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Searching for Demography's Missing Link: Momentum

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Abstract

This paper is both more theoretical and highly applied; both methodological and policy-oriented. Empirically until recently there has been little work on momentum effects. By way of case-studies on momentum effects, the paper reviews published policy-oriented work on New Zealand on national growth and age-structural transitions; on fertility patterns in New Zealand; and on survivorship and longevity, and the more local discussion of Maori-Pakeha differentials. The conclusion is that more attention must be paid to momentum. It calls for the demographic community to lead in moving policy analyses away from demography as a naive art form to one that is more multi-dimensional and sophisticated.

Stories that Demography Tells

Demography deals with the most central and intimate parts of the human experience: sex, conception and birth, socialization, marriage and family, work and changing places, and, finally, death, whether this occurs in bed or is due to violence, the external causes as violence is so cutely called. This is inherently interesting for it is the stuff of Soap Opera, but by presenting this in a very technical way some in our community manage successfully to make demography's soap opera boring.

So what, then, could be more exciting than the subject of my paper, momentum? I can see you waiting in anticipation as the very word grabs you and sends chills up and down your spine. But perhaps instead, you are wondering what in the heck is momentum, and what on earth has it got to do with all those saucy, vital subjects that I have just outlined. Well rather a lot as it happens, but in discussing this we have to go back to technical

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demography and even further back than that into theoretical mathematical demography.

Before I do so I have a few other introductory comments. Beyond covering the sauciest aspects of life, demography deals with phenomena that have another appealing feature, in this case, however, statistically appealing. It is a truism, but one that certainly makes the life of the analyst, particularly the modeler, somewhat easier, that many demographic factors follow highly deterministic trajectories over time. No matter how hard you try as a parent you cannot have birth two before birth one; you cannot get divorced before you get married, or leave a job before you start it. The most deterministic paths are followed by birth and death, of course, while labour force participation, migration and nuptiality all involve comings and goings, traced by movement through multi-state models.

To add to this, some key demographic variables are self-defined. Not only that but they mean the same in most languages. For example, look up the definition of live-birth or of death in the *United Nations Multi-lingual Demographic Dictionary*. Of course, statistical precision may not accord with social construction: in Ghana, the infant out-dooring ceremony at about seven days – that is when the child has survived the highest risk neonatal period – is an example of the difference between statistical purity and social usage. Moreover, a false sense of precision may be imposed on some data collection processes: registered marriage is extremely neat and precise, but was imposed on existing Maori customary marriage patterns, and even the conjugal patterns of some Pakeha. Whether census-based or survey-based, labour force statistics are full of false precisions: unemployment rates, hours worked or income to take three examples. The rule is that the further you go from the certainties of birth or death, or perhaps crossing a border, the less precise become the definitional tools.

Another endearing feature of demographic change is that it is often inexorable, and this is the fact that underpins analyses of momentum. Once you are born into a cohort only “death may do you part”, to misquote the Anglican marriage ceremony. In this day and age you can report your ethnicity in different ways at different times; you can seek an operation to change your gender; but you can never leave the cohort into which you are born. We have you in our clutches!

Unless a population is exposed to extremely high levels of migration, moreover, cohort size is set down at birth – even in New Zealand cohort size

changes due to migration are at the margins of significance. Old age and death of course eventually wipe the cohort out – inexorability could be avoided only if oldies were popped out on ice-flows, or if some highly-age specific calamitous epidemic were to occur.

In this paper I want to look firstly at the theoretical underpinnings of the analysis of momentum, and along with this cohort studies, for momentum is primarily a phenomenon that occurs to cohorts. Then to illustrate this I want to take some case studies relating to some substantive issues, some very much in the news.

Mathematical Demography

Let's start by going back momentarily to the 17th century, to the Royal Society of London, to the discipline they called “political arithmetick”, and to the days of the founders of demography, people like Graunt or Halley – the latter of whom, as we well know, also moonlighted a bit as an astronomer. Their life-table work laid down the importance of the cohort as a unit of analysis, and inherent in that was the notion of momentum. I also note this because demography is a very old academic discipline, not some Johnny come lately – most social sciences date from the breakup of philosophy and theology in the 19th century whereas demography dates from the 17th Century. From those days down to the present mathematical demography has contributed enormously to our field in three major ways.

