Multiple social interactions and reproductive externalities: An investigation of fertility behaviour in Kenya

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Abstract

This paper examines empirically the impact of reproductive externalities on fertility behaviour in one developing society - Kenya. We examine this issue by quantifying the effects of group membership on the number of children ever born. In contrast to the work of Moulton (1990), and Pakes (1983), who examine the consequences of simply ignoring group effects in regression analysis, the focus of this study is the identification of structural forms of social interaction operating across individuals in the context of fertilty behaviour. However, although a number of commentators are careful to point out the conditions under which structural forms of dependence may be separated from residual dependence, we also highlight the importance of different expressions of structural dependence. Thus, although in the majority of empirical applications which include social interactions, a single mode of social interaction is assumed, following the typology suggested by Glaeser, we consider a model which includes multiple expressions of social interaction. If the assumption of a single model of interaction is made, erroneously, then it is possible to arrive at incorrect inferences.

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1 Introduction

The shift in society from a high to a low-fertility regime, as witnessed in historical European populations and in some East Asian developing economies over relatively short periods of time, has shown that this has significant repercussions for economic development and the quality of life. Recently both economists and demographers have examined the balance between economic and non-economic factors in orchestrating a fertility transition. Classic studies of fertility such as those reported by the Princeton Fertility Project highlighted that the transition to low fertility in historical European populations occurred in a variety of different socio-economic and institutional contexts, with a significant role being played by the local social environment and language (Coale and Watkins (1986), Federici, Mason, and Sogner (1993)). More recent studies in developed and developing countries alike have emphasised the role of the social climate and the influence of social interactions on demographic behaviour (Egero and Hammraskjold (1994), Kohler (2001), Hank (2001)). These empirical findings have led many economists naturally to focus on modelling the influence of social interactions on contemporary fertility transitions (Manski (1993), Manski and Mayshar (2002)) and on the reproductive externalities and coordination failures associated with fertility behaviour per se ((Dasgupta (2000); Kohler (2001)) .

In keeping with this literature, this study examines social interactions in the context of fertility behaviour in Kenya. But we highlight a crucial point often overlooked in both the theoretical and empirical literature on this issue. Simply, that there are different levels at which social interactions occur. We argue that this has profound implications, both theoretically and empirically, for studies of fertility behaviour and social interactions, and for the study of social interactions and economic phenomenon, more widely. For example, individual behaviour about fertility may be influenced by individuals' multiple social identities - regional identities, ethnic identities, religious identities, linguistic identities. The key question for the empirical modeling of social interactions is whether, and to what extent, singular or plural identities predominate in order to influence decision-making about economic outcomes. In the context of fertility behaviour, these identities have implications for the total number of children ever born to couples. We argue that *multiple social interactions* matter, and that their consequence needs to be addressed both theoretically and empirically. We do so by modelling these interactions formally - specifically with respect to geography and ethnicity - and then by applying this model to an empirical dataset from Kenya.

We conceive of the fertility of a Kenyan woman to be influenced by a range of factors such as her individual characteristics and the characteristics of the household to which she belongs. However, we are also interested in the influence of reproductive externalities - the social environment and context within which the woman makes her fertility choices. We postulate that the social environment impinges on a woman's behaviour through the multiple interactions that she undertakes at the household and group level. In this context we investigate the impact of both fertility behaviour and characteristics of appropriately defined groups of other individuals, including household members, members of a village cluster and ethnic group. In doing so we consider the possibility that both *local and global forms of interaction* may coexist and be important, characterised by different mechanisms of social interaction. Decomposing the influence of reproductive externalities into household-level, cluster-level and ethnic group interactions, has implications for the manner in which we conceive of the mechanisms by which social interactions facilitate a fertility transition.

The research presented in this paper quantifyies the effects of multiple social interactions and group membership on the number of children ever born. In seeking to disentangle the effects operating at the level of the individual from effects which are mediated by the outcomes of group behaviour, central to our analysis is the identification of the *channels* through which reproductive externalities are propagated. In this respect, we also highlight the existence of model uncertainty as to whether these effects are mediated through household composition, ethnic affiliation, a neighbourhood cluster effect, or some combination thereof. An important conclusion of the present study is that the existence of multiple channels of social interactions implies that the analyst needs to exercise caution in making inferences. Specifically, we argue that *both local and global interactions will be significant for fertility behaviour and that ignoring the existence of one or the other may lead to spurious inferences.* Other studies of fertility bahaviour do consider the question of spurious inference, but they do so more in the context of the omitted variables that account for unobserved variation between groups. We argue that by not recognising the *multiple* nature of social interactions, this could lead to misspecifications in models that attempt to capture these social interactions quantitatively.

The research has considerable policy relevance to population policy in Kenya, and to development policy more widely. For example, we argue that to the extent that fertility is influenced by 'local' and/or by 'global' interactions, each kind of interaction will suggest a different role for policy. For example, if local interactions are important, specifically targeted interventions in areas of high fertility will be effective. More signifiantly, we argue that if a singular form of interaction is presupposed, and more global interactions are ignored, then the inference based upon the assumption of a single form of social interaction, may be spurious. Second, that education for women and the role of the media may be important in order to influence ideas about social norms concerning fertility. And that economic characteristics interact with social norms, so that raising income will be a significant factor for fertility decline.

