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Since 1960 South Africa has seen a steep fall in fertility levels and currently the total fertility rate is the lowest on the African continent. Given the high prevailing levels of fertility in African countries, a better understanding of the factors behind the fertility transition can be valuable not only for South Africa, but also more widely for other African countries.

This paper uses the National Income Dynamics Study data to construct a retrospective panel to investigate reasons for the decline in fertility in South Africa since the 1960s. The analysis attributes a large share of the observed fertility decline across birth cohorts to improving education levels and the lower prevalence of marriage. However, a considerable segment of the transition is ascribed to the unobservables. This may include HIV/AIDS, the increased use of contraceptives and changes in both intra-household relationships and the social role of women.

1. Introduction

South Africa has witnessed a decline in fertility since the 1960s. According to the estimates of Moultrie and Timaeus (2003) total fertility rates were around six children per female in the 1960s and by the 1990s it had dropped to between 3 and 4. While some authors contend that the drop in fertility has been remarkably sharp (Swartz, 2002; Kaufman, 1997), this is not universally acknowledged and Caldwell and Caldwell (1993) argue that given South Africa's state of development and the resources invested in promoting family planning one may have expected a steeper decline.

What is however not disputed is that this is the furthest fall in fertility witnessed on the African continent (Moultrie & Timaeus, 2003). Given the concern regarding the relatively high fertility rates that prevail in African countries, understanding the factors behind the decline in South African fertility may be significant and valuable not only within the South African context, but also more widely.

The National Income Dynamics Study (NIDS) data provide a rare opportunity to better understand the fertility patterns over this era. Not only does it provide a window unto fertility patterns over the past three decades, but the richness of the data also allows us to examine the factors that influenced the fertility decisions during this era. This is a significant period because as Moultrie and Timaeus (2003) show, the steepest fall in South African fertility occurred since the mid-1980s. The data enable the construction of a panel to model fertility decisions using female respondents' detailed birth histories and a matching panel of variables based on a range of retrospective questions.

This approach represents at least three significant contributions to the existing literature. Firstly, as far as the authors know, there have been no previous attempts to examine the South African fertility decline using a multivariate framework with a large number of regressors. Secondly, the richness of the NIDS data enables us to incorporate influences that are frequently omitted from the analysis of fertility decisions including the effect of schooling, economic fluctuations and past fertility outcomes. This is significant because the inclusion of these variables will reduce concerns about the possible contamination of coefficients via omitted variables. Lastly, the panel approach allows us to use a model specification with period and individual fixed effects that enhances the robustness of coefficient estimates to endogeneity.

The paper starts with an overview of the fertility decline, documenting patterns and trends and outlining the main literature. Section four outlines the empirical approach and section five reports the results. Section six concludes.

2. Background

The decrease in fertility rates in South Africa is well documented (Caldwell & Caldwell, 1993; Moutrie & Timæus, 2003; Udjo, 1998; Chimere-Dan, 1997; Department of Health, 1998). South African fertility has shown a strong decline since the 1960s. White fertility was already at reasonably low levels in the 1960s and the decline in fertility was therefore largely led by a decline in African and Coloured fertility.

Moultrie and Timæus (2003) compare the 1998 DHS, 1996 and 1970 census data to estimate trends between 1948 and 1996. They find that fertility for the African population started to decline gradually from the 1960s onwards and then the decline accelerated in the 1980s. Where the total fertility rate for African women was around 7 children in the late 1950s, this had declined to 3.5 by 1996. The largest share of this decline happened since the mid-1980s.

In our empirical analysis we consider the fertility decisions of women who were born after 1960, and who would have been at their peak reproductive years between the mid-1980s to the mid-2000s. This covers the period during which the steepest drop in the fertility decline occurred. In this section we describe the most significant government interventions and the factors that affected social institutions and norms. Because the aim is to capture the main formative influences for our sample of women, we consider the period from the 1970s onwards – when those born in 1960 would have been in their teens.

One of the most prominent explanations for this steep observed decline in fertility is the apartheid government's notorious population control programme. The programme aimed to promote family planning via a combination of supply measures (making contraception more widely available, providing information on family planning) and demand measures (advancing education, primary health care and the economic participation of women) (Caldwell & Caldwell, 1993; Swartz, 2002: 54; Chimere-Dan, 1993: 34). The impact of the population policies may have been enhanced by rapid urbanization that brought individuals born and raised in rural areas in contact with city dwellers who generally had more exposure to and awareness of contraceptive methods. (Moultrie & Timæus, 2001: 210; Moultrie & Timæus, 2003: 280).[1]

Over this period there was a significant shift in the motivation and aims behind these policies. Policies such as the 1974 state-funded National Family Planning Programme were motivated by apartheid era ideologies and intended to curb African population growth rates to avoid the 'population bomb' (Kaufman, 1997: 24-25; Moultrie, 2005). The programme included controversial measures such as the contraceptive injection Depo Provera and ambitious targets for sterilisation (Brown, 1987). Since 1994 the focus has been increasingly on improving the health and status of South African women. The Choice on Termination of Pregnancy Act was introduced in 1996 and this policy made it easier for women to have safe and legal abortions. The effect was an increase in the rate of legal abortions and a decrease in maternal deaths during birth. In 1998 a new population policy was launched and it was completely detached from population growth and focussed on improving the status of women and changing male perspectives on contraception (Cooper *et al.*, 2004).

Due to the high cost of these population programmes, there is considerable debate on their effectiveness. Surveys show that contraception knowledge and usage is much higher in South Africa than in other African countries. According to the Demographic and Health Survey of

[1] From 1987 to 1989, 56 per cent and 74 per cent of women in Johannesburg and Cape Town respectively used contraception methods, while only 43 per cent of rural inhabitants practised a form of contraception (Caldwell & Caldwell, 1993: 247). These differentials form part of a well-established relationship: Moultrie and Timæus (2001: 210) show that by 1993 African fertility was still 15% lower in metro areas than in rural areas - after controlling for a range of other related influences.

1998 all South African female respondents were aware of at least one way to prevent pregnancy, while three-quarters of women reported that they had used contraceptive methods (Department of Health, 1998: 18-20). This is considerably higher than rates for the rest of Sub-Saharan Africa: similar surveys show that 66 percent of women in Cameroon, 49 percent of women in Sudan and 40 percent of women in Senegal had never heard of any method of pregnancy postponement and in Sudan and Senegal the share of women who made use of contraceptives was below 6 percent (Bongaarts *et al.*, 1984: 526).