Firstly, it has established the rules about commonalities in human behaviour, especially on the bio-social side: how we survive parturition and infancy, when we become parents, and when we die. It has been very successful in this, developing its own corpus of theory. On the more social demographic side of course it must draw on theory from across the social and medical sciences.

Secondly, mathematical demography helps us establish rules about populations as collectivities, and this will be the area of focus of my paper. This part of mathematical demography, reflected for example in stable theory, has evolved far from its common origins with biometric and actuarial theory. Through elaborate explorations around the conditions of quasi-stability, and a huge volume of empirical studies across almost every population on the planet, mathematical demography has developed the tools that have allowed demographer-practitioners across the Third World to apply models drawn from stable theory in order to estimate vital rates in the

absence of adequate registration data. In historical demography we often do the same thing.

Two closely interrelated phenomena about collectivities, coming down to us from the founders of the discipline, are central to this paper: cohorts, and momentum. A true cohort is followed over time and relates to an entity with a common statistical quality at a common starting point, normally birth (*OED, New Shorter* 1993). The members of the cohort are identified by this as they are followed over time either to death, or to some other so-called “death state” when they leave the status on which the research is focused. For mortality studies this would normally be at death *per se*; in fertility studies it could be menopause; in labour studies it could be retirement. The term cohort as adopted, say, by bio-medical science and economics really relates to a panel of individuals followed over a short period of time, say five years, although the Christchurch and Dunedin longitudinal panel studies and a few of their ilk stand apart as they have been running a very long time.

Surveys such as the NZW:FEE (1995) collect such data retrospectively on individuals, a sort of retrospective panel. They have disadvantages because they depend on recall, the quality of which varies between different variables; but they have distinct advantages relating to cost, to avoidance of loss to follow-up problems and because they can cover a much wider range of real cohorts over very long time spans. In the NZW:FEE we have data on women born between 1936 and 1975.

The great value of a population cohort study, as against a panel study, is that the size of the unit being studied, and its current needs and impacts are a function of the events and experiences they have been exposed to earlier in life, and about which, if one is fortunate, there are data, both on members of the cohort themselves, or on co-variates. In this regard the experiences of a cohort should be seen as an analogue of the sorts of experiences to which individuals in a panel study might be exposed. I return to this point later as it is extremely important, as, for example, when we come to the study of population mortality as against individual mortality.

Momentum is most easily conceptualised as a demographic behavioural pattern followed by cohorts: most commonly it is the impetus built up by a cohort for some phenomenon. This allows one to study purely demographic impacts on the population (eg. age-momentum as analysed by Rowland 1996; or deterioration in cohort survival, as studied by Bourbeau and Legare 1981,

on Norway). By following the momentum built up by cohorts it also is possible to look at the effects of non-demographic factors. The actuary Willets has argued that in health, for example, “the experience of different generations – before birth, in childhood and in adulthood – is a powerful determinant of experience in later life and has predictive possibilities” (Willets 2004:39). Norman Ryder (1965) took this further by looking at social applications of cohort analysis.

If we turn to the literature there are precious few studies on momentum. Most outstanding was that of leading methodologists, Andrei Rogers and J Woodward, who were looking at “ageing in place” as against inflows of migrating retirees (1988). Their conclusion was that momentum was a major factor in the growth of elderly populations in the United States except in those regions that were significant retirement zones. Rowland (1996) has applied the concept to national ageing.

The third contribution of mathematical demography is that it has taken its knowledge of population behaviour and translated this across to applied areas and developed measuring tools. These relate firstly to statistical reporting *per se*: that is, to the conventional techniques of demography that typically come down to us from Farr, who was also a founding father of epidemiology; to the intrinsic indices; and to the non-conventional indirect estimation techniques that are most commonly based on stable population theory. But secondly the development of these tools also relate to their application to interpretations. For the major demographic variables there are thus real international benchmarks against which trends in New Zealand can be compared. We really do know what is a very high birth rate, or a high growth rate, and whatever. In part this is a result of the availability of data collected in standardized ways, with built-in quality controls, covering a very wide range of historical, even paleo-historical, and contemporary populations.