Section 2 summarizes the literature on social interactions and fertility behaviour. In section 3 we provide an anthropological overview of ethnic groups in Kenya, highlighting the characteristics which are relevant for fertility behaviour. In section 3 we present a model of reproductive externalities with social utility effects for both spatial proximity and ethnicity. In sections 4 and 5 we consider the distinction between multiple *levels* of social interaction, with the focus on the composition of the various groups which mediate interaction effects, and the *types* of social interaction, following Manski's typology of endogenous, exogenous, and correlated effects. In section 6 we examine a number of issues relating to conducting inference on social interaction, including population and empirical identification, and any limits to inference which follow from the use of a single cross-section. In section 7 we consider the form of a number of non-linear models of fertility behaviour, and in section 8 we introduce the data. We discuss our results in section 9, and section 10 concludes.

2 Literature review: Social interactions and fertility behaviour

The theoretical literature on economic models of social interactions models the influence of non-market institutions on market institutions in order to affect economic outcomes (Brock and Durlauf (2003); Glaeser and Scheinkman (1999)).There is a well-established and diverse literature that has investigated the impact of social interactions on economic phenomenon as documented by Brock and Durlauf (2003). This study argues that there have been two approaches adopted to investigate social interactions. The first is the impact of social interactions in predetermined groups (Akerlof (1997); Brock and Durlauf (2000)Brock and Durlauf (2001)). This literature emphasises how interactions affect individual and group-level outcomes in a cross-section. Brock and Durlauf also argue that a second strand of this literature focuses on how social interactions lead to group formation with particular emphasis on the growth of residential neighbourhoods. This literature has focused on questions of geographic proximity, ethnicity, and the kinds of groups that lead to social interactions ((Aizer and Currie (2002); Borjas (1995); Ginther, Haverman, and Wolfe (2000); Conley and Topa (2002)).

In the context of how fertility behaviour is influenced by social interactions, we can think of this phenomenon as follows: consider differences in the variance over fundamentals within a given population, relative to the variance in outcomes.Conditional upon identifying a fixed set of fundamentals as comprised of a vector of characteristics of both the individual and the household, then an atomistic model of fertility behaviour simply focusses on the direct affects attributable to a change in these fundamentals. Subsequently, if we then observe that the variance in fertility outcomes is in excess of that which might be accounted for by differences in fundamentals, and that sign of any change is that which would be predicted by fundamentals, an extension of the standard fertility model to allow for the existence of social multiplier effects would seem reasonable (see, for example, Becker and Murphy (2000)). The conventional economic household demand model of fertility behaviour posits that a couple's fertility is a function of the money costs of children and the opportunity costs of the value of parental time (Becker (1981)). More recent theoretical work of Dasgupta (1993), Kohler (2000), and Dasgupta (2000) has argued that a couple's fertility may be influenced by the level of fertility of all other couples within a society.In the most general sense, this is what is meant by 'social interaction' in a fertility context: it is the public interaction between individuals in a society as they perceive each other and observe each others' fertility behaviour. This consequently alters their social environment, which in turn ultimately influences their private decision-making about fertility. As a consequence, the existence of social interactions may lead to multiple equilibria and coordination failures in demographic decision-making, shown by a high level of variability in outcomes for a given set of fundamentals.

For example, Montgomery, Kiros, Agyeman, Casterline, Aglobitse, and Hewett (2001) make the distinction between *social learning* and *social influence*. In a developing society like Kenya, the latter may occur through the effect of ethnic allegiance; whereas learning may be mediated by the experience of living within smaller groups, such as extended households, or clusters of households in close proximity. Fertility behaviour may then be mediated by social interactions both *within* one or more of these groups, or by interactions across different groups.

In the social interaction literature, three hypotheses are often advanced to explain the observation that individuals belonging to a common reference group tend to behave similarly, even after controlling for a set of observed individual characteristics. These hypotheses, as outlined by Manski (1993) are:

a) *endogenous* effects: the propensity of an individual to act in some way varies, ceteris paribus, with the actions of their reference group. For example, a desire to conform might result in an attempt to minimise the difference between their choice of action and that of other members of their reference group. Durlauf and Walker (1998) note that an endogenous effect is analogous to a pure contagion effect in epidemiology. However, although in this instance the likelihood of infection is an increasing function of the proportion of population infected and density (Feller (1971), a contagion effect alone is not sufficient for social interaction. As noted above, for an endogenous social interaction effect we require the combined effect of contagion and social influence.

b) *exogenous or contextual* effects: the propensity of an individual to behave in some way varies, ceteris paribus, with the exogenous, observed mean characteristics of the reference group. This reflects a type of externality which differs from that above: with endogenous effects it is the *actions* of other members of the group which influences individual action; with exogenous effects it is the characteristics of other members of the group which influences own action.

c) *correlated* effects: individuals in the same group tend to behave similarly because they have similar individual characteristics or face similar institutional environments. This may or may not reflect a type of 'social' effect. For example, it may be that correlated effects amongst members of a reference group are the result of a common, unobserved characteristic which is not socially-determined, e.g. wealth. Insofar as this could appear to be a social effect, it is entirely spurious. So long as the source of the correlation is unobserved, correlation within reference groups cannot be definitively ascribed to 'social effects'.

