework in which respondents can be nested in distinct higher level units. The modelling strategy enables them to assess the role of place-based attractiveness, net of average socio-demographic context compositions. The results show that migrants are pulled towards rural and coastal amenity-rich destination environments, which indicates the persistence and strength of counterurbanisation processes.

With more and more people worldwide affected by climate change, a timely and relevant additional line of research studies the influence on spatial mobility of weather as an environmental and regional condition. For instance, *Sedova* and *Kalkuhl* (2020) link household panel data with weather forecasts at the district level for India and utilise panel regression models, including fixed effects at the household and district level. They find that temperature and precipitation extremes in rural India affect mobility. Here, adverse weather shocks reduce international migration and rural-rural mobility but instead push migrants to cities in richer Indian states. These climate migrants are mostly unskilled agricultural workers. Using similarly combined data pooled for Ethiopia, Malawi, Tanzania, and Uganda, *Mueller et al.* (2020) show that weather extremes reduce out-migration from urban areas but are not a predictor of rural migration using fixed effects models.

Conflict can also be a contextual condition that pushes people to leave their places of residence and is in fact a major reason for international migration (*International Organization for Migration* 2019), but individual-level evidence of the relationship between conflict and mobility is scarce when drawing on panel data. A notable exception is a study by *Bohra-Mishra* and *Massey* (2011) who rely on panel data from Nepal to study the likelihood of local, internal, and external migration due to civil conflict using an event history framework. The study provides evidence in support of a threshold model of migration, where violence must reach a high level to increase the likelihood of migration.

Moving from a regional to a local scale, a large body of literature is concerned with spatial mobility and neighbourhoods. *Baker et al.* (2016) use HILDA to study the relationship between housing affordability, mobility, and neighbourhood quality. In so doing, they use a dynamic random effects panel model to demonstrate that the context of where an individual lives is causally influenced to a significant degree by the prior context, which is often of the same type. The authors augment the model with the Mundlak approach (i.e. includes as an explanatory variable the means of the time-variant variables), which allows for potential correlation between the individual-specific effects and the explanatory variables, and ensures unbiased and consistent model estimates in the context of random effects regression. Results show that those persons facing housing affordability issues are more likely to move and are more likely to move to disadvantaged neighbourhoods. *Vaalavuo et al.* (2019) use Finnish register data with fixed effects regression to show that native Finns are more likely to translate income growth into improvements in neighbourhood quality

when compared with immigrants. Not applying a fixed effect regression framework would underestimate the difference between the native population and immigrants.

4 Conclusion

After decades of collection (which can be costly) and use of panel data, it is imperative to monitor research advances in the field of spatial mobility and to evaluate the capacity to build an evidence base that not only informs policy but also contributes to theoretical development. The aim of this article is to establish the benefits of panel data for spatial mobility research and to illustrate this by providing an overview of recent progress in research. The necessarily limited selection of themes and studies presented in this overview does not do justice to the vast literature that exists, but it should show the strong level of engagement among spatial mobility researchers with panel data and illustrate the value of panel data in the study of spatial mobility. Furthermore, this overview has explained how spatial mobility is a multi-faceted phenomenon. Panel data can be extremely useful in establishing the diverse and complex patterns of mobility and immobility, isolating key relationships in a range of outcomes for mobile and immobile populations, and deciphering the causal mechanisms underlying these processes. The overview also revealed that some limitations in extant data collection and the under-utilisation of the data available might be slowing down further progress. There are several critical issues which we believe to be essential in order to continue making progress.

The key advantage of panel data is the repeated observation of individuals, but this is often not fully exploited in empirical research. Among researchers who study spatial mobility, it is important to increase expertise in methods devised to examine data with longitudinal and panel structures (e.g. fixed effects models, event history analysis, multi-level models). Many of these methods enable more accurate inferences than cross-sectional analyses, pooled cross-sections, or time series analyses by isolating within-individual change from between-individual differences. Additionally, they enable the modelling of complex associations that better characterise spatial mobility phenomena by uncovering temporal relationships or acknowledging complicated clusters of individuals in social relationships or structures (among others).

We still largely ignore how the increasing fluidity and complexity of the life course, with multiple and differentiated life transitions, is affecting how spatial mobility is (re-)negotiated throughout individuals' lives. To shed light on these matters, research should take advantage of long-running, multi-purpose panel studies to examine changes and continuities in space for long life segments, from childhood to older age, and across generations, while accounting for problems of attrition. Such analyses should deepen the role of spatial mobility at different life course positions as well. This would allow us to shed more light on the links between aspirations, diverse motivations, and outcomes – including subjective wellbeing, health and lifestyle, environmental quality, climate and green spaces, social relationships and solidarity, and political attitudes. Greater knowledge about these links would enable

us to gain new insight into the role of spatial mobility as a boost or a bottleneck to advancement throughout the life course.

Panel datasets increasingly (but not sufficiently) include sets of questions that enable relevant intersections to be established among diverse forms of spatial mobility. Very limited progress has been made in terms of unveiling how relocation mobility (which has been declining in many countries) as well as commuting and other recurrent mobility practices (which are on the rise) are intertwined and have an impact on life outcomes. At the same time, immobility is simply considered to be the absence of mobility, the causes and consequences of which remain largely understudied *(Schewel* 2020). The same can be said of the links between internal and international mobility, although this is a general gap in spatial mobility research (*Kin/Skeldon* 2010). While the vast majority of panel data collections are not devised to examine the entire process of international migration, creative research designs that combine complementary data sources from registers, surveys, social media, and other digital sources across origin and receiving countries can be valuable solutions. For example, *Panichella* (2018) combined German and Italian household panel data to assess the social mobility of southern Italians who move internally (to northern Italy) and internationally (to Germany).

Panel data is also better able to explain mobility-related phenomena beyond individuals and their properties. As this overview has shown, panel data is largely used in empirical analyses informed by approaches that emphasise social relations and structural factors. However, a relatively small fraction of these applications use advances in dyadic, multi-level, and other modelling strategies to deal with heterogeneity at supra-individual levels. Understanding the social embeddedness of spatial mobility also requires us to deepen our knowledge of social relationships beyond the household (*Mulder* 2018) and to consider mobility as relational practices that link lives together; one example of this is children circulating around the homes of their separated parents (*Coulter et al.* 2016), even though there are only a small number of panel studies, such as *pairfam*, which collect detailed information on ties outside the household.

Evidence from extant research also calls for further assessments of the links across micro-, meso- and macro-levels of analysis, and for the combination of multiple levels to be taken into consideration. For instance, some studies found relevant context-level variation on individual-level, partner-specific outcomes of decisions about household relocations taken at the couple level (*Lersch* 2016; *Nisic/Melzer* 2016). Advancing knowledge on the role of geographic, economic, cultural, or socio-political conditions for spatial mobility processes can be achieved by exploiting variation across temporal and spatial contexts, including cross-national comparisons.

There is also untapped potential in panel data in the form of large surveys and registers, to understand the micro-level foundations of context-level change resulting from differential movement of individuals by features such as age, gender, education, class, or race. Selective mobility can reshape population compositions in origin and destination areas, and, if substantive, both drive social change and reconfigure the inequality structures of cities, regions, and countries. Stratified

mobility patterns cause a myriad of local and urban processes such as gentrification, ethnic segregation, or socio-economic polarisation, as well as broader spatial processes such as rural depopulation, social diffusion, or economic redistribution. These merit further study but cannot be fully understood without assessing the features and behaviours of individuals over time.

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