Some Case Studies

In an earlier national-level paper on New Zealand I showed how the inexorable forces of momentum were derived essentially from birth cohort sizes. In New Zealand's case, by comparison with most other Western Developed Countries, because birth cohort sizes have varied very significantly momenta produce highly disordered cohort flows – more severe disorder is observed in some former Soviet bloc countries, notably

Russia and Romania. Momentum in general has major implications for all social and economic development, whether in the market or the policy sectors; when it is disordered, as in New Zealand's case, this makes policy and market analysis even more complex (Pool 2003).

The differing patterns of momentum and associated age-structural transitions have come under the spotlight internationally over the last few years (Tuljapurkar *et al.* 2005; Pool 2005; Pool *et al.* in press). The resultant literature shows that ageing is only one aspect of age-structural transition, and that it is at the end of such transitions, a relatively long way off in New Zealand's case. But before this disordered cohort flows will pass across the age-pyramid, and this is the key factor of population and development in many countries, including New Zealand. In some countries, and New Zealand is a good example, when ageing does occur, momentum effects assure that disordered cohort flows occur at old ages, producing fluctuations between when the elderly population is weighted towards the younger elderly and when it is dominated by the older elderly (Pool 2003). This is the context for what we are observing in New Zealand.

But let us move beyond national populations. Let us see the effects on particular demographic factors: the sex ratio, mortality, fertility.

Sex Ratio at 30-34 Years

When I was a member of the cast of a student revue back in the 1950s we had a song about "Sweet Little Freshettes, sheltered from all forms of vice...". It ended "They'll just have to save their tender young hearts to the next boat of immigrants lands", the implications being this is how a shortfall of men would be made up. Of course, in those days the immigrants were often likely to be young British or Dutch males, rather than Asian females. I was reminded of this when I read all sorts of articles in the weekend papers about the sex ratio at, for example, 30-34 years. The conclusion seemed to be that the imbalance should be blamed on migrants, in this case Asian women migrants. Migrants have always been the scapegoats for all our ills, yet paradoxically they are also seen as the saviours of our economy. So I asked myself, were they being unfairly blamed, was that the only or real explanation for the shortage of men, or conversely the excess of women at these ages? A cross-sectional analysis might suggest this, but would taking a cohort momentum view suggest alternative explanations that would require the question to be asked again?

Let's look by gender and ethnicity at the history of the people aged 30-34 years in 2001, who were born in 1966-71. Data on them are presented in Table 1. In reviewing these data, for Non Maori most loss is by attrition, death or migration, and at these ages mortality will be a very minor factor. For Maori there is the added problem of inter-ethnic mobility. We can overcome this factor by citing figures for the total population. That said, buttressed by the sure knowledge that the Maori figures are not affected to any degree by Asian migration, or indeed by any other inflows except those of returning New Zealanders, the Maori data give us an idea of what would have happened to Pakeha if it had approximated a semi-closed population, or of what would have happened to Pakeha if replacement migration had not occurred. What shows up is that, not having compensating flows, Maori sex ratios are heavily affected by emigration; for Pakeha the effect is muted by gender differentials in inflows from other sources that are not composed of returning New Zealander.

We can look only at net effects – we do not know the composition of the various inflows and outflows. Nevertheless, the results are fascinating. Sex ratio changes are miniscule until 1986. Assuming that change in cohort size comes overwhelmingly from migration, then first emigration and then immigration play a role in shaping the sex ratio. It is the massive outflows of both sexes, but particularly males, in the periods of restructuring, and to a lesser degree the late 1990s that are the prime cause of the male deficit, or the surplus of females. This has been but partly compensated by inflows recently of non Maori females. For women, there is actually a net outflow over the period 1986 to 2001. A total of 13,800 went and 13,713 arrived. But for men the net figure was far higher: the net outflow was 22,623 but they were replaced by a mere 1,893 net inflow.

In sum a cohort analysis confirms that Asian migration may have played a role in distorting the sex-ratio. But its role was merely to counterbalance huge outflows of the resident population. And in this it was far from successful – barely so for females, not at all for males. If there is culpability for the deficit of males it rests more with radical restructuring either side of 1990 than with Asian females.