Recent economic analyses of fertility behaviour have been much concerned with social interactions (see Montgomery, Kiros, Agyeman, Casterline, Aglobitse, and Hewett (2001), Hank (2001), Nauck (1995), Becker and Murphy (2000), Kohler (2001), and Manski (2000)), and it is possible to identify endogenous, exogenous and correlated effects on fertility decisions. In a fertility context, there is an endogenous effect if, ceteris paribus, a woman's CEB tends to vary with the average CEB of members of her ethnic group or locality, perhaps because she suffers a utility loss from deviations from group behaviour. There is an exogenous or contextual effect if, ceteris paribus, a woman's CEB tends to vary with (or more plausibly inversely with) the average educational attainment of her ethnic group or locality. For example, the existence of educated neighbours may foster positive attitudes towards smaller family size. Alternatively, women's 'exit options' may be widened within the society at large, whether or not they actually take up more education.[1] Finally, there is a correlated effect if, ceteris paribus, women in the same ethnic group or locality tend to have similar CEB because they are, for example, similarly wealthy. The three hypotheses would have different policy implications. Consider, for example, an intervention to provide free contraception to some members of an ethnic group or a number of neighbourhoods. If there are endogenous effects, then an effective policy of free contraception may both directly reduce the fertility of the recipients but, as their fertility decreases, indirectly reduces the fertility of all other members of that ethnic group or neighbourhood, with a feedback to further fertility reductions by the recipients of the free contraception. Exogenous effects and correlated effects will not, in general, generate this kind of social multiplier effect.

The potential effects of education on fertility can be decomposed into 3 components. The first is the effect of individual educational attainment on individual-level fertility. In a developing society, this would be dependent on the money-costs of acquiring an education and the opportunity costs of wages foregone. Secondly, education also exerts an influence on fertility in terms of mean group behaviour i.e. the mean level of education prevalent in the society might exert an impact on an individual's decision to have a child. Finally, there is also an iconic value of education in the sense that some individuals may aspire to the attributes of other higher educated groups in a population. In some developing societies, the iconic value of an education is very high. For example, sociologists of India often comment on the phenomenon of 'Sanskritzation' in which lower-caste groups take on the characteristics and customs of the upper castes in order to gain greater legitimacy and status in the Indian social system. Frequently this manifests itself in the desire to acquire an education, or to continue one (Srinivas (1994)). There are two points that need to be noted here. First, the fertility decisions of the less-educated are influenced by the *actions* of the better-educated. This theory does not (nor does it need to) suggest a change in preferences as women are merely influenced by the actions of other women. Second, note that in this theory, the mean exogenous effect of a policy directive, say to encourage education for women, cannot in effect be distinguished from the mean level of endogenous interactions between better- and less-educated women belonging, for example, to the same ethnic group in a society. The latter is responsible for prompting the less educated women also to adopt low fertility norms, which in turn causes the particular group and eventually the society as a whole to

[1] Another argument is that women with more education who also display lower fertility do so because they are married to men who belong to families in which education is more highly valued. The argument goes that the sample of better-educated women who have lower fertility do so becasue they are married to (educated) men who share these low fertility norms (Basu (2002)).

move to a low-fertility equilibrium.

So the existing literature on social interactions and fertility behaviour concentrates on modeling reproductive externalities theoretically, and on translating these models empirically by identifying neighbourhood, cohort, and other effects. In this context, Manski's disctinction between endogenous, exogenous and correlated effects, is important.

3 Anthropological overview of ethnic groups in Kenya

Multiple social interactions and channels of message transmission about fertility behaviour are important at the level of ethnicity. This section highlights the key features of the ethnic groups in rural Kenya using historical and anthropological studies, with particular focus on the features of Kenya's major ethnic groups that have relevance for fertility behaviour.

The population of Kenya consists of three main groups - the Africans, Asians and Europeans. Although the last two groups mainly reside in towns, 90% of the African population continues to live in rural areas (see Meck (1971)). The tribal groups of rural Kenya live in clearly defined settlements in the more remote areas; in the Lake Victoria basin, the highlands and the coast, there is a more heterogeneous population structure (Morgan and Shaffer (1966):2; Meck (1971): 24). The tribes can be defined broadly into four groups as classified by their language: the Bantu, the Nilotic, the Nilo-Hamitic, and the Hamitic. Within these four broad language groups, ethnic groups represent an additional sub-division. According to the 1969 *Population Census* there are 42 different ethnic African groups in Kenya (Rep (1970)). The five largest groups, accounting for over 75% of the population, are the Kikuyu (22%), Kamba (11%), Kalenjin (12%), Luhya (14%) and Luo (18%).[2] The Kisii and the Meru both comprise 6% of the total population. Other groups, such as the Maasai and the Somali constitute 15% of the population.[3]

Today the regional breakdown of the different ethnic groups is as follows: the Kalenjin reside in the Rift Valley; the Kikuyu live in the Central region, but have also migrated to Nairobi and Rift Valley. The Meru/Embu reside in the North and East. The Luhya live in the Western province, but have also migrated to Nairobi and Mombasa. The Luo live in Nyanza, with Kisumu as their capital, but have also migrated to the Rift Valley. The Kamba live in close proximity to Nairobi and exhibit ethnic affiliation to the Kikuyu. The Mijikenda/Swahili live in the Coast province.

As shown in Table 1 Census data from Kenya depict a steady increase in the total population of Kenya since 1948 to the present. The total fertility rate in Kenya has fallen from an average of 6 births per woman in 1948 to approximately 4.5 births today (Ajayi and Kekovole (1998)). However, the most significant declines in fertility have occurred in the last twenty years: the DHS studies conducted in 1989,1993 and 1998 showed that the TFR dropped from 6.7 in 1989 and 5.4 in 1993 to 4.7 in 1998.

[2] According to the most recent Census.

[3] The Asians, Europeans and Arabs make up about 1% of the population.

This drop in fertility is considered one of the most dramatic recorded anywhere in the developed and developing world (Ajayi and Kekovole (1998): 116). The fertility differences by ethnic group are also very large, as shown in Table 5. For women aged 40-49, the mean CEB varies from 5.91 for the Kikuyu to 7.56 for the Luo.

If we examine the evolution of these ethnic groups historically, the Maasai and the Kalenjin entered what is now modern Kenya from the north; those of Bantu origin such as the Kamba, Kikuyu, Mijikenda, Luhya and Kisii came from the south and west (Oliver and Gervase (1963)).[4] In this study we consider a number of ethnic groups: first, the Kalenjin, who are a heterogenous ethnic group and who live in Kenya's Rift Valley province (Were (1967)). They are considered prosperous small-scale farmers, who keep a great deal of livestock. Closest to Nairobi geographically, they are politically and economically Kenya's dominant ethnic group (Kenyatta (1966)). Their location in the eastern Rift Valley allows them to enjoy a level of political proximity that, in part, determines their (relatively) superior economic status. For example, agricultural innovation first arose among the Kikuyu who also absorbed land reform more readily than other groups (Meck (1971): 27). The Kikuyu are primarily agriculturists, but they also act as traders, craftsmen and run small businesses.

The Meru and Embu groups neighbour the Kikuyu to the north and east. The Luhya, who live in Kenya's Western province, are a less homogenous group compared to the Kikuyu and Kamba (Were (1967)). Among the Luhya, there is a distinction that needs to be made between those in the north and those in areas such as Kakamega, with high population density.[5] In these regions, a high proportion of the Luhya population are engaged in out-migration to the cities of Nairobi and Mombasa which allows them to return home only once or twice a year. The Luo live in Nyanza province. Although the rate of population growth is almost as high as the Luhya, they are a more urbanised people, with relatively high migration to urban centres and to the Rift Valley province (Ominde (1968)). In the past the Luo were less responsive to social and economic change compared to other tribes (Meck (1971)). For example, land reform met with a great deal of resistance among this group as it was believed to conflict with religious beliefs.

For the Kamba, the division of labour is traditional, but anthropologists comment that there is one distinctive feature of Kamban society: they are involved in interterritorial trade. Today and in precolonial times Kamban trade (mainly in ivory) extended from the west coast to Lake Victoria and to Tanzania. Today this wanderlust is reflected in the large proportions of Kambans who are engaged in trade, transport activities, and tourism (Berg-Schlosser (1984). Proximity to Nairobi and their close ethnic affiliation to the Kikuyu are particularly significant. The Mijikenda and Swahili groups reside in Kenya's Coast province. The Mijikenda consist of

[4] The geographical boundary of modern Kenya is purely a colonial artefact, defined as the 'East African Protectorate' in 1895 by a series of treaties negotiated initially between the UK and Germany between 1884 and 1890, and then with Ethiopia and Uganda in 1907 and 1926 respectively. Kenya became a crown colony in 1920 and achieved formal independence from colonial rule in 1963. But the practice of colonialism in Kenya had one important consequence - it created the administrative demarcation of Kenya's regions that continues in the post-independence period (Leys (1974)).

[5] In some areas as high as 161 persons per square kilometer (Berg-Schlosser (1984)).

nine distinct sub-groups - Giriama, Duruma, Digo, Rabai, Chonyi, Kambe, Kauma, Ribe, and Jibana.[6] They are the most agricultural of all of Kenya ethnic groups.

Initiated first by Jomo Kenyatta, education policy in Kenya has been pursued actively by the government, with remarkable success, especially with increases in primary and secondary school enrolment for girls. From independence onwards, five education commissions have been set up to develop this sector, reflected in the high rates of primary and secondary school enrolment in this country. However, despite the general increases in the uptake of education and policies such as school fee remission and the development of *harambee* or self-help community schools which foster these, the mean number of years of schooling differs considerably by ethnicity. The educational characteristics of the ethnic groups are relevant for fertility behaviour: the mean number of years of education varies considerably by ethnic group in Kenya, as shown in Table **??**. This factor has relevance for social interactions as we might expect the importance of social interactions on fertility to be acting through, or at the very least, to be mediated by the effect of education. The Kikuyu are the best educated, compared to other ethnic groups in Kenya (Berg-Schlosser (1984): 60; De Wilde (1967): 39). The Luhya populations, are also highly literate groups. Most Kamba are enrolled in formal schooling. Among the Kalenjin, levels of education are, in general, less than other groups. Most Kikuyu are Christians, probably because they were the Kenyan tribe with the closest links with Christian missions historically (Meck (1971): 27). Over 90% of Luhya and Luo are Christians, compared to over 60% of Kamba. Some of the Mijikenda sub-groups, such as the Digo, are Muslim.

These tribal groups are broadly characterised by three main features that have relevance for social interactions: the importance of the family group, the clan, and the system of age-grading[7] (Meck (1971)). Anthropological studies of the Kikuyu argue that among them, fathers exert a less important role for economic decision-making, that relations between the extended family are strong, and that they exhibit a highly evolved sense of ethnic identity (Berg-Schlosser (1984)). Anthropologists comment that among the Kikuyu, the most economically and socially effective unit is the *mbari*: 'a group of families who trace their descent from a common ancestor following the paternal line, often for up to seven or eight generations. In addition to its functions as the most important traditional land-holding unit in Kikuyu society, the *mbari* is an important social reference-group for many Kikuyu and still plays an effective role in many economic and social relationships including the more modern ones.'(Berg-Schlosser (1984) 53).

The Luhya do not have as powerful a clan organisation as some of the other groups (Meck (1971): 28). Anthropologists comment that a feature of the Luhya that makes them quite distinct from other groups is the relatively strict accepted norms of behaviour, particularly with respect to marriage and interactions between the sexes (Berg-Schlosser (1984): 114)

[6] The word'Mijikenda' means 'nine towns' or 'tribes'.

[7] The system of age-grading is a form of vertical stratification which every member of a tribe goes through during the course of their lives, with each 'age-grade' made distinct from the other with certain rites of passage (Kenyatta (1961):2; Berg-Schlosser (1984): 55).

One of the most notable features of these ethnic groups is their pattern of residence. It is important to emphasise that the notion of the 'village' in this society is rather more diffuse than in the compact settlements of Europe and elsewhere[8]. Although there are differences between ethnic groups, families are grouped mainly in homesteads that are located in clusters, and which forms the basis of community interaction. In some of these clusters, for example, among the Kikuyu, there may be groups of households who are not merely co-resident, but also related by blood and marriage (the *mbari*). In other clusters, there are households that are located in close proximity, but where individuals in these households are not related to other individuals in neighbouring households. For example, the Kalenjin live mainly in homesteads that are individual family based. Property is usually inherited along paternal lines or male agnates. The smallest unit of territorial composition in Kalenjin society is the '*temenik'* or hamlet, a cluster of homesteads; these are usually grouped into 'villages' of 15 to 60 *temenik.*The Kikuyu live in homesteads on land owned by the family, and surrounded by fields (or 'shamba'). Traditionally land was owned by many households which constitute the extended family (or '*mbari*') located on the same 'ridge' which is the traditional geographical division[9] (Berg-Schlosser (1984): 50). Supplementing the organisation of Kikuyu society based on kinship, there is also a geographical demarcation. The '*itura*' or village consists of a group of families. This is further subdivided into those living on the same ridge (or '*rugongo*'). It is important to note that the former is not a 'village' in the European sense.

The pattern of Luo settlement is similar to other communities, although their homesteads usually consist of families who own land, dispersed as a safeguard against climatic conditions. The Kamba are also agriculturists, and their pattern of settlement is similar to the Kikuyu (Middleton and Kershaw (1965)). The traditional land-owning unit is the extended family. In terms of territorial residence, the most basic unit is the *ukambani,* which is a homestead that comprises several extended families. Several of these are grouped to form a *kivalo* within which social interactions, especially marriage, take place. For the Mijikenda, the main form of residence is the *mudzi* or village which consists of groups of agriculturists and fisherman.

Table 2 provides a summary of these characteristics.

4 A Model of Reproductive Externalities with Geography and Ethnicity

One of the primary objectives of our analysis is to examine the extent to which the distribution (or moments thereof) of fertility outcomes in a population influence individual fertility behaviour. Specifically, we investigate the extent to which aggregate fertility behaviour generates strategic complementarities and thereby affect individual fertility decisions at multiple levels. A fundamental prerequisite for

[8] A key point to note here is that villages are not defined units of settlement, although their boundaries are well-known locally. These boundaries are usually marked by trees, stones, and so forth (Berg-Schlosser (1984): 139)

[9] This was altered with the land reforms of 1950 when ownership of land was transfered to individuals.

conducting inference on this problem is a theory of social interaction as applied to fertility behaviour. Although economic theory is reasonably informative as to the functional form over the individual component of the utility function, the analyst faces considerable uncertainty in terms of how to characterise the effects of social interaction on individual fertility decisions. Here we consider a number of dimensions on this uncertainty: First, over a population of individuals we do not know the appropriate reference group. As Manski notes, the data cannot identify an appropriate grouping, and as a result relatively strong prior information is required in order to identify a reference group effect. Moreover, based upon our discussion in Section 2 it is likely that social effects operate at many levels both within the household and among the wider community, such that there may exist more than one reference group, each assuming different roles such as social learning and social influence. In addition, for any particular group we do not know the functional form of the social utility function.

The effects of *reference groups* are a composite of mechanisms affecting individual fertility behaviour. Such effects might include the *direct* effect of the fertility behaviour of other household members, neighbours, and members of an ethnic group on a woman's decision making. We refer to these effects as direct, insofar as they enter directly into the utility function of individuals faced with the decision whether to have children, and how many. For example, a household's fertility decision may be influenced by the fertility behaviour of extended family and neighbours residing locally. We also consider indirect effects which also affect fertility decisions, such as the influence of intrahousehold effects stemming from the previous fertility behaviour of parents or parents-in-law. We also might consider the possibility that the strategic complementarities are partly a function of demographics, giving an additional role to individual characteristics.

Formally, we consider a population with household h characterised by a location j, a type s - here ethnicity - and a vector of characteristics $\mathbf{x}_{h.}$. We assume that both j and s are fixed for all individuals, with characteristics potentially varying across individuals, type and location[10]. Our point of departure is the standard Beckerian utility function (Becker (1981), Willis (1973)) for household h

$$U_h = U(n_h, q_h, z_h, \mathbf{x}_h,), \tag{1}$$

where U_h denotes the utility function of household h, n_h represents the number of children, q_h is the quality per child or the household investment per child, $\mathbf{z}_h$ is all sources of satisfaction to the husband and wife other than those arising from children, and $\mathbf{x}_h$ denotes the vector of socio-demographic characteristics which affect preferences. By including the stochastic term ε_h we allow for imperfect information on the part of the analyst., where $\varepsilon_h = \gamma_s + \gamma_j + \gamma_h$.

The production function of child services c_h, a product of the number of children n_h and the quality per child q_h, we write as

[10] Note that at this juncture we leave j as simply denoting a group of households whose fertility behaviour and/or characteristics are relevant for the fertility decision of household h.

$$c_h = n_h q_h = f(t_c, x_c). \tag{2}$$

In (2) child services are assumed to be a function of the total amount of time parents devote to children, t_c, and the total amount of goods g_c that they devote to them during their lifetimes. We write the budget constraint as

$$I_h = n_h q_h \pi_c + n_h p_h^n + q_h p_h^q + \mathbf{z}_h \boldsymbol{\pi}_z,$$

where I_h denotes household income (exhausted on n_h, q_h and $\mathbf{z}_h$), π_c is the shadow price of child services, and $\boldsymbol{\pi}_z$ is a vector of shadow prices for all other commodities. p_h^n is the fixed price applying to the component of child costs independent of the level of q_h chosen, and p_h^q is the fixed price applying to the component of child costs independent of the level of n_h.

If we extend the above atomistic utility model to incorporate a theory of social interactions we write

$$U_h = U(n_h, q_h, z_h, \mathbf{x}_h); S^j(n_h, \mathbf{n}_{-h}^j), S^s(n_h, \mathbf{n}_{-h}^s), \varepsilon_h), \tag{3}$$

. In (3) n_h represents an individual effect on utility of the number of children born to family h. $S^j(n_h, \mathbf{n}_{-h}^j)$ represents a social utility term for location j, given by some unknown function of the number of children choices made by all other members of location j; $\mathbf{n}_{-h}^j = (n_{1,}^j n_2^j, ..., n_{h-1}^j, n_{h+1}^j, ..., n_{M_j}^j)$, where M_j denotes the number of individuals in location j. $S^s(n_h, \mathbf{n}_{-h}^s)$ represents a social utility term for type s, namely the impact of some function of the number of children choices made by all other members of type s, where $\mathbf{n}_{-h}^s = (n_{1,}^s n_2^s, ..., n_{h-1}^s, n_{h+1}^s, ..., n_{M_s}^s)$.

Rewriting (3) as additive in individual and social utility terms, we have

$$U_h = U_{ih}(n_h, q_h, z_h, \mathbf{x}_h) + S^j(n_h, \mathbf{n}_{-h}^j) + S^s(n_h, \mathbf{n}^{-s}) + \varepsilon_h, \tag{4}$$

where $U_{ih}(.)$ denotes the individual component of utility. Differentiating the Beckerian first-order conditions with respect to social interactions yields the second-order conditions

$$\kappa_{hl}^j = \partial^2 S^j(n_h, \mathbf{n}_{-h}^j)/\partial n_h \partial n_l^j > 0, \tag{5}$$
$$\kappa_{hl}^s = \partial^2 S^s(n_h, \mathbf{n}_{-h}^s)/\partial n_h \partial n_h^s > 0. \tag{6}$$

In examining the form of (6) and (5) we define strategic complementarity as representing the increasing marginal utility of household h as a direct result of the fertility choices of all other households in the group. The precise form of interaction will obviously depend on the functions S^j and S^s. Two forms of social utility are consistent with totalistic and constant strategic complementarity (SC). Focussing on SC operating at the level of the village cluster, these may be written as

$$S_1(n_h, \overline{n}_{-h}^j) = \theta n_h \overline{n}_{-h} \tag{7}$$
$$S_2(n_h, \overline{n}_{-h}^j) = \frac{-\theta}{2}(n_h - \overline{n}_{-h}^j)^2, \tag{8}$$

where (7)represents a proportionate spillover form of social utility, and (8) represents social utility as a measure of conformism. Since (8) can be rewritten as

$$\theta n_h \overline{n}^j_h - \frac{J}{2}(n_h^2 + (\overline{n}^j_{-h})^2),$$

then

$$\frac{\partial^2 S_1(.)}{\partial n_h \partial \overline{n}^j_{-h}} = \frac{\partial^2 S_2(.)}{\partial n_h \partial \overline{n}^j_{-h}},$$

and there is an equivalence of noncooperative equilibrium under proportionate spillers and conformity effects in cases where the analyst considers the choice over whether to have children, as in a binary discrete choice model. (see Proposition 7 in Brock and Durlauf (2001)) However, given count data on the number of children ever born, such that $n_h = 0, 1, 2....$ then $\partial S(.)/\partial n_h$ is given by $\theta(\overline{n}^j_{-h} - n_h)$.

If behaving like others confers additional status on a household (Bernheim (1994)) agents may desire to conform. There may also be a compelling reason to conform if such status in the community bears economic benefits, e.g. in the allocation of local resources. It is also likely that ethnic groups possess loss functions which differentially penalise behaviours which are different from the norm. Representing both social utility terms as measures of non-conformism, we then write

$$S^j(n_h, \mathbf{n}^j_{-h}) = E\{\textstyle\sum_{l \in j} \kappa^j_{hl}(n^j_h - n^j_l)^2\} \quad (9)$$

$$S^s(n_h, \mathbf{n}^s_{-h}) = E\{\textstyle\sum_{l \in s} \kappa^s_{hl}(n^s_h - n^s_l)^2\}. \quad (10)$$

In (9) κ^j_{hl} represents a measure of the disutility accruing to h from deviating from the behaviour of l, $S^j(.)$ being the total disutility over all pairs in location j. For $\kappa^j_{hl} > 0 \ \forall h \neq l \in j$ there is an incentive to conform.

If we are willing to assume that social utility exhibits strategic complementarities that are totalistic and constant (see Cooper (1988)), then we may impose a number of restrictions[11]. The restriction $\kappa^j_{hl} = \kappa^j/2(M_j - 1)$ is consistent with a model of uniform *local* interaction, with equal weights assigned to all members of location j[12]. We note that although such a restriction may be theoretically difficult to justify, it is, in general, not possible to identify separate measures κ^j_{hl} if there is no information as to the relative location of all h, l within each location. Faced with such limited information this restriction is required when theory is confronted with data, and follows from as assumption that, in the case of type, all individuals are equally influential with respect to fertility decisions; and, in the case of spatially defined cluster, all individuals are located at the centroid. (10) captures the disutility from deviating from behaviour based upon type. Again the restriction $\kappa^s_{hl} = \kappa^s$ is consistent with a model of social interaction with uniformly local effects. Note

[11] Note: below we examine this definition more closely when we consider local and global interaction effects.

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[12] By setting $\kappa^j_{hl} = \kappa/2(\sum_j M_j - 1)$ we assign equal weights over all locations.

also that given the existence of a number of ethnic groups, it may be possible to motivate the existence of different magnitude of strategic complementarities across for groups.

We note that (4) allows a distinction between *local* interactions, whereby individual behaviour is influenced by the decisions of a relatively small number of well defined neighbours; and *global* interactions in the sense that individual behaviour may also be determined by the decisions of a larger, more geographically diffuse ethnic group.[13] This specification, including two social utility terms, allows for *multiple social interactions* - the possibility that social interaction is both localised at different levels, within a specific location, and more diffuse across a larger, geographically diffuse sub-populations classified by type. In the context of this study such a formulation allows us to examine whether after controlling for social interaction effects accruing through geographical proximity, there is a residual effect due to the desire to conform to a set of behaviours ascribed by ethnicity. As a corollary of this, such an approach allows us to determine whether there is a local (geographic) expression of ethnicity in terms of interaction effects.

5 Multiple Levels of Social Interaction

The focus of this study is the identification of structural forms of dependence operating across individuals in the context of fertility behaviour, as a result of various forms of social interaction. In this regard we make the following observations. First, we admit uncertainty as to what constitutes an appropriate reference group, in that within the data there is no information which points to the existence of specific groups of individuals which represent a network within which social interaction takes place. However, using a number of anthropological sources we have identified that within rural populations in Kenya, families are grouped mainly in homesteads that are located in relatively small clusters, and this group forms the basis of community interaction. In addition we have information which allows us to distinguish between clusters which, for certain ethnic groups, are comprised of households which are blood related, with obvious ramifications for interaction.[14]

Second, although commentators such as Manski (2000) and Brock and Durlauf (2000) are careful to point out the conditions under which structural forms of dependence may be separated from residual (correlated) dependence, we also highlight the importance of different expressions of structural dependence. Although in the majority of empirical applications which include social interactions, a single mode of social interaction is assumed, following the typology suggested by Glaeser and Scheinkman (1999) (in conjunction with the notion of local and global interaction) we consider a model which includes multiple expressions of social interaction.

[13]In referring to a local interaction individuals have incentives to conform to the behaviour of a small number of appropriately defined neighbours. In contrast a global interaction refers to a situation where individuals face incentives to conform behaviour to the mean (weighted or unweighted) of a common reference group.

[14]In other contextx the locus of interaction might consist of a well-defined set of households who live within a given geographical space such as a street (see, for example, Guinnane, Moehling, and O'Grada (2001a)).

We argue that if the assumption of a single mode of interaction is erroneously made, then it is possible to arrive at incorrect inferences as to the precise mechanism of social interaction. Thus, although it is of course necessary to adequately control for the effects of a common environment before making inference on the existence of a social interaction effect, it is similarly important to ensure that, conditional on such controls being made, an observed form of interaction, is not, at least in part, determined by the effects of an omitted form of interaction.

5.1 Social Learning and Social Influence

The model of reproductive externalities outlined above suggests that externalities caused by multiple social interactions within communities could lead to multiple equilibria, in which a community could become stuck in a sub-optimal but self-sustaining mode of behaviour. However, in seeking to disentangle individual effects from the various manifestations of mean group effects it is necessary to go beyond the rather uninformative nomenclature of social interaction, and understand the precise mechanisms which translate aggregate fertility behaviour into an effect operating at the level of individual decision making.

In using this framework to analyse cross-section dynamics we consider two distinct processes by which social interactions influence fertility.[15] First, through what we denote as a process *social learning*,[16] which we use in the same sense as Ellison and Fundenberg (1993), namely where fertility decisions are determined, in part, by the accumulated experiences of others living locally. For example, we might consider the probability of both *exposure* to new technology, and subsequent adoption, as partially determined by geographic proximity, representing such an effect using spatial clusters of like individuals[17] (see Montgomery, Kiros, Agyeman, Casterline, Aglobitse, and Hewett (2001), p. 4). Second, *social influence*, Glaeser's stigma interaction, relates to the constraints on decision-making imparted by institutions, ethnic and/or political groups. We believe the distinction between local and global interaction is useful in understanding the processes of social learning and influence. A local interaction occurs in relatively small groups consisting of individuals that may know each other and are able to observe individual fertility outcomes. For example, in the case of the Kikuyu we might expect the extent of such interaction to be on average higher given that clusters of households are generally comprised of groups of individuals which are related by blood and marriage (the *mbari*). In such a situation one might expect to find a stronger normative influence relative to clusters comprised of households, as in the case of the Kalenjin, which live mainly in homesteads that are individual family based. In contrast, global interactions, occurring amongst geographically dispersed ethnic groups, take the form of allegiances to group norms with the existence of sanctions for certain types of behaviour. The

[15] Critical here is the separation of an instant exposure to a message and a subsequent change in behaviour. See Bongaarts and Watkins (1996)

[16] Glaeser's learning interaction

[17] Demographic studies that focus on urban populations have used measures of urbanisation, street-level and neighbourhood effects will be significant for fertility (Guinnane, Moehling, and O'Grada (2001b))

question of which interaction predominates to influence fertility, is important.

In the context of fertility we emphasis the role of three metrics. First, the metric ethnicity postulates that the status of women, and attitudes towards children, may differ substantially across ethnic groups, with differential evaluation of the psychological costs and benefits of bearing children. Given that the Kikuyu exhibit the greatest sense of ethnic identity, this suggests that individuals departing from a set of group norms may feel a higher level of sanction, relative to members of another group. For these reasons, ethnic groups are especially likely to adopt and maintain different practices to those of other groups.[18] Second, we have noted that in the case of Kenya, situated between the individual, the household and the ethnic group, are relatively small clusters within which physical proximity dictates that individuals directly observe and bear the costs of the decisions of others. The third level of interaction, within the household, consists of, for example, the influence of extended family on contraceptive uptake and fertility. In studies of South Asia (Hajnal (1982), Iyer (2002)) the household which defines the locus of interaction can be very widely defined, including not only the immediate family, but domestic servants, distant relatives and so forth. In contrast, the household in Kenya constitutes a well-defined and fixed unit of analysis.

As an example, consider the case of social interaction and contraceptive use. A process of interaction through social learning emphasises that women share experiences on the effectiveness of a new contraception technology, with greater use resulting in better information and reduced cost of use. In contrast an interaction through *social influence* highlights the effects of use by other community or ethnic group members in signalling the acceptance and lack of sanctions attached to its use.

5.2 The Cross-Section Dynamics of Adjustment

Incomplete ..

6 Econometric Inference on Social Interaction

In contrast to various dependence metrics which characterize time series models, the assumption of independence across observational units forms the basis of parameter identification in a broad class of cross-sectional models. Appealing to this type of identification is not appropriate when there exists natural groupings of observations in the data. As Honore (2002) notes, there are at least two reasons why such a grouping is interesting. First, the failure to account for the group structure can result in inefficient estimation, especially when estimated coefficients are determined by between-group variation[19]. Fixed and random effects models represent methods to account for omitted *group-specific* heterogeneity. However, it is important to emphasise that until recently group-level variables have, in general, been employed as

[18] There has been a great deal of research on the effects on fertility of religion and ethnic group membership (Gellner (1981); Sander (1995); Iyer (2002)).

[19] See Moulton (1986), Chamberlain (1982) and Mundlak (1982).

a control for the effects of similar environments, with inference generally conducted on the impact of individual characteristics on fertility outcomes. In this context the situation is reversed in the sense that one of the principal objectives is to examine the extent to which *between* group effects are determinants of fertility, after the necessary controls for within group (correlated) effects.

The second rationale for examining group effects, and the reason for the reversal, is that the relationship between observations in the same groups might be of interest in itself. In addition, rather than simply ensuring that there are enough individual controls in order to make inference on group effects, we seek to differentiate between the various manifestations of such effects, following the work of Manski (1993) .... We note that in a number of empirical studies of fertility, demographers have often used *multilevel* (variance components) techