

## **The Fundamentals of Longitudinal Research: An Overview**

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### ***Abstract***

This paper outlines briefly the historical development of ideas related to longitudinal studies and their advantages over cross-sectional studies. Then it points out a few complicating factors that arise with the analysis of longitudinal data and highlights some of the approaches adopted to manage those complicating factors and illustrated in the papers included in this Special Issue. The overall aim is to promote a better understanding of the information that longitudinal data provide and of the suitable techniques needed to analyze such data.

### ***Résumé***

Cet article trace brièvement le développement historique des idées liées à l'avantage des études longitudinales par rapport aux études transversales. Je précise ensuite quelques facteurs qui compliquent les analyses des données longitudinales et je met en valeur certaines des approches adoptées pour contrôler ces facteurs et j'illustre par des exemples tirés de cette édition spéciale. Le but général est d'atteindre une meilleure compréhension de l'information que les données longitudinales fournissent et des techniques appropriées requises pour analyser de telles données.

**Key Words:** Longitudinal versus cross-sectional, causality, panel attrition, panel conditioning

## Pros and Cons of Longitudinal Research

Although the first longitudinal study on record dates from 1759 when Gueneau de Montbeillard recorded his son's growth to the age of 18 (Buffon, 1837), it was not until the 1920s that we find significant longitudinal studies that have advanced our knowledge of development and growth. Questions on advantages and disadvantages of longitudinal research were raised in the 1920s, with the criticisms of cross-sectional methods. In essence, most of those arguments were to discard age as a defining element of a population and replace it by duration since only the latter could properly explain growth. Such arguments, and counterarguments, already contained the key ideas associated with a longitudinal study for examining developmental sequences and their interrelations.

It was also around the 1920s, when a monumental work was undertaken by Lewis M. Terman of Stanford University to study the developmental histories of gifted children. Under the title of *Genetic Studies of Genius*, his team's research followed both prospective and retrospective methods to study the factors that contributed to superior achievement, particularly achievement in the realm of intellect. Not only a thousand gifted children were followed over their life course but gifted adults also were studied backward to the period of childhood. Terman and his team carried on the study for over thirty years until his death in 1956. The five significant volumes published as a result of this monumental work (Terman, 1925, 1929, 1930, 1947, 1959) bear evidence to what longitudinal research can do to the advancement of our knowledge.

More elaborate discussions on advantages and disadvantages of longitudinal research had to wait for four more decades. Two important studies are worth citing here. One is that of an eminent psychologist, Rene Zazzo (1967) of the University of Paris who presented his paper in 1966 to the Symposium on Longitudinal Studies. And the other is the Report of the National Foundation for Educational Research in UK. This Report tried to identify the distinctive contribution of longitudinal studies to the advancement of the social sciences (Wall and Williams, 1970). After a careful and scrupulous evaluation of the advantages and disadvantages of longitudinal studies, both of them were not in favor of continuing longitudinal studies for reasons that are valid even today. The Report of the National Foundation finally said: "We do not share the pessimism of many, but we are still aware that unbounded optimism as to the outcome of continued study of representative national or regional samples of the same individuals over time is *not now* and probably *will never be* justified." (Wall and Williams, 1970:70, italics mine)

Many other studies since then have clarified the basic distinction between cross-sectional and longitudinal data that we readily accept today but not necessarily apply in practice. Cross-sectional information deals with *status*, while longitudinal information concerns with *progress and change* in status. This implies that the term "longitudinal data" denotes repeated measurements of the *same* individuals over a

time span *long enough to encompass a detectable change* in their developmental status. Sir Cyril Burt, well known for his innovative techniques (of factor analysis) in the 1920s, used the term “*conspective*” for cross-sectional as opposed to “*prospective*” for longitudinal data. And, Zazzo himself proposed that a longitudinal study, which examines the same population at recurring intervals, was nothing but “*evolutive transverse*” (that is, cross-sectional-developmental).

Defining a cross-sectional study as one that deals with status and a longitudinal study as one that deals with progress and change has erroneously led us to view the latter as an antonym of the former. What is, however, more surprising is that many of us do not hesitate to apply to the latter the design and analytical procedures devised for the former. Zazzo's criticisms of longitudinal studies were precisely based on this anomaly. He aptly pointed out (even in the 60s) how longitudinal studies inevitably go for larger and larger samples when a few subjects would suffice for the discovery of developmental sequences. In addition, since the essential aim of longitudinal studies is freedom in search of the unknown, standardized tests, many of which have been devised for cross-sectional investigation and involve rigidity in theory and in instrumentation, cannot be invoked in longitudinal studies. Zazzo did not hesitate to dub all these as illusions. According to him, the most perverse of these illusions is to consider the length of observation to be coincident and coterminous with the process of development – “the ancient fallacy that confounds the reality of what is observed with the process of observation.” (Wall and Williams, 1970:16)

The span of observation time for a longitudinal study is indeed a crucial point, with related questions like measurement error and attrition of individuals from observation. The span of observation depends mainly on the issue of investigation and its rate of change. This is one of the obvious disadvantages of any longitudinal study. It is unfortunate that the beginning and the end of many longitudinal studies depend mostly on the availability of funds! It is interesting to note that during his work, Terman devoted each year a portion of his own salary to collect data on gifted children in the hope that once a beginning had been made, funds would somehow be found for a realization of the larger plan.

Most of us accept today that longitudinal information is necessary especially for causal studies on individual behaviour. This acceptance rests on the understanding that longitudinal studies can show the nature of growth, trace patterns of change, and possibly give a true picture of cause and effect over time. Social processes have become increasingly complex and if we would like to grasp this complexity, we need longitudinal data for establishing temporal order, measuring change and making stronger causal interpretations. While discussing the progress made in social science research, Smith and Torrey in a 1996 issue of *Science* aptly stated: “Longitudinal data are important for studying individual transitions and the cumulative effects of life cycle transitions on later-life outcome and for studying cultural differences and changes. Longitudinal research on transitions is also important in understanding the life cycles of social conflicts, the evolution of

governance, and the development of economies.”

But some of us may think otherwise. It is expensive to collect longitudinal data, in terms of money, time and energy; it needs more complex and unfamiliar statistical procedures to analyse the collected data; and, so few computer software are available to do the job properly. Added to these is the problem of access to longitudinal information because of questions of privacy and confidentiality. What is the point, then, of all the trouble and expense to collect data of such richness when that richness cannot be tapped? After all, cross-sectional data are not uninformative about the processes of change. For example, most censuses ask questions on where respondents lived one year or five years earlier and we are able to make inferences on changes that have taken place during the intermediate period. Demographers in particular have for long been collecting at least a partial demographic history through cross-sectional surveys. Similar strategies can capture many other processes of change as well. With accurate measurement of present status and with some retrospective information, hypotheses about possible causes may always be inferred, though not conclusively tested.

Debates on advantages and disadvantages of cross-sectional versus longitudinal data can and will continue *ad infinitum* until researchers can show that longitudinal data do make a difference in social research. Almost eight decades have passed since the debates on the issue started, and statistical techniques have advanced since then. We may still discuss about the costs and benefits of collecting longitudinal data in the same way as it was done even three decades ago. But, we can see a remarkable shift in the acceptance of longitudinal data as more suitable, and even essential, for certain kinds of research. Besides, in Canada, as in many other developed nations, discussions are being held and opinions are solicited for replacing age-old data collection methods such as censuses and even retrospective surveys with prospective surveys; this, despite the fact that funding situations in the near future are not clear. There is more and more of an atmosphere of acceptance of the need to collect more longitudinal data and a willingness to analyse such data. It is time, therefore, to set aside debating on the costs and benefits of such endeavours and instead to spend one's energy on tapping the rich information being collected. Longitudinal surveys are here to stay and social scientists are fortunate to have rich data sets at their disposal.

Despite the general acceptance of usefulness of longitudinal data, it is not an exaggeration to say that many researchers are not ready to use adequate techniques for analysing such data. A content analysis of 203 longitudinal strategic management studies done by Bergh and Holbein (1997) reveals that most researchers not only do not test and control for violations in the assumptions underlying longitudinal analysis but also do not test the stability and form of empirical relationships over time.

This cannot be remedied unless we find a way to disseminate new and correct techniques of analysis to would-be users of longitudinal data. This special issue is a

modest attempt towards achieving that goal by putting together both theoretical and technical orientations towards longitudinal research. Before introducing the collection of papers presented in this volume, a few observations are in order regarding the factors that complicate the analysis of longitudinal data. This is done mainly with the purpose of tempering the “unbounded optimism” that some entertain regarding longitudinal studies.

### **Complicating Factors in Longitudinal Studies**

Before launching into any longitudinal research, one should be aware of some important factors that can complicate the analysis of longitudinal data. Most social science researchers rely on secondary longitudinal data, and unless these complicating are taken care of, they will seriously undermine the inferences that we make from statistical results, especially for policy purposes.

#### **Socio-psycho-dynamism**

The major virtue of any longitudinal information is that it is inherently socio-psycho-dynamic. Longitudinal studies are meant to uncover that dynamism. This essentially implies that for analysing longitudinal information, we need to reorient ourselves to using dynamic models in our studies and be ready to abandon static models of all types, however much we cherish them. This particularly applies to such techniques like multiple regression and path analysis. As Rogosa (1995) has shown, a regression analysis that simply considers “scores” from different waves of a longitudinal survey as “covariates” in the model is flawed because the estimated parameters depend only on the times at which the observations were taken and have nothing to do with the “scores” themselves.

It makes sense to say that we have to use dynamic models for analysing dynamic data and not static models for analysing dynamic data. More than a decade ago, Tuma and Hannan (1984) forcefully argued for using dynamic models in social science, and social scientists are using them more than ever before, thanks to computer packages that can handle dynamic analysis. There is one more question, however: to continue with deterministic models or to go for stochastic models. This question becomes all the more important for longitudinal studies because a large amount of variation is inherent to any set of longitudinal data simply because of the possibility of observing variation at different time points. What is the general source of all these variations that we observe? Only if we know it!

However, one thing we know for sure. Variation can or cannot be controlled prior to observation. If we cannot control variation (as is the case with many longitudinal observations in social science), then variation owes its existence to chance, a phenomenon that the famous statistician Jerzy Neyman called “dynamic indeterminism”. Our analysis then needs to take account of this indeterminism in

individual and social behaviour. Kenneth Boulding's words (1981) – which appear on the cover page of this Special Issue – become relevant here. We may never prove indeterminism either in the universe or in social systems. But, uncertainty in individual and social behaviour exists beyond doubt. As in the subatomic world, our very observation can affect the systems and individuals to behave in a certain way (see below for more details). “Social systems have Heisenberg principles all over the place.”

Deterministic models are easy to deal with. In technical terms, the deterministic differential equations (DDE) are somewhat easy to solve. But they sacrifice realism for simplicity. Stochastic differential equations are most of the time difficult to solve, but they capture realism. We often argue that results will not be very different if we use deterministic or stochastic models. After all, we are limiting our analyses most of the time to the ‘average persons’ and ‘average systems’, and ‘regression to the mean’ is inevitable even in a longitudinal study. Again, Rogosa (1995) shows that this is a myth that we cherish.

So, the ever-increasing availability of longitudinal information offers us the best chance to examine the dynamic indeterminism that characterizes human behaviour. With dynamic observations through longitudinal surveys, we need then to move on to extend our predictive models to situations where indeterminism operates, to extend our normative models built on the theory of rational decisions to where uncertainty prevails. This is more easily said than done. However, with longitudinal information we have a better opportunity to pursue these goals.

### **Causal Relationships**

Whether we use static or dynamic models, deterministic or probabilistic models, one of the main aims of scientific investigations has been to discover causal relationships, although we admit that such relationships can also never be proved. The most often advanced arguments for longitudinal data point to the prevalence of ambiguities in causality with cross-sectional data. These ambiguities can arise in many different ways and it is still not clear how longitudinal data will help ‘solve’ the situation. Social research is replete with examples of uncertainties about the direction of causal relationships. The uncertainty is serious in attitudinal research that examines the relationship between attitudes and behavior. If data from different waves (on the *same* individuals) are available, the direction of causality has a better chance of being identified. This is especially true with a nonrecursive causal relationship (that is, X to Y as well as Y to X) such as the one observed in attitudinal research: attitudes influence behavior and behavior results in adjustment of attitudes. Or it can happen in socioeconomic contexts such as the Malthusian vicious circle: increased food supply per capita leads to increased fertility and increased fertility leads in turn to decreased food supply per capita. Obviously such a nonrecursive causal relationship cannot be clearly established with cross-sectional data and we hope that longitudinal data will help solve the problem.

Will longitudinal information be able to prove such a relationship? Theoretically yes, but in practice, there are many doubts. Because even some simple questions about the modes of observation do not have clear answers. Some of these questions are: What is the optimal length of time between interviews? How many interviews (or waves) are necessary to achieve the research objectives? How long should observation continue before a change is observed or a causal mechanism is identified, and so on. It would be foolhardy to imagine that causal mechanisms can be clearly established with three or four waves. Social processes are characterized both by stability and change. Even if changes are taking place in our times faster than we can imagine, diffusion of change takes its own time. The practice of suppressing the ‘small numbers’, either in data disposal or during the analysis, on grounds of privacy and confidentiality eliminates any chance of capturing the moment when change and its diffusion starts to take place. Questions of confidentiality are at odds with the aims of developmental studies, and the logic of protecting the former is incompatible with the logic of promoting the latter.

Closely connected to the above discussion of causality is the requirement there should be no other plausible explanations for the statistical association. It is nearly impossible, even with longitudinal data collected over many waves, to satisfy this requirement. A simplistic textbook approach to causal analysis may be content with examining a few control variables included in the analysis. But it is obvious to any serious researcher that social processes are too ‘noisy’ to yield to any strong evidence of causal relationships. Not only it is impossible to identify all the potential sources of an observed relationship but also many of these potential sources are effectively unmeasurable. Traditional analytical approaches have not been of great help in these circumstances, and newer (more sophisticated) approaches (like unobserved heterogeneity) have neither succeeded in disentangling the real causal relationships. But as argued in the previous section, paying more attention to randomness in model building may help us to advance in this direction.

### **Measurement Error**

Like all other measurements, longitudinal repeated measurements are also subject to error. In fact, measurement error needs greater attention in repeated measurements than in cross-sectional studies because of the unsolved problem of how many times and when to measure the variables of interest to capture the change in the process under study. It is possible to obtain measures that suggest change when actually there was no change at all or measures that suggest no change when actually there was a change. Consider, for example, measures of distress or scores that denote some ability or other. Often, moods dictate human performance and observation times may fall on “wrong” days or moments.

Fallible human memory and tendency to provide rational explanations for one’s behaviour also play their role in measurement error. Events considered to be

critical by researchers may appear trivial to respondents and be quickly forgotten. In remembering 'past' events, cultural stereotypes as well as personal explanations and justifications can be a source of adulteration. In this connection, we should also note that a long-term study of the same individuals carries with it the risk that participants in the study can concoct information for many reasons of their own. The experience of Blau and Duncan (1967) is worth remembering. When they compared the respondents' reports of their fathers' occupations with the census records, they found only 70% agreement.

### **Changes in Conducting Surveys**

Measurement error can also creep in because of the changes in measurement introduced over time. Lack of standardization in data collection across time may arise for legitimate reasons. The passage of time leads to changes in the hypotheses and hence in framing the questionnaire, and to unseen and unforeseeable changes in instrumentation and theory. In studies that carry on even for a few years, new hypotheses will always arise either from the study itself or from general advances in the relevant fields of social science. The longer an enquiry continues, the more likely is change to occur and diminish the value of what has already been done. And, it is possible that a reevaluation (if at all an evaluation is possible since a concurrent analysis is practically difficult in many situations) and new knowledge may invalidate the rationale of the study itself. All these introduce subtle problems in longitudinal research. When new hypotheses are introduced, for example, how can one verify them since the relevant data were not collected in the previous waves when their significance was not perceived?

It is therefore not uncommon to start out the first wave of a longitudinal survey with a comprehensive and 'mixed bag of variables and measures,' hoping that they will be of use at some stage or other, then to add a few more variables and discard a few others as time goes on. A similar thing can happen even with the selection of participants in the study. The National Longitudinal Survey of Children and Youth in Canada, for example, started with a selection of a maximum of four children in a household in the first wave, but then cut it down to a maximum of two in the second wave to alleviate the response burden experienced by households with larger number of children. Such changes over time easily end with so much disparate and irreconcilable information accumulated over time that any useful (developmental) analysis becomes impossible. Indeed, it is well known that most of the collected data go unanalysed. Or, analyses are done in cross-sectional style for lack of sequential information over time.

### **Problem of Attrition**

Over long periods of time, attrition of the sample definitely occurs, and it is often difficult to state precisely the comparability of the initial and final samples.

Maintaining contact with the participants and sustaining their motivation is difficult and costly, even with small groups of 300 or so. One wonders how it would be when modern surveys go for much larger samples of 20,000 or higher. However, experience shows that even over a period of 20 years, it is possible to maintain the interest and participation of 80% of the initial sample even when this is large and representative. Attrition rates vary from studies. The Panel Study of Income Dynamics and the Survey on Income and Program Participation report rates of 75-80%. In so far as respondents are lost in later waves of data collection, measuring change may be confounded because those respondents who are lost may differ in some systematic way from those who are retained. This is especially serious if losses come disproportionately from those with extreme values on the variables on which the research focuses. Thus, it is not only the magnitude of the attrition but also the pattern of attrition with respect to critical variables in the study that may be problematic. To maintain low rates of attrition, substantial resources must be available for tracking respondents.

### **Panel Conditioning**

With panel surveys, we need to examine seriously the so-called panel conditioning or Hawthorne effect whereby the very act of being interviewed and reinterviewed changes people's attitudes and behaviour, if not a simple reporting of attitudes and behaviour. If there is a possibility that individuals can modify their behaviour because of the very fact of being included in the study, then the sample may become less and less "randomized" over time. It is also known that panel conditioning may affect the quality of the data reported by the participants in a study. The longer their participation in the study, the less likely they are to report certain socially unacceptable situations such as unemployment or mental health. And, respondents learn from the many interviews – if answering one item truthfully leads to a string of questions, they learn how to avoid the string of questions next time. Unfortunately, the literature on the impact of conditioning is sparse and there is an urgent need to examine this problem in depth with the existing multiwave surveys. To do it properly, however, we need a control sample alongside the panel, which implies increase in the costs of conducting a study. A rotating panel design may reduce the problem of conditioning since it will replace the panel members regularly. Readers can refer to Waterton and Lievesley (1988) for a detailed discussion on panel conditioning and for some findings from the Social Attitude Panel Study in Germany.

The above discussion was not meant to dampen the enthusiasm of researchers in doing longitudinal studies but, as was mentioned before, to temper the unbounded enthusiasm that some entertain with the new fad in the world of research. The point of all these discussions is that longitudinal data, particularly in the social sciences, carry with them their own limitations. These limitations, however, should not distract our attention from the far greater limitations of cross-sectional data. A longitudinal study is still essential if we wish to determine the influence of

conditions, acting over a long period of time, on the same individuals. The fact remains that a heavy commitment is called for, not only of resources by funding agencies over a long period of time but also of efforts on the part of those devising techniques to tackle the above methodological problems and of willingness to learn and apply these techniques on the part of researchers.

### **Topics Covered in this Special Issue**

As discussed in the last section, since the main purpose of collecting longitudinal data is to follow the socio-psycho-economic development or behavior of individuals over time, researchers need to have theories or paradigms to explain the developmental changes observed in an individual or a group of individuals. Obviously, one can think of many theories and paradigms depending on one's tastes and preferences and on the nature of the study in question. Seeing human life as a process of development along three main dimensions, namely biology, cognition and emotion, Frans Willekens discusses in his paper titled "Theoretical and technical orientations toward longitudinal research in the social sciences", the life course perspective that has been predominantly adopted in recent demographic research. The life course perspective offers an opportunity to move beyond the identification of factors that affect demographic behaviour and to pay attention to the causal mechanism underlying these factors. He addresses three important issues: What is the added value of the life course perspective in our research? What are the basic concepts used in life course research and what modifications do they need in the context of using longitudinal information? And, if empirical observations are manifestations of underlying processes and if our emphasis should be on the processes rather than on their manifestations, how do we then capture the features of the underlying processes?

One of the important aims of the Workshop on Longitudinal Research was to share the experiences of researchers engaged in longitudinal research in various settings and in various countries. Martin Diewald's paper titled "Unitary social science for causal understanding: Experiences and prospects of life course research" is one such sharing of experiences in working with the longitudinal data available in Germany. He does this with a specific problem that confronts all researchers, namely the problem of causal explanations of social phenomena. Recalling the ebullient enthusiasm with which life course research started in Germany in the early 1980s with the two major surveys, GLHS and GSOEP, he points out how the claims and promises of life course research are still dreams to cherish not only because of lack of adequate data but also because of the primary rationales of those two surveys. In particular, he points to the lack of fuller integration of two research traditions in the social sciences, namely the life course research and individual psychological development research. He argues that it is not simply a question of widening the coverage of research questions in the surveys but more a matter of thinking together for arriving at powerful causal explanations of social phenomena. To achieve this end, he suggests that we can no longer hold on to the Durkheimian

view of “explaining the social by the social”. It is a challenge to all researchers interested in doing longitudinal research; a narrow disciplinary focus will not lead us far, what is more urgently needed is an interdisciplinary effort at devising longitudinal designs that would ultimately lead us to achieve that analytical power needed for causal explanation of social processes.

Another lesson learned from fifteen years of research, this time with the surveys in Canada, is shared with us by Celine LeBourdais and Jean Renaud in their paper titled “Using event-history analysis: Lessons from fifteen years of practice”. The two authors of this paper focus on two distinct, yet closely related, issues not only of longitudinal research but of all types of research, namely theory in search of data and data in search of techniques. LeBourdais focuses on her experiences of working with the retrospective data from the General Social Surveys. In particular, she points out the impressive progress made in data collection in Canada during the last two decades that has enabled her to examine the close linkages between conjugal, parental and employment histories. And yet, none of the existing surveys (including longitudinal surveys) is able to provide complete information on the past conjugal, family and employment histories together that can be used to test the theory at hand. Different surveys focus on different topics as if individual lives have separate compartments of attributes totally unrelated to one another. Serious attention needs to be paid to fill this gap at the survey design stage, which obviously calls for collaboration between data collection agencies and researchers in the field.

Jean Renaud shares with us his rich experiences of having conducted a small-scale longitudinal survey on the progress and development of immigrants into the province of Quebec. The problems he has experienced can be summarized simply as “data in search of adequate techniques” and echo what was discussed in the last section. Renaud points out in particular how with each successive wave, the progress and development experienced by the new immigrants lead to more and more complex transition patterns, thus invariably to smaller and smaller number of individuals. Current techniques of analysis are no longer able to keep all the original complexity of the data. Put together, LeBourdais and Renaud argue for another type of integration, this time the integration of social theory and mathematical modeling.

And that too is precisely the focus of the paper by Tom Burch. In his paper titled “Longitudinal research in social science: Some theoretical challenges”, Burch argues that the proliferation of data produced by longitudinal surveys may be to the good as we hope, but will not necessarily or automatically lead to better scientific knowledge. On the contrary, the sheer amount of detail may lead to discouragement with respect to the prospects for theory development. After pointing out how in demography, theory has been smothered by data with illustrations from the well-known empirical studies in demography, Burch suggests to us to view theory in a different way and to reflect more on the contributions from the contemporary philosophy of science that has increasingly challenged the logical positivist view. To the extent that current longitudinal data sets leave too many factors in the black

box, “theoretical models” should hold primacy in social science since they summarize what we know about how social systems work at a deeper level.

Besides the theoretical issues of longitudinal research, the workshop aimed also at discussing some of the more recent and innovative techniques that can be used for analysing longitudinal data in the social sciences. Benoit Laplante and Benoit-Paul Hebert, in their paper “An introduction to the use of linear models with correlated data,” discuss the problem of correlated data when observations are not selected independently because of sampling or study design (as in longitudinal surveys that contain repeated measurements). They present the basic ideas involved in the techniques that correct for this problem in a format that can be easily understood by researchers familiar with anova-type procedures. These techniques, known under different names like random effects, mixed effects, hierarchical models, and multilevel models, . . . are being used more and more in longitudinal research. They also try to address, not solve, the problem of measurement error discussed in the last section. The authors are not able to provide an empirical illustration with the Canadian data sets, since the data from subsequent waves of the current longitudinal surveys are still not available to researchers.

One of the surprising puzzles in social science research is that researchers seem to need more (and ‘better’) data even as more and more data are being collected. Policy research in particular needs an integrated and coherent data system for making any realistic inferences. Different surveys tap on different information and all these data need to be integrated and ‘matched’ for meaningful research on development. (See LeBourdais’ reflections above) One of the recent state-of-the-art approaches to meeting these demands in the social sciences (an old art in the physical sciences though) is the technique of microsimulation modeling. Douglas Wolf shares with us his experiences of using microsimulation techniques and shows how useful it can be for model builders. Among the many models suitable for longitudinal data, he selects those models that are often used in demographic applications: Models of duration and of sequences, failure-time (hazard) models, as well as linear models for continuous and discrete outcomes, and shows how microsimulation can be done for these models. The point that he emphasizes in this paper echoes Burch’s reflections – see above): Models should be taken seriously. Pointing out the various other uses of microsimulation and advantages and disadvantages of using microsimulation, he addresses one of the particularly useful areas mentioned in an earlier section, namely the problem of missing data. For lack of space, it was not possible to include illustrations for the different procedures that Wolf suggests in this paper, but extensive references to other research works that have used these procedures should be helpful to those who are interested in using this handy tool.

Longitudinal data typically provide information on individuals’ life courses encompassing various domains of interest. As discussed by Willekens, the life course perspective helps in dealing simultaneously and adequately with the once-problematic age-period-cohort effects. Viewing the life courses as sequences of

transitions from one status to another has a distinct advantage in that the familiar stochastic frameworks can be applied directly to analysing these sequences. The computer package LIFEHIST that I have been working on for more than seven years incorporates the familiar multistate (increment-decrement) life table techniques into stochastic frameworks, especially of Markov, semi-Markov and non-Markov processes. The paper on 'Analysis of life histories – a State Space Approach' gives some details on the types of analysis that can be done with this package. The package will include in the near future a few more specific programs for using diffusion models to study innovation and adaptation in human behaviour.

As stated elsewhere, one of the aims of this Special Issue is to present empirical illustrations of techniques that adequately capture the socio-psychic dynamism buried in longitudinal data. These techniques are as complex as they can be, and yet the authors have tried their best to present their illustrations in a format that can be easily followed by others.

One of the most important contributions by life course and event-history studies is the relevance of parallel and interdependent processes for understanding the causal mechanisms in operation in a society. The paper by Hans-Peter Blossfeld and Melinda Mills titled "A causal approach to interrelated family events: A cross-national comparison of cohabitation, nonmarital conception and marriage" demonstrates the usefulness of 'causal' approach to studying interrelated family events, as opposed to 'system' approach. They find the causal approach to be more useful from the analytical point of view as it helps tackle the problems of simultaneity, lag effects and temporal effects, and illustrate this with an analysis of two interdependent processes, first pregnancy/childbirth and first marriage for five different countries. Contradictory findings in previous studies on the effects of pregnancy/childbirth on the process of entry into marriage of couples living in consensual unions shed light on the correct analytical procedures that should be used for examining interdependent processes. The comparative results from the five countries encourage them to look for possible theoretical and statistical explanations of these two interdependent processes, including the unobserved heterogeneity of the decision process common to both.

The paper titled "Sequence analysis in demographic applications" by Francesco Billari illustrates the adaptation of the technique of sequence analysis that is heavily used in biological sciences to event-history data for the sake of obtaining a holistic view of the life course. Representing life courses as a sequence of events or as a sequence of 'words,' Billari shows how we can avoid the problems raised by standard distribution-based statistical methods of analysis because of the inherent complexities that data on life histories invariably have at some stage or other. Billari recommends using the algorithm known as "optimal matching" in the biological sciences for this purpose and illustrates it with the application to the data on education, family, employment and fertility histories gathered by the Italian Fertility and Family Survey.

Andrew Harvey and Clarke Wilson present another interesting example of sequence analysis using time-use data in their paper “Evolution of daily activity patterns from 1971 to 1981: A study of the Halifax activity panel survey”. The important idea in their paper is that a person’s life is not simply a collection of unconnected activities but they are manifestations of contextual dimensions that may or may not have meaning to the individuals. Daily activities in a person’s life also manifest the normative behaviour. Time diaries usually collect information on contexts, and therefore analysing the time-use data should reveal their impact. The authors use data from the Halifax panel survey on two days a decade apart (1971 and 1981) and the software CLUSTALG, which is an adaptation of the original software used in biology for social science applications. Their sequence analysis shows the stability in people’s lives as well as the value of the algorithm known as sequence alignment in studying human behaviour. In spite of the difference of ten years in the sampled individuals’ lives, during which period they would have experienced various events that could have changed their lives in many ways, the authors find that individual stability persists and outweighs historical change.

That brings us back to one of the salient features of longitudinal information discussed in the previous section. Stability and change are the two essential characteristics of developmental processes, and longitudinal data have a distinct advantage over other forms of data for examining both stability and change. Fernando Rajulton and Zenaida Ravanera focus on this specific issue in their paper “Stability and Change: Illustrations with categorical and binary responses” and demonstrate how both the aspects can be examined with categorical and binary variables. Social surveys chiefly collect information on status in categorical and binary forms. Analysis of this information is usually restricted to simple cross-tabulations, and then the data are discarded. The aim of this paper is to show that much more can be done with categorical and binary variables than meets the eye. In fact, analysing categorical and binary information from the subsequent waves of a longitudinal survey needs rather sophisticated techniques, and this paper illustrates how even the more recent thinking on unobserved heterogeneity can be brought into the analysis of binary sequences.

Discussions on measurement issues, latent variables and causal relationships have led to the recommendation of using structural equation models in analysing life histories. Structural equation models, in particular, allow researchers to account for and estimate the size of measurement error and thus help to produce more accurate estimates of causal relationships than models of traditional use. Piotr Wilk’s paper titled “Women’s employment transitions and change in psychological distress” illustrates this by using the data from the two waves of the survey on Employment Status and Mental Health of Families conducted in London Ontario. The paper includes as much description as possible of the procedures involved for the sake of readers who may like to use SEM in their research. The aim of this illustrative paper is to show the advantages of longitudinal analysis over cross-sectional analysis and to compare the results each produces. An important conclusion of this paper should be highlighted here. Analysis of longitudinal data that focuses on both

stability and change may lead us to conclusions that are different from the ones that we normally arrive at using cross-sectional data. Policy and intervention programs may need to be altered based on the results from longitudinal analysis.

In his paper titled “Modelling hierarchically clustered longitudinal survival processes with applications to child mortality and maternal health”, Barthelemy Kuate-Defo discusses the importance of merging the statistical tools available under different traditions, namely hazard modeling and multilevel analysis, and shows how they can be integrated for longitudinal research. Drawing on the earlier attempts to formulate methods for analysing failure-time processes in the presence of multilevel correlated observations, he gives general formulations for hierarchically clustered survival models in the special cases of single spell, multiple spells data. He illustrates their applications with the prospective data collected by the *Enquete sur la mortalite infantile et Juvenile* (EMIJ) in Yaounde, Cameroon, on infant and child mortality and multiple episodes of illness experienced by mothers after childbirth. In doing so, he addresses the attrition problem encountered with the multiple spell observations and shows a way to handle that problem in practical analysis. He also includes in his paper an illustration for multilevel discrete time hazard modeling since in many contexts researchers may have to deal with discrete time observations.

In addition to the above papers on theoretical, methodological and technical considerations involved in longitudinal studies, this Special Issue includes three papers on the current and on-going longitudinal surveys in Canada. These papers give an overall picture of these surveys and their salient features. They are written by those who have been directly involved in the designs of the surveys, and they bring to us their experiences of what has gone into the make-up of those surveys, what changes have already been introduced, and what changes may be introduced in the future. I would strongly persuade the readers to have a copy of these papers on their desks whenever they plan to make use of any one of these longitudinal surveys. They contain in a nutshell what is found in hundreds of pages of the published guides on the use of these survey data.

Philip Giles talks about the main features of The Survey of Labour and Income Dynamics (SLID), which has as its primary objective the understanding of the economic and family well-being of Canadians: how Canadian families and individuals live through the dramatic and fast shifts in the country's and world's economy. He also tells us what can be done and what cannot be done with the SLID data. For example, since the survey collects information from the individuals, it will not be possible to present data for the same families over time because families change. However, the data will allow analysis of the same individuals with respect to their family characteristics.

Sylvie Michaud, in her turn, tells us about the evolution of the National Longitudinal Survey of Children and Youth (NLSCY) that was designed to monitor development and well-being of Canada's children from infancy to adulthood. The

survey has gone through three cycles and already several changes have been introduced. To many researchers who are interested in using the data from this survey, this summary presentation of the changes as well as the collection methodology will be a handy reference.

Douglas Yeo shares with us how the National Population Health Survey (NPHS) has evolved over time and the many changes and modifications introduced since its start in 1994. This is one of the surveys where we see clear examples of how the changing priorities, new hypotheses, new supplements and conflicting demands may shape the future course of a longitudinal survey. In the first place, it is also one of the surveys that was designed to be flexible and to be responsive to changing needs, interests and policies. Thus, because of the increased demand on information on changing health conditions of Canadians, a cross-sectional sample is interviewed side by side with the longitudinal sample. Yeo points out how complex the processing has become just with two or three cycles and what additional burdens are placed on the processing staff and how they are planning to meet these challenges in the future. The story of the NPHS is a typical story on the evolution of a longitudinal survey.

## **Conclusion**

Longitudinal data introduce many complexities, and facing these complexities is a great challenge to researchers. From the discussions presented in this paper on the fundamentals of longitudinal research and from the experiences of many researchers involved in the field who have presented their ideas in this Special Issue, a few important points emerge for our reflection. First, we need to develop strong theories and paradigms that adequately explain dynamic behaviour of individuals and systems. Second, techniques for taking account of the complexities inherent to longitudinal information will also necessarily be complex, but what we urgently need is dissemination of these techniques in a comprehensible form with detailed empirical applications. Last, but in no way the least, we need to develop a fully unified approach across disciplines. Keeping to one's own turf is surely not a way to success in longitudinal research. Researchers from different disciplines need to work together, share their ideas in developing theories and analytical methods. This is the only way to generate a better understanding of the dynamic indeterminism detected in human and social behaviour.

### **References:**

- Bergh, D. D. and G. F. Holbein, 1997. "Assessment and redirection of longitudinal analysis: Demonstration with a study of the diversification and divestiture relationship," *Strategic Management Journal* 18: 557-571.
- Blau, P. M. and O. D. Duncan, 1967. *The American Occupational Structure*. New York: Wiley.

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- Boulding, K. E., 1981. *Evolutionary Economics*. Beverly Hills, California:Sage.
- Buffon, 1837. A Sur l'accroissement successif des enfants; Gueneau de Montbeillard mesure de 1759 a 1776. *Oeuvres Completes*. Paris: Furne et Cie.
- Rogosa, D. 1995. Myths and methods: "Myths about longitudinal research" plus supplemental questions, in J. M. Gottman, *The Analysis of Change*. New York: Lawrence-Erlbaum.
- Terman, L. M. et al. 1925. *Genetic Studies of Genius. Vol.I. Mental and Physical Traits of a Thousand Gifted Children*. California: Stanford University Press.
- Terman, L. M., 1929. *Genetic Studies of Genius. Vol.II. The Early Mental Traits of Three Hundred Geniuses*. California: Stanford University Press. [This particular volume was authored by Catharine M. Cox.]
- Terman, L. M., 1930. *Genetic Studies of Genius. Vol.III. The Promise of Youth: Follow-up Studies of a Thousand Gifted Children*. California: Stanford University Press. [This particular volume was authored by Barbara S. Burks, Dortha W. Jensen and Lewis M. Terman in this order.]
- Terman, L. M. and M. H. Oden, 1959. *Genetic Studies of Genius. Vol.V. The Gifted Group at Mid-life: Thirty-five Years' Follow-up of the Superior Child*. California: Stanford University Press.
- Terman, L. M. and M. H. Oden, 1947. *Genetic Studies of Genius. Vol.IV. The Gifted Child Grows up: Twenty-five Years' Follow-up of a Superior Group*. California: Stanford University Press.
- Tuma, N. B. and M. T. Hannan, 1984. *Social Dynamics, Models and Methods*. New York:Academic Press.
- Wall, W. D. and H. L. Williams, 1970. *Longitudinal Studies and the Social Sciences*. London: Heinemann Educational Books Ltd.
- Waterton and Lievesley, 1988. Attrition, conditioning and attitude change: Some findings from the Social Attitudes Panel Study. In Uncles (ed.), pp.73-88.
- Zazzo, R. 1967. "Diversite, realite et mirages de la methode longitudinale: Rapport introductif au symposium des etudes longitudinales," *Enfance* 20: 131-136.