Table One: New Zealand Cohort Born 1966-71, Maori and Non-Maori by Gender

Date	Age	Maori		Non-Maori	
		Males	Females	Males	Females
1971	0-4	**	**	132,424	127,036
1976	5-9	**	**	138,414	132,355
1981	10-14	27,561	26,865	128,289	122,637
1986	15-19	24,847	24,555	128,061	122,613
1991	20-24	20,796	22,059	115,182	113,058
Difference 86-91		-4,071	-2,496	-12,879	-12,879
1996	25-29	20,343	22,809	112,110	118,041
Difference 91-96		-453	+750	-3,072	+4,983
2001	30-34	18,195	21,060	114,003	126,021
Difference 96-01		-2,148	-1,749	+1,893	+7,980

Sex Ratios

1971	0-4	**	104
1976	5-9	**	105
1981	10-14	103	105
1986	15-19	101	104
1991	20-24	94	102
1996	25-29	89	95
2001	30-34	86	90

Interpretation

- 1971-76:** Approximates normal sex ratio at birth. Non Maori of both genders grow *pro rata* through passive migration.
- 1976-81:** Non Maori of both genders decrease *pro rata* by passive emigration.
- 1981-86:** Nothing very much happens.
- 1986-91:** An interesting control is that by definition Maori are not Non-Maori and few Asians are counted as Maori. Net loss of Maori males of 1,575. Net loss of Non Maori males of 3,324. Loss of all males of 4,899.
- 1991-96:** Loss of a further 3525 males, but offset by a gain of 5,733 females. Of these, though, 750 (13 per cent) Maori, and assuming that that is some indication of a return migration, not all of the 4,983 would have been Asian.
- 1996-2001:** Loss of large numbers of Maori, and a net loss of a further 255 males. Gain of 6,231 females. Gain of 1,893 Non Maori males none of whom, by definition, could have been Asian females.

Restructuring (1986-1991) drove 16,950 males of this cohort out of New Zealand, plus 12,051 females, a surplus of 4,899 males. Changes in the early 1990s drove out a further 3,525 males, recalling that this was also the era in which both Asian males and females arrived. This was counterbalanced by the inflow of Maori and Non Maori women. Even at the end of the 1990s there was a net loss of males, driven by Maori trends.

Thus restructuring pushed out 20,475 men from this cohort, and the late 1990s saw another 2,148 go, a total loss, mainly in the period 1986-96 of 22,623, replaced by 1,893 men.

Restructuring also drove out 12,051 women, and another 1,749 went at the end of the 1990s, a total of 13,800, who were replaced by 13,713 immigrants or returning New Zealanders.

In sum, for the production of the imbalanced sex ratio top marks go to the outflows accompanying radical restructuring, and only a very distant second rank to an inflow of young women, Asian or other.

- ** The definitional changes in the 1970s produce inexplicable shifts in the size of this Maori cohort, whereas from 1981 the baseline seems to carry across to other censuses and the changes are much more explicable.

Cohort Effects in Mortality

In a paper that Jit Cheung and I have in the press (in *Genus*) at present we looked at Pakeha patterns of mortality around the dawn of the 20th century. In a paper published in the *New Zealand Population Review* we extended this analysis to the early 21st century for both Maori and Pakeha. The results were very interesting in both instances. As they are published there is no need to document them here. The analysis can be divided into two: the earlier period and the more recent.

In the earlier period Pakeha rates of infant and childhood survivorship improved dramatically between the 1870s and the early 1900s. In the cohort of 1871-76, 82 per cent of boys would reach age 10; by 1891-96, this had jumped to 88 per cent, but by 1911-16, this had climbed more gradually to 91 per cent. For girls the comparable cohort figures were 84 per cent, 89 per cent and 93 per cent. Age 10 is the crucial age to which to survive – the chances then of reaching age 50, even in a higher mortality population such as Pakeha were in the early 20th century, are reasonably high.