It is difficult to ascertain to what extent high levels of contraceptive use can be attributed to the population programmes because there were also large shifts in the demand for contraception over this period that were unrelated to these programmes. The population programmes provided women with access to family planning services and contraception, but changing social norms around female fertility ensured that there was a strong demand for such services.

This period also witnessed dramatic shifts in the social norms relating to fertility.[2] These shifts occurred in response to the restrictive apartheid era migrant labour system that regulated the flows of African workers.[3] Under this system African men often had to leave their wives and children behind in rural homelands areas to seek work in the cities. The long absences of the men created considerable financial and social uncertainty and placed much strain on these households. Women responded by attempting to gain more control over their own lives and many eventually started to function as the heads of their households (Swartz, 2002). As predicted by Notestein's demographic transition theory, the women responded to the precarious situations that they faced by trying to secure their own income flows, delaying or avoiding marriage (Kaufman, 1997: 22; Zwang & Garenne, 2008: 102) and limiting fertility.

It is interesting to note that there appears to be an interaction between the delaying or

[2] The pioneer of the demographic transition theory, Frank Notestein, emphasised that high fertility rates are associated with collective norms that favour the notion of the extended family over that of the individual and traditional institutions and structures that create few prospects for women outside of the orthodox roles of wife and mother (Notestein, 1953).

[3] Ten homelands were demarcated as areas where Africans would reside. Africans working in cities in the rest of South Africa were treated as guests and required permission to stay from the authorities. This permission to stay was captured in their passbook, which they had to always carry with them (Kaufman, 1997). Section 10 of the 1951 Native Laws Amendment Bill required that Africans could not stay in an urban area for longer than 72 hours unless they were born there or had stayed there for at least 15 years or had worked for one employer continuously for ten years. Dependents of individuals satisfying these conditions were also allowed if they usually lived with the workers and had entered the area legitimately.

avoidance of marriage and the limiting of fertility. Palamuleni *et al.* (2007: 127) argue that women who are not married may find it easier to limit the number of children they want to have because there are fewer restrictions and expectations from family members and husbands regarding ideal family size. Many authors (Swartz, 2002; Kaufman, 1997) have noted that the decrease in marriage rates – especially amongst African women – reinforced the fertility decline. However, Chimere-Dan (1997) finds that lower marriage rates have had a weaker than expected impact on fertility due to the breakdown of the traditionally strong relationship between marriage and fertility – especially amongst younger women. Nzimande (2007) argues that higher pre-marital fertility may be partly due to the postponement of marriage and shows that pre-marital fertility is more prevalent in co-habiting unions.

The market responded to the growing independence of women and the associated attempts to secure their own livelihood with a gradual broadening of the space for female employment. Formal restrictions were lifted and there was a reduction in gender bias and discrimination. Significantly, Burger and Von Fintel (2009)'s analysis of labour market trends show that there has been a gradual convergence in male and female participation rates as well as the likelihood of male and female employment over birth cohorts ranging from the 1930s to the 1990s.

It is likely that fertility decisions have also been affected by shifts in intergenerational household dynamics that occurred over this period. Caldwell (1976) contends that because wealth tends to flow upward, from younger to older generations, in developing countries, it is a natural response for households to have more children to increase this flow of income. In such an environment children function as a type of old-age pension. This theory is relevant for South Africa because the escalation of pension payments to African senior citizens over this period is likely to have muted intergenerational reliance within this group and this would have reduced the influence of concerns about security in old-age on fertility decisions.

One of the puzzles relating to the South African fertility decline is why fertility initially fell quite slowly. Moultrie and Timæus (2003) confirm that the largest share of the drop in fertility has occurred since the mid-1980s. Yet most of the social and institutional forces described here have been operating for much longer. However, Moultrie and Timæus (2003) argue that the delayed reaction may be attributable to 'the structural constraints on African women under apartheid, that is on their mobility, livelihoods, and access to reproductive health delivery systems, [and not related to] any recalcitrance or lack of desire on the part of women to limit their fertility' (280). Conversely, the steep decline since the 1980s is viewed as a reflection of the 'gradual freeing up of South African society' (2003: 280).

3. Literature survey

There have been a large number of studies investigating fertility decisions in South Africa. Overwhelmingly, attention has been concentrated in five areas, namely the government's population policies (Caldwell & Caldwell, 1993; Kaufman, 1997; Moultrie & Timæus, 2003; Swartz, 2002; Chimere-Dan, 1993; Cooper *et al.*, 2004); changing social norms and institutions – including notably, marriage (Palamuleni *et al.*, 2007; Swartz, 2002; Kaufman, 1997; Moultrie & Timæus, 2001); the role of age (Chimere-Dan, 1997; Moultrie & Timaeus, 2003); the role of geography (Moultrie & Timæus, 2003; Moultrie & Dorrington, 2004) and also the effects of HIV/AIDS[4] (Moultrie & Timæus, 2003; Garenne *et al.*, 2007).

While there has been some attention to the role of educational attainment in fertility decisions (e.g. Department of Health, 1998; Moultrie & Timæus, 2001) the literature is relatively sparse given the importance of the topic. According to theory and the international literature higher levels of education decrease desired fertility and close the gap between desired and unwanted fertility. Education affects these outcomes via various channels. More educated mothers generally have higher earning potential and therefore the opportunity cost of child-rearing is higher when measured in terms of foregone salaries and wages. Higher education levels may also increase a woman's awareness and knowledge of family planning and contraception. Given that there has been a dramatic rise in educational attainment for African women over this period, this would be an important hypothesis to examine.

With the exception of a brief mention in Moultrie and Timæus (2001), studies examining the relationship between income and fertility are also largely absent from this literature, despite strong theoretical arguments and international studies suggesting that it could play an important role. According to Becker (1960: 209) 'the development and spread of knowledge about contraceptives during the last century greatly widened the scope of family size

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[4] Women who know that they are HIV positive might be more reluctant to have children (Moultrie & Timæus, 2003: 281) due to the associated risks. However, Zaba and Gregson (1998) find little evidence of behavioural changes and conclude that HIV/AIDS may rather work via the symptoms and medical outcomes associated with the disease. These include a decrease in Spermatozoa in men who have progressed to AIDS; an increased risk of foetal loss amongst HIV-positive women; an increased vulnerability to other sexually transmitted infections which reduce the chance of conception; and an increase in mortality amongst women in their child-bearing years (Garenne *et al.*, 2007). Kalemli-Ozcan (2006) expects HIV/AIDS to increase fertility because women may react to increasing mortality by having more children. However, it is important to note that this theory is based on cross-country data from the entire continent and not necessarily applicable to the South African context specifically.

decision-making' and this has created more space for economic variables to feature in a significant way in fertility decisions.

According to Turchi (1975) and Becker and Tomes (1976) the household fertility decision can be viewed as a trade-off between whether scarce time is spent having and raising children or rather on other desirable activities. This trade-off is subject to a budget constraint, which is determined by the rate at which the household members' time can be transformed into consumer goods and services through the wage rate. Hence, Becker (1960: 211) argues that a long-run increase in income will lead to an increase in the demand for children. However, higher income may also discourage fertility because rising wages increase the opportunity cost of raising children. The first influence is described as an income effect and the latter as a substitution effect. Ex ante, it is not clear which of these two influences would dominate (Ben-Porath, 1974: 189).

Lastly, there also appears to be only a few studies (e.g. Aggarwal *et al.,* 2001) that consider how fertility decisions are shaped by previous fertility outcomes such as the gender of children or the death of a child.

The literature suggests that a household can anticipate or react to the risk of a child dying in at least two ways: by replacement behaviour or by hoarding behaviour. Replacement behaviour is backward-looking: when a child is lost, he or she is replaced by having another child. Hoarding behaviour happens when ex ante there is compensation for the potential loss of a child by having more children (Birdsall, 1988: 519). Hoarding behaviour is usually prominent in a country when the child mortality rate is high, and the over-compensation for the possibility of child loss naturally leads to higher fertility.

Similarly, internationally there is evidence that strong gender preferences may boost fertility because childbearing will continue until the ideal number of boys or girls have been born. Research has shown that there is a strong preference for boys in some regions (Bhat & Zavier, 2003: 637; Clark, 2000; Campbell & Campbell, 1997; Das, 1987; Hartmann, 2010). This gender bias is often attributed to the higher income-earning capability of the males in certain societies, and therefore their ability to provide better old-age support to parents.

The lack of attention to the influence of educational attainment, income and past fertility outcomes are seen as shortcomings of the existing literature and the inclusion of these variables in our analysis is seen as part of the contribution of this paper.

However, the major contribution of the paper is in terms of its empirical approach that allows it to consider the influence of a large range of factors on the fertility decline observed in South Africa using a multivariate retrospective panel approach. Significantly, this also allows us to control for both confounding individual and period fixed effects that can contaminate coefficient estimates.

Traditionally the empirical approaches found within this broad literature fall into three categories. Firstly, a substantial share of the work examining social norms and government's population policies is qualitative and descriptive. Examples include the work of Moultrie (2005), Kaufman (1997) and Brown (1987).

Then, there are also a large number of studies that employ quantitative analysis, but restrict the focus largely to an in-depth analysis of one or two important bivariate relationships such as that between fertility and education or fertility and age. Conventionally, the work would use a cross-sectional data set. Examples are Udjo (2001) who considers the relationship between marriage and fertility using the 1996 Census and Camlin, Garenne and Moultrie (2004)'s examination of the impact of HIV/AIDS on contraception and fertility using retrospective fertility data from surveillance sites and the Demographic and Health Survey of 1998.

Additionally, there are also a number of studies that have used multivariate regression analysis to study the factors behind fertility decisions at a specific point in time. Examples of such studies include Aggarwal, Netanyahu and Romano (1997)'s multivariate tobit regressions using the Project for Statistics on Living Standards and Development survey of 1993 and Palamuleni, Kalule-Sabiti and Makiwane (2007)'s predictions of the total fertility rate based on the Davis and Blake (1956) model and using the 1998 Demographic and Health surveys.

The next section will discuss the empirical approach of this paper in more detail.

4. Empirical framework

As explained in the introduction, in this paper we construct a model to explain fertility decisions using female respondents' detailed birth histories and a matching panel of variables based on a range of retrospective questions. Our aim with this analysis is to gain insight into the factors that contributed to the steep fertility decline in South Africa. The data and methodological approach used to achieve these goals are discussed below.

4.1 Omitted variable bias

Suppose the number of live births for individual i in year t, y_{it}, can be expressed as

$$y_{it} = \theta(a_{it}) + \boldsymbol{x_{it}\beta} + \eta_i + \tau_t + u_{it} \qquad [1]$$

where $\theta(.)$ represents the potentially non-linear effects of age, a_{it}, $\boldsymbol{x}_{it}$ is a vector[5] that contains other observable determinants of fertility, η_i and τ_t represent unobservable individual- and time-specific fertility effects and u_{it} represent unobservable determinants that vary across time and individuals. In this case the individual fixed effect, η_i, captures individual fertility determinants that are unobserved by the econometrician and do not vary over time, and includes time invariant aspects of individual reproductive health, attitudes and preferences. Time-varying factors, τ_t, that are common across individuals may include government policies with respect to family planning, HIV incidence rates, or the availability of different types of birth control.

There are various ways in which attempts to estimate the coefficient vector $\boldsymbol{\beta}$, could go wrong. Firstly, our regression model may omit fertility determinants that are correlated to our regressors, which would induce omitted variable bias in our coefficient estimates. Suppose we are interested in the causal effect of schooling (which is observed in the data and hence included in the $\boldsymbol{x}_{it}$ vector) on fertility. A bivariate regression or cross-plot using cross-sectional data will produce unbiased estimates of these effects if all other fertility determinants – which are now reflected in the model error terms – are mean independent of schooling. In reality, there are a number of observable factors (such as marital status, income, province of residence) as well as unobservable factors (e.g. labour market preferences, knowledge regarding family planning) that may be correlated with schooling. In such cases, the regression results will not tell us anything about the causal effect of schooling on fertility.

In the absence of valid instruments for all of the determinants of interest, the only way to estimate these effects is to control for all fertility determinants that may be correlated to our variables of interest. Naturally, our ability to do this depends on the data at our disposal. Some of the determinants of fertility, such as schooling, marital status and geography, are readily available from most household surveys. Other determinants, such as the complete

[5] Variables in bold are vectors rather than scalars.

birth history, infant mortality, reproductive health and contraceptive usage, are usually only recorded in specialised demographic surveys. A third type of characteristic is inherently unobservable – personality type, fertility preferences, expectations about the future, the nature of the household decision making process, the details of the institutional framework that shapes the incentives to have children – and can only be dealt with using some combination of instrumental or fixed effects estimators, proxy variables and heroic behavioural assumptions.

The NIDS dataset offers a unique opportunity to study the effect of South African fertility determinants of the first type in a way that is less vulnerable to omitted variable bias than was the case for most of the studies discussed in section 3. The empirical analysis in this paper uses a multivariate regression approach on an individual-level panel dataset constructed from the NIDS data. Although the survey is cross-sectional, respondents were asked questions regarding education, fertility, migration and marital status retrospectively, and this information can be used to construct a panel data set. In addition to the retrospective panel feature, the NIDS data set has a considerably larger set of variables than the Census and a larger sample than the Demographic and Health Surveys (DHS).

However, the NIDS data also poses a few specific challenges. Retrospective panels invariably suffer from recall bias, particularly for events that occurred infrequently or long ago, or that were not particularly noteworthy (Baddeley, 1979: 25). Although this is less of a problem in surveys that use multi-pronged questions[6] (as was the case in NIDS) one would still expect fertility to be under-captured. Furthermore, using the 2008 sample of individuals to construct past fertility behaviour is complicated by non-random mortality that would make the current population an unrepresentative sample of older generations. Both of these problems are likely to grow in severity, the further into the past our retrospective sample reaches. For this reason, we restrict our attention to women born after 1960. The data appendix to this paper outlines a few external validity tests that demonstrate that the NIDS retrospective panel is able to accurately replicate fertility behaviour since 1985, which is approximately when women born in 1960 would have reached their peak age-specific fertility rate.

Another potential problem, discussed in the data appendix, is that some of our control variables are measured with error. Ideally, we would like to control for province of residence and individual income in our regression, but the NIDS questionnaire did not ask questions

[6] Blacker and Brass (1979: 49-50) attribute a large part of measurement error in retrospective fertility data to shortcomings in survey structure. When a multi-pronged question approach is used the margin of error for retrospective fertility outcomes is found to be much lower than in cases where a single survey question is used.

that would allow us to construct precise time-varying measures for these variables. In the case of the province variable, individuals were only asked where they resided at birth, in 1994, 2006, 2008 and before their final move. This information can be used to construct a noisy measure of province of residence, which differs from the true province by a random measurement error term. Even though this variable is not as informative as knowing in which province the individual resided in each period, it can still solve the omitted variable problem as long as the measurement error term is uncorrelated to the other model regressors[7]. By a similar argument, the inclusion of a measure of the average per capita income by race and year is expected to produce less biased coefficients estimates than would be obtained without any measure of income.

4.2 Age, cohort and period effects

Equation [1] can be rewritten in terms of the average level of individual fixed effects for those women born in the same year:

$$y_{it} = \theta(a_{it}) + \boldsymbol{x}_{it}\boldsymbol{\beta} + \delta_c + \tau_t + e_{it} \qquad [2]$$

where $\delta_c = E(\eta_i | c_i = c)$ and $e_{it} = u_{it} + \eta_i - \delta_c$. In this case δ_c captures the effect of cohort-specific unobservable fertility determinants for all individuals born in birth year c. Certain research questions require estimating each of the age, cohort and period effect profiles, but this poses an identification problem: an individual's age is the difference between the current year and their birth year, and hence these three effects cannot be separately identified without imposing additional restrictions. The tension between these three factors have additional significance in this context due to the fierce debate amongst demographers between the choice between the period and cohort approach (e.g. Bhrolchain, 1992).

In certain research questions such restrictions naturally present themselves, which allows the disentangling of these effects. For example, Deaton (1997: 126) proposes restricting time effects to be orthogonal to time when these effects are assumed to vary in a cyclical manner that averages to zero in the long-run[8]. However, when both time and cohort effects are expected to have long-run trends, this restriction is not an option. Browning *et al* (2012) review a number of commonly used restrictions, including the so-called intrinsic estimator of Yang *et al* (2004), but find that the age, cohort and period profiles differ substantially depending on these identifying assumptions. In a similar vein, McKenzie's (2006) finds that the curvature of these profiles can be uniquely identified, but that the slopes and levels depend

[7] See Wooldridge (2002: 64) for an analogous discussion on the use of proxy variables.

[8] For a recent application of this method to South African labour market data, see Burger and Von Fintel (2009).

on the nature of these additional restrictions. Since this paper is primarily interested in estimating the effect of a number of observable fertility determinants, and knowing how these factors contributed to the fertility transition, we will not attempt to disentangle the cohort and time effects.

4.3 Fertility transition decomposition

Apart from estimating the effect of specific fertility determinants, we are also interested in knowing how important these factors were in explaining the South African fertility transition. There are many ways to frame this transition, but in our analysis below we specifically look at the declining probability of giving birth associated with women born in later birth years. Stated in terms of the fertility model in equation [2], we want to explain why $E(y_{it}|c_1) - E(y_{it}|c_2) > 0$, where c_1 is assumed to represent an older birth cohort than c_2. Women from younger generations may have fewer children because they possess observable characteristics $\boldsymbol{x}_{it}$ that are less conducive to high fertility, or because the unobservable fertility determinants that they faced over their reproductive lifetimes were consistent with lower birth rates. Importantly, our identification strategy does not allow us to determine whether those unobservable effects were cohort- or period-specific. The average unobservable fertility effects faced by a woman of cohort c, $E\left(\delta_{c(i)} + \tau_t|a_{it}, c\right)$, arises both from possessing certain cohort-specific unobservable attributes, δ_c, as well as being of reproductive age in a time during which certain period effects, τ_t, occurred. We can attempt to identify the importance of each of the observable fertility determinants by decomposing the change in the expected birth cohort fertility rate.

Conventional decomposition methods – such as the Oaxaca-Blinder approach (Blinder, 1973; Oaxaca, 1973) – is inappropriate in this context, because in our retrospective panel women from different birth years are observed at different ages. Specifically, women from older generations are also observed at older ages, whereas this is not the case for members of younger generations. Decompositions that do not take this into consideration will mistakenly ascribe any life-cycle variation in the explanatory variables (such as the likelihood of being married increasing with age) to cohort-level differences in the expected values: $E(\boldsymbol{x}_{it}|c_1) - E(\boldsymbol{x}_{it}|c_2)$.

For this reason, we also want to condition on age when we compare fertility rates. This allows us to decompose the conditional fertility decline more sensibly between two birth cohorts as $E(y_{it}|a_{it}, c_1) - E(y_{it}|a_{it}, c_2) = \delta_{c_1} + E(\tau_t|a_{it}, c_1) - \delta_{c_2} - E(\tau_t|a_{it}, c_2) + \{E(\boldsymbol{x}_{it}|a_{it}, c_1) -$

$E(\boldsymbol{x}_{it}|a_{it}, c_2)\}\boldsymbol{\beta}$ [3]

In order to apply this method, the population of African women is divided into five-year birth cohorts, and the average conditional fertility decline between two successive cohorts is decomposed. Conditional fertility rates and observable characteristics are estimated by regressing birth rates and the model regressors on an exhaustive set of age and birth cohort dummies, and taking the appropriate predicted values.

5. Empirical analysis

5.1 The determinants of South African fertility

We now estimate the model presented in equation [2] using the NIDS retrospective panel data. The dependent variable is the number of live births in a given year. Multiple births in one year are fairly rare – 345 out of a total of 19,335 births – so this is similar to a binary fertility variable. The sample is restricted to women in their reproductive years (ages 15 to 49) and – in order to address concerns regarding the sample selection issues that arise due to non-random mortality and recall bias – to those born after 1960. The age and birth year functions are both approximated using splines with 5-year gaps between the knots, whereas the schooling effect is modelled as a spline with different slopes for primary, secondary and tertiary schooling.

Table 1 reports the estimated coefficients for our fertility model: columns 1 to 4 estimate equation [2] for all South African women, African, Coloured and White[9] women respectively, using OLS, and column 5 estimates equation [1] for African women using the two-way fixed effects (2FE) estimator, which allows for unrestricted individual and time effects. Starting with the fertility outcome for all races, we observe that the probability of giving birth increases rapidly between the ages of 15 and 20, and then more slowly until peaking at 25, after which point fertility declines with older age. This is consistent with the age-profile estimated in Figure A2 shown in the appendix. The results in columns 2 to 4 show a similar age pattern for each of the races, although fertility is quicker to decline for White women once they reach 30. [10] The race coefficients in column 1 demonstrate that even after controlling for differences in schooling, relationship status, geography and infant mortality, African and Coloured women have higher fertility rates than White and (particularly) Indian women.

[9] Given the small number of Indian women in the sample and the consequent measurement problems, the results from the fertility regression for this population group on its own are omitted.
[10] Due to perfect multicolinearity between age, year and birth year, the age coefficients in the 2FE regression cannot be sensibly compared those in the other columns.

There is a negative and significant relationship between the income growth rate and fertility (column 1), which demonstrates that the fertility rate is countercyclical for South African women as a whole. The income effect is therefore shown to dominate the substitution effect for fertility. The race-specific results show that this effect is only significant for African women. Although the coefficient estimate on the log per capita income variable in the regression for all women is positive, its estimated effect is small and statistically insignificant. The effect is also insignificant for women of each of the race groups. Both of these effects are omitted from the 2FE regression due to being linearly dependent on the set of time dummies.

The education spline coefficients reveal that moving from no schooling to completed primary schooling increases the probability of giving birth, but that each additional year of secondary or tertiary education decreases this probability. At first glance this may appear counterintuitive, but is in line with previous findings for developing countries showing a non-linear and inverse u-shaped relationship between education and fertility (Jejeebhoy, 1995; Cochrane, 1983; United Nations, 1987). Although the primary school effect is significant, it is relatively small compared to the much larger decrease in fertility associated secondary and tertiary education.. The race-specific regressions reveal the same schooling-fertility pattern for each of the population groups, and these results are robust to making allowance for two-way fixed effects in the model.

The relationship status coefficients for the total population show that being married or in a long-term relationship substantially increase the probability of having children relative to someone who has never been married (the reference group), whereas this probability is only slightly higher for women who are divorced or widowed. However, this pattern varies between the population groups. White and Coloured women who are in long-term relationships are no more likely to have children than women who have never been married, whereas African women in long-term relationships have almost the same probability as married women. Widowed and divorced Africans have the same low fertility rates as the never-married, whereas this rate is significantly higher for White divorcees. Again, this result survives the 2FE specification, which means that it is not driven by a correlation between marital status and unobservable period or individual fertility effects.

The number of existing children variable captures the impact of the number of previous children on a woman’s future fertility outcomes. The relationship is shown to be negative and significant: the more children a woman has had, the fewer she is likely to have in the future.

The replacement effect coefficient estimate is positive and highly significant, which shows a strong inclination for women to react to the death of a child by giving birth to more children. Both the previous children and child replacement effects are stronger for White than for African women, with the effect for Coloureds lying in the middle. This behaviour may provide tentative evidence of a stronger role of a desired or targeted family size amongst Whites.

Both gender bias variables are positive and significant for the population as a whole. Women are therefore more likely to have more children if they have not yet had both boys and girls. The sizes of these coefficients are very similar, which suggests a preference for having a gender mix but no bias in favour of children of either gender. This is surprising given the gender bias in favour of boys found in other countries, often attributed to the higher income-earning capacity of males in certain societies (Hartmann, 2010: 6). The results in columns 2 to 4 show that this pattern mainly applies to African women, whereas Coloured and White women have no observable preference for mixed genders.

Our estimates also support previous results by Palamuleni *et al.* (2007: 123) who found that fertility was the highest in Limpopo, Mpumalanga and KwaZulu Natal and the lowest in the Western Cape, Gauteng and the Free State. The population group-specific regressions are broadly consistent with this provincial pattern with the exception of the Free State, which is a high fertility province for White and Coloured women, but a low fertility province for African women.

The birth year splines shows that even after controlling for other observable characteristics, there was still some combination of generation- and period specific unobservable factors that led to declining fertility for women born between 1965 and 1970 (women who would have reached peak fertility between 1980 and 1985). The race-specific regressions reveal that this fertility decline was mainly driven by African women, whereas Coloured and White women show no significant birth year effects.

Table 1: Fertility probability regression results

VARIABLES	[1] All OLS	[2] African OLS	[3] Coloured OLS	[4] White OLS	[5] African 2FE
Age spline (15,20)	0.0305***	0.0314***	0.0306***	0.0198***	0.0447***
Age spline (20,25)	0.0013	0.0006	0.0026	0.0066	0.0221***
Age spline (25,30)	-0.0065***	-0.0066***	-0.0101**	-0.0003	0.0130***
Age spline (30,35)	-0.0077***	-0.0072***	-0.0031	-0.0166**	0.0096***
Age spline (35,40)	-0.0103***	-0.0101***	-0.0085	-0.0046	0.0017
Age spline (40,45)	-0.0048**	-0.0058**	-0.0008	0.0058	-0.0007
Age spline (45,55)	-0.0211***	-0.0190*	-0.0403*	-0.0361	-0.0126
Birth year spline (1960,1965)	0.0025	0.0031	-0.0028	0.0032	
Birth year spline (1965,1970)	-0.0046***	-0.0049***	0.0027	-0.0009	
Birth year spline (1970,1975)	-0.0025	-0.0025	-0.0022	-0.0031	
Birth year spline (1975,1980)	0.0002	0.0001	0.0036	-0.0024	
Birth year spline (1980,1985)	0.0006	0.0005	-0.0034	0.0047	
Birth year spline (1985,1990)	-0.0003	-0.0007	0.0069	-0.0041	
Coloured	-0.0159**				
Indian	-0.0422***				
White	-0.0382***				
Education spline: primary	0.0032**	0.0027**	0.0093**	0.0082	0.0061
Education spline: secondary	-0.0106***	-0.0098***	-0.0141***	-0.0085	-0.0128***
Education spline: tertiary	-0.0070**	-0.0148***	-0.0086	-0.0058	-0.0283***
Married	0.0779***	0.0776***	0.0850***	0.0836***	0.0992***
Long-term relationship	0.0552***	0.0594***	-0.0034	0.0038	0.0666***
Widowed	0.0178	0.0140	0.0275	-0.0034	0.0168
Divorced	0.0233*	-0.0042	0.0313	0.0561*	-0.0265
Children	-0.0064**	-0.0048*	-0.0195***	-0.0359***	-0.1057***
Replacement effect	0.0289***	0.0261***	0.0450**	0.0644**	0.0715***
No boys	0.0263***	0.0294***	0.0207	-0.0151	0.0830***
No girls	0.0258***	0.0238***	0.0069	-0.0045	0.0855***
Eastern Cape	0.0097	0.0080	0.0230	0.0509*	-0.0461
Northern Cape	0.0170*	0.0076	0.0264*	0.0380	-0.0022
Free State	-0.0096	-0.0158	0.0210	0.0300	-0.0004
Kwazulu-Natal	0.0255***	0.0220**	0.0097	0.0191	0.0651
North-west	0.0188**	0.0168*	0.0866***	0.0082	-0.0129
Gauteng	0.0099	0.0089	0.0295	0.0104	0.0343
Mpumalanga	0.0283***	0.0261***	-0.0305	0.0196	0.0640
Limpopo	0.0251***	0.0217**	0.0093	0.0546*	0.0845*
Outside SA	0.0043	0.0080	0.0040	-0.0057	0.0615
Income growth rate	-0.1686*	-0.2007**	-0.3152	-0.2910	
Log of per capita income	0.0008	-0.0088	0.0819	0.0039	
Constant	-0.4977***	-0.4695***	-0.8855**	-0.3477	-0.8923***
Observations	80,602	62,937	13,089	5,004	62,937
R-squared	0.037	0.035	0.039	0.055	0.096
Number of pid					4,164

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

5.2 Explaining the South African fertility transition

The decomposition method developed in section 4.3 is now used to decompose the fertility decline for African women born in different five-year intervals. Note that we are comparing the effect of changes in the fertility determinants on the expected number of births[11] given by women from different birth cohorts, rather than by calendar years. The values reported under 1960-1964 therefore correspond to the change in the number of children a women born between 1960-1964 can expect to have compared to a women born between 1955-1959. The results are presented in Figure 1 and Table 2 below and reveal that the largest part of the fertility decline can be ascribed to increasing education, changing relationships, and

[11] This is calculated by taking the effect on a women's probability of giving birth in a single year, and multiplying by 35 (the assumed duration of a women's reproductive life).

unobservable factors.

Figure 1: Decomposition of the South African fertility decline, per birth decade

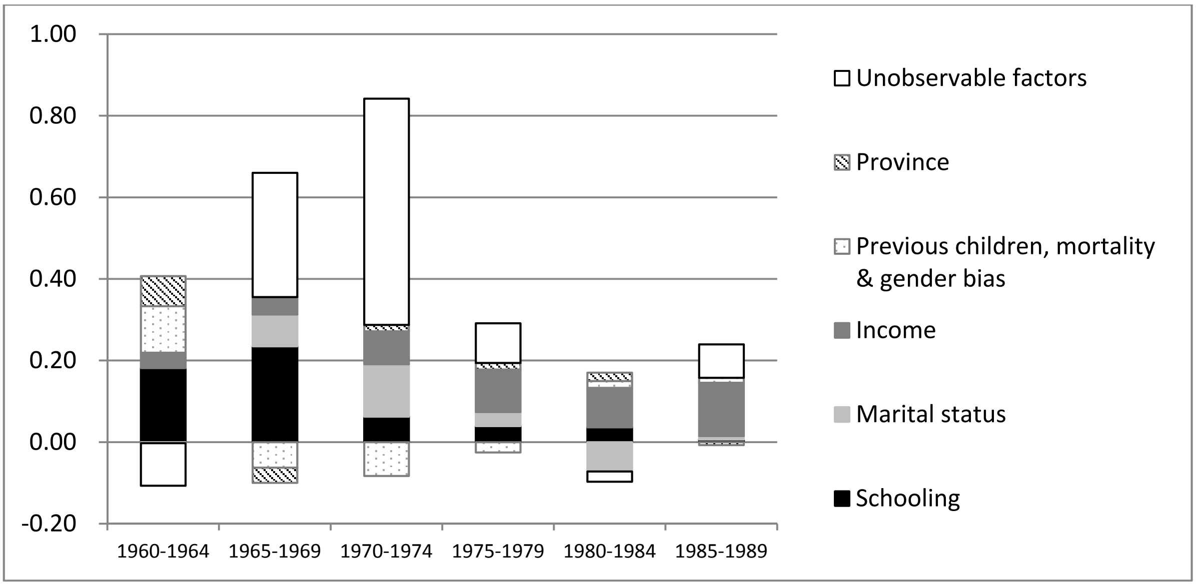

Table 2: Decomposition of the South African fertility decline, by birth cohort

Variables \ Birth cohort	1960-1964	1965-1969	1970-1974	1975-1979	1980-1984	1985-1989	TOTAL
Schooling	0.18	0.23	0.06	0.04	0.04	0.01	0.56
Marital status	-0.00	0.08	0.13	0.03	-0.07	0.01	0.18
Income	0.04	0.04	0.08	0.10	0.10	0.13	0.49
Previous children, mortality & gender bias	0.11	-0.06	-0.08	-0.03	0.02	0.01	0.00
Province	0.07	-0.04	0.02	0.02	0.02	-0.01	0.08
Unobservable factors	-0.10	0.30	0.55	0.10	-0.02	0.08	0.91
TOTAL	0.30	0.56	0.76	0.27	0.07	0.23	2.22

African women born in the first half of the 1960s will expect to have 0.3 fewer children over their lives than women born five years earlier, and more than half of this decrease can be ascribed to their higher levels of schooling. In fact, the increase in education – secondary education in particular – was the biggest single contributor to the decrease in fertility for women born between 1960 and 1970. Although this effect continued to drive down fertility for those born after 1970, its importance as a driver of the fertility transition waned over time.

Changes in relationship choices also contributed to the fertility decline. The effect of lower marriage rates on fertility grew stronger for successive birth cohorts until reaching a peak for those born in the first half of the 1970s, and starting to decline. Gender bias and the number of previous children both played a relatively minor role in the fertility decline, whereas migration patterns and improvements in child health contributed to the fertility decline experienced by women born in the first half of the 60s, but not after that. Economic factors were less important for women born during the 1960s, but for those born since the 1970s – who were in their peak childbearing years after the economy started to emerge from the recessionary debt crisis – rising economic growth seems to have contributed to lower fertility levels. Unobservable fertility determinants (significantly including a large share of the social norms outlined in section 2) were not prominent initially, but caused a substantial fertility decline for those born in the second half of the 1960s and the first half of the 1970s, before also gradually decreasing in importance.

In total, African women born in the late 80s are expected to have at least two fewer children than those born in the late 50s. Better access to schooling, decreasing marriage rates and growing incomes can explain more than half of this decrease. The remainder is mainly due to unobservable factors that are difficult to pin down, but this category of influences appears to have an amplified impact for women born between 1966 and 1975 and who were likely to make fertility decisions in the 1990s. Given the timing, candidate explanations include HIV/AIDS, increased contraceptive use, and changes in intra-household relationships and the social role of women.

6. Conclusion

This research examines fertility decisions by using the National Income Dynamics Study of 2008 (NIDS) to explore the factors contributing to the observed decline in fertility over the past five decades. As far as the authors know, no other research on South African fertility trends has been published using this data set.

The NIDS data provides a rare opportunity to better understand the fertility patterns in an era where there was very little publically available and transparent analysis of fertility trends due the political and ideological nature of population policies and the lack of reliable Census data on the African population. Through its retrospective questions, NIDS provides a window on this period that allows us to investigate the influence of various factors contributing to the fertility decline.

Using this data set, we were able to explain a large component of the fertility decline observed across birth cohorts. This analysis shows a prominent role for improving education levels and the lower prevalence of marriage in the fertility decline.

However, a large part of the puzzle remains unsolved. Unobservables also play a large role and this category may include many factors, such as HIV/AIDS, increased contraceptive use and changes in intra-household relationships and the social role of women. Some of these influences may also be difficult to disentangle, including the interaction between changes in intra-household dynamics and the availability of family planning services and contraceptives. Kaufman (1997:17) makes the point that "women took decisions to use family planning not solely because of educational materials or accessibility of clinics, but because circumstances in their lives compelled them to do so"…however "the services it provided undoubtedly facilitated declines in fertility and increased contraceptive use". Similarly, Moultrie and Timæus (2003: 208) argue that it may not be any single factor, but rather the gradual opening up of South African society that allowed African women more freedom and independence to react and respond to new alternatives and emerging social forces and institutions.

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Appendix 1: Data

The NIDS data was collected by the South African Labour and Development Research Unit (SALDRU) during 2008. The survey asked females aged 15 and older to report the number of live births, their date of birth and – where applicable – the dates of child mortalities. As discussed in section 4, this type of retrospective birth data is expected to suffer from recall bias, and this bias is likely to increase with the recall period.

A.1 Missing birth year data

Our analysis of the data shows that, apart from failing to report all births, respondents also neglected to report birth years for 1,221 out of the total 19,683 recorded births. In order to explore the nature and extent of the resulting measurement error, we construct a variable that expresses the number of births with missing birth years as a share of total reported births for each woman, and regress this on a number of explanatory variables. The coefficients and standard errors (in brackets) of this regression are presented in Table A1 below. The results demonstrate that missing birth years are more likely to occur the older the woman is at the time the survey is taken, the more children she gave birth to, the lower her level of schooling and if she was African or Coloured rather than Indian or White (the reference group in this regression).

Table A1: OLS regression for unreported birth years as share of total live births

Birth year	-0.003*** *(0.0003)*
Number of reported live births	0.016*** *(0.0022)*
African	0.031*** *(0.0111)*
Coloured	0.039*** *(0.0127)*
Indian	0.014*** *(0.0141)*
Years of completed schooling	-0.009*** *(0.0003)*
Constant	0.266*** *(0.0240)*
R squared	0.2186
Observations	7126

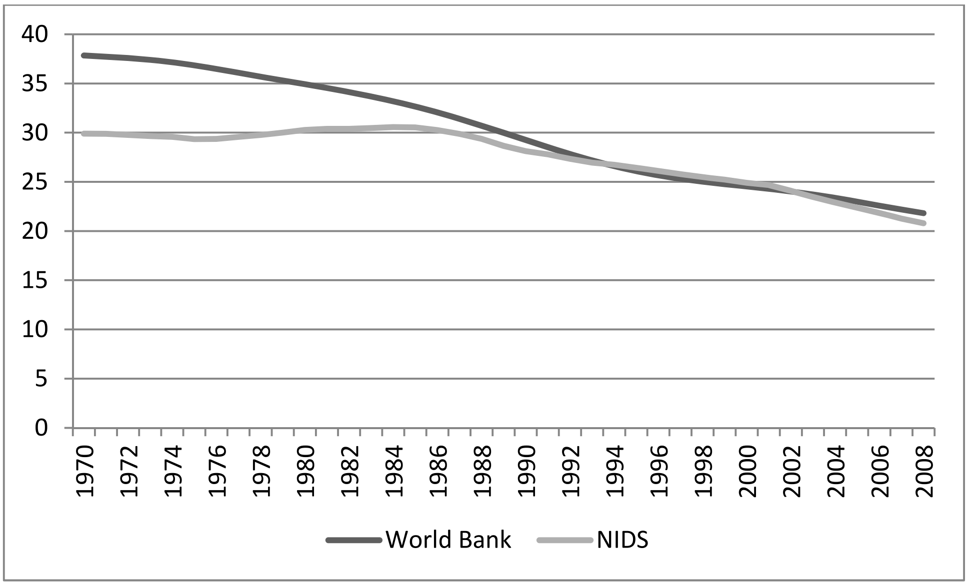
When constructing an annual panel data set, these undated births must be set to missing, which will exacerbate the under-capturing of fertility. In an attempt to reduce the effect of this bias we exclude women who fail to report the birth year of at least one of her children from the panel. The motivation for this restriction is that fertility is known to be under-captured for these women, but may not be for the rest of the sample. However, the fact that these women are disproportionately drawn from those with a large number of children means that this is unlikely to completely remove the downward bias. Since this is also shown to be more of a problem for women born longer ago – the same women who are likely to suffer from recall bias – the magnitude of fertility under-estimation can perhaps be addressed by restricting our sample period to the more recent past.

A.2 External validity checks

In order to investigate the magnitude of this bias, we compare a crude birth rate measure derived from the NIDS retrospective panel[12] with the estimates of the crude birth rate from the World Bank (2012). Figure A1 reveals that the NIDS data produce a crude birth rate that is very similar to the World Bank estimates for the 1985 to 2005 period, but that the under-capturing of births becomes a serious problem as soon as we look further back than 1985. This pattern is consistent with the bias that we would expect to arise from the above-mentioned sources, and suggests that the post-1985 sample is relatively reliable.

Figure A1: Comparison of crude birth rates (1970-2005): World Bank and NIDS data estimates

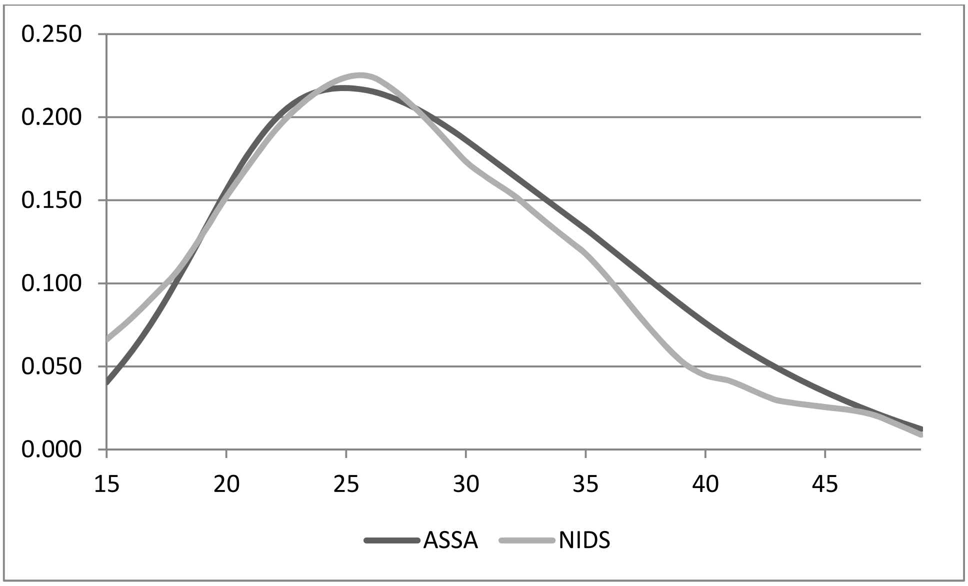
[12] The crude birth rate is calculated in the following way: for each calendar year we first calculate the proportion of women between the ages of 15 and 49 who reported giving birth in that year. This is done via a kernel weighted local polynomial smoother. We then multiply this number by 1000 and divide it by the share of the total population that consisted of females aged 15 to 49. This share is calculated from the gender and age group-specific population numbers from the ASSA 2008 lite model (for 1985-2008), from Udjo (1998) for 1970 and from linear interpolation for the years between 1970 and 1985.



Source: World Bank (2012); NIDS, own calculations

Although Figure A2 demonstrates that the 1985 total birth rate was accurately captured by the retrospective element of the NIDS data, we may still be concerned that this overall rate obscures biases in the cross-sectional distribution of fertility. As an additional check of the external validity of the sample, we therefore compare the 1985 age-specific fertility rates as estimated from the NIDS data (again using a local polynomial smoother) and the Actuarial Society South Africa (ASSA) 2008 lite model (ASSA 2008). The NIDS data produce slightly lower estimates for women aged 30 to 45, but are generally very similar to the ASSA estimates.

Figure A2: Comparison of age-specific fertility rates (1985): ASSA and NIDS data estimates



Source: Actuarial Society South Africa; NIDS, own calculations

The analysis shows that the NIDS data are broadly consistent with the fertility trends documented elsewhere. It also demonstrates that the reliability of this retrospective panel decreases as the recall period lengthens and we find that the recall of events occurring before 1985 may be problematic. For this reason our empirical analysis will be restricted to the sample of women born after 1960: those who were in their highest birth probability years between 1985 and 2008.

A.3 Variables

The NIDS data also asked retrospective questions about schooling progress, the duration of relationships and migration that allow us to construct time-varying measures of years of education, marital status and province of residence. However, for the last two variables the questions asked are not informative enough to perfectly reconstruct the time variation in the variables of interest, so that we have to settle for proxy variables that provide noisy measures of the determinants that we want to control for.

With regards to schooling, the NIDS questionnaire asked respondents about the highest level of schooling completed, the first and last years in school and how many times each grade was repeated. This allows the construction of an accurate panel data measure for years of schooling completed at different points in time.

NIDS also asked respondents about their current relationship status – whether they were married, living with a partner, divorced, widowed or never married – as well as the duration of this relationship. The data therefore allow us to assign a relationship status to individuals for the duration of their current relationships, but provides no information about what happened before the start of this relationship. Values for these observations are inferred from the relationship patterns observed for other women, but will necessarily be a noisy measure of the actual relationship status. However, the results obtained in section 5 were found not to be sensitive to the omission of year-individual combinations for which these values had to be imputed.

A similar issue is encountered with the retrospective questions regarding area of residence. Individuals were asked where they were born, where they lived in 1994 and 2006, where they lived before moving to their current location, and when this most recent move occurred. This information can be combined with their current location to construct a relatively informative province of residence variable, although any migration between these dates (excepting the most recent one) will not be captured. Where individuals are known to have migrated between provinces and no date for this move is supplied (which is always the case unless this was the final move), individuals are assumed to have moved only once, and on the date that lies halfway between the two dates for which place of residence was reported.

The NIDS data do not contain any retrospective information on employment, wages or income, so we use estimates of real per capita GDP for different race groups in different periods, taken from Van der Berg *et al* (2006). The real GDP growth rate was taken from the South African Reserve Bank Quarterly Bulletins. In some specifications we also included a measure of the real discounted value of the child support grant, measured at period-specific grant values and eligibility ages. However, this variable was found not to significantly affect fertility outcomes.

We construct a variable capturing the number of children that women have had at a specific point in time based on the detailed retrospective birth records. To measure the impact of fertility as 'replacement' behaviour we also include an indicator of the number of children that have died (again measured at different points in time).We explore gender preferences by including dummy variables for whether a woman has had any boys or any girls. Again, this variable is created for the same individual at various time periods so that we can use it in our panel.