A feature of life-tables is that they capture the effects of differentials in the force of mortality across the life cycle. Even in higher mortality populations the force is concentrated at young and old ages, with much less impact between childhood and the late middle ages. As mortality declines, the force shifts to older ages. Even in high mortality populations a small minority reach old age and go on to very old age – the secret is getting to, say, 65 years. For Maori cohorts born at the end of the 19th century 25 per cent would have died before their first birthday; 50 per cent before the end of childhood; obviously very few were left to get to age 65 years. The very small minority who did might have included among them the odd person who reach the “oldest of the old ages” – we know one of them, Dame Whina Cooper. If we go to the opposite extreme 90 per cent of Pakeha born in 2001 can expect to reach retirement ages.

The rapid decline in the in the force of mortality at younger ages among Pakeha cohorts in the late 19th century gathered a momentum that pushed more and more people not only across into adulthood, but also to survive to reach 50 years of age. This is shown in Table 2 which relates to the probabilities of survival for cohorts across wider age ranges – from birth to age 10 years; from 10 to age 50. Gains in survival to age 10 had been through their most rapid period of change by 1896 and then slowed thereafter. The effects of gains at childhood then flowed into older ages.

This was because cohorts with more favourable experiences in terms of exposure to risk factors, and to mortality and morbidity were reaching older life-cycle stages. The underlined values show the shifts in relative force between life-cycle phases.

Table 2: Inter-cohort differences (absolute) in survivorship at childhood (0-9 years) ($_{10}p_0$) and between ages 10 and 50 years ($_{40}p_{10}$), Pakeha cohorts 1871-76 to 1931-36

Difference between the cohorts of	Males		Females	
	$_{10}p_0$	$_{40}p_{10}$	$_{10}p_0$	$_{40}p_{10}$
(1891-96) - (1871-76)	<u>0.05871</u>	0.03845	<u>0.05374</u>	0.04352
(1911-16) - (1891-96)	0.03471	<u>0.04624</u>	0.03326	<u>0.05286</u>
(1931-36) - (1911-16)	0.03968	0.02039	0.03159	0.02525

Note: greatest change per cohort underlined. There are differences in the two spans – 10 years for $_{10}p_0$ and 40 years for $_{40}p_{10}$.

This table shows that there was another factor starting to appear. The differences between the cohort of 1911-16 and that of 1931-36 had dropped off by comparison with those ahead of them, especially at ages 10 to 50 years. This signals the onset of cohort deterioration to which I will now turn my attention. In passing, one of the bitternesses my cohort can carry into old age is that we were one of the first Pakeha cohorts to suffer deterioration, and ours was one of the worst. This cohort of overfed Plunket babies suffered relatively higher levels of ill-health when we became adults.

Cohort deterioration occurs when the survivorship of a given cohort at any life-cycle phase is lower than that of its predecessor. From the Pakeha birth cohorts of the 1920s this was evident across a wide range of adult ages, particularly for males. Explanations for deterioration revolve around two alternative postulates. It could have been due to the effects of improved regimes of maternal and infant care introduced in the inter-war decades of the 20th century, regimes that permitted high-risk babies to survive to become “frail” adults; or it could have been the lifestyles adopted by the same cohorts later in life – in this case we are talking about the behaviours and environments in the 1950s and 1960s to which were exposed cohorts born in the interwar years.

Coming forward to the 1990s, a cohort view throws into question cross-sectional analyses relating to Maori health. The arguments by Blakely and his colleagues in their highly publicized work on the theme of decades of

disparities, is that the economic and social climate of the late 1980s and 1990s was such that it had direct impact on Maori-Pakeha health differentials. Our data do not lead us to reject outright this view, but instead to argue that it is simplistic. Before we hear the standard explanation, that it will all be due to ethnic definitional problems, I must add one further qualification: as Jit Cheung and I point out the deterioration was not due to changes in ethnic reporting such as a postulated over-enumeration of Maori in 1996, which, if it were true, would see denominators inflated and death rates reduced, rather the contrary to what we found. To add to problems there is the strong possibility that in the early 1990s Pacific Island deaths were misreported as Maori. If anything our results veer towards being overly conservative.

Cohort analyses show that deterioration set in as early as 1981 for some cohorts, and occurred systematically across cohorts at adult ages over the early 1990s. If Pacific Island deaths that had previously been recorded as Maori were being more carefully assigned by the end of the decade, then Maori survivorship around 1991 would have been higher than is often argued, and levels of survivorship in 2001 would have been lower than they had been in 1991. In short, there was deterioration through the decade, but a pattern foreshadowed by deterioration much earlier. We concluded "That the deterioration in 1991-96 was a residual effect of a long history of cycles of cohort gain and deterioration reinforced by period effects coming from restructuring" (Pool and Cheung 2003:123). The period effects cited by Blakely *et al.* had an impact on what was already a bio-medically vulnerable population with health needs often determined by experiences sustained many years before when these cohorts were at childhood ages.

The cohort approach that recognizes momentum effects makes a nonsense of the Wellington policy/political orthodoxy that would wish away ethnic differences in health and other factors. Socio-economic differences are very important, make no mistake, but each ethnic group also has a totally different cohort history and no amount of spurious policy analysis can eliminate the differential burden of risk that ethnic cohorts carry with them. Just take one fact: Maori women at older ages (any one childbearing before about 1975) will have had on average twice the number of children of their Pakeha peers, and thus, assuming that the physiological burden of childbearing is spread equally by parity, and that Maori women on average had access to exactly the same quality of gynaecological care as

their Pakeha peers, then the health risks associated with this, including diabetes, will be twice as high. Of course the reality is that their risks will have been greater.

Momentum Coming from Fertility Timing Changes

When a shift upwards in fertility by age occurs, there is often a hiatus as those who normally would have had their babies at young ages postpone them. This will be followed by a flush of births as women who were postponing their births then decide to have them. This was exactly the mechanism that produced the Baby Blip, a phenomenon we normally associate with Pakeha.

Table 3: Maori Age-Specific Fertility Rates (per 1000 women), 1991 and 2002

Age group	1991	2002	Difference
Less than 20 years	74	63	- 11
20-24 years	141	140	- 1
25-29 years	118	128	+ 10
30-34 years	70	98	+ 28
35-39 years	30	49	+ 19
40-44 years	7	13	+ 6

In contrast, for Maori the force of fertility has notably been towards younger ages. Yet if a longer perspective is taken, between 1991 and 2001, a gradual shift is seen to be taking place, as is shown in Table 3. These data suggest that Maori may be embarking on a new phase in their family transition, the first being the radical decline in family sizes in the 1970s, and the present one a move upwards in the patterns of family building. The net result of this shift-share amounts to an increase in fertility, the equivalent of 0.25 live births per woman. This is, in fact, most of the difference between the TFRs of 1991 (2.19) and those of 2002 (2.47). The question arises, then, whether the increases in Maori fertility in the late 1990s, normally attributed to definitional changes, were not due in part, or even instead, to changes in the rhythm of Maori childbearing, and the momentum this has introduced.

The year 1991 saw the ending of the old pattern of very early childbearing, which came about by very rapid decreases in fertility at older maternal ages, a typical stage in a rapid fertility transition (see Pool 1991). Let us not forget that Maori went through a very rapid Baby Bust in the 1970s and 1980s. In contrast, by 2001 the onset of the new pattern had occurred. If the growth in the TFR had been purely through definitional change, as is frequently argued, then we would not have seen such a systematic shift from early to late childbearing.

Conclusion

Cross-sectional analyses often produce misleading results. This is particularly true of demography which by its nature is a diachronic science, not a synchronic one. We are interested in changes over time, and thus varying period effects. But we are a life science also interested in changes over the life cycle. And we are interested in the intersection of these.

As individuals carry their earlier experiences with them, so too do generations. This produces an impetus in the behaviour of cohorts, an impetus we call momentum. Often in fact this momentum will be driven by inexorable forces.

I have shown here through case studies that momentum effects are very real, and that by ensuring that they are taken into consideration a much more valid picture can be gained of demographic patterns and trends. My argument is that we must put the analysis of momentum into all serious demographic research – synchronic analyses may suffice for the “lesser breeds” of disciplines, but not for one that traces its genesis to the very foundations of modern science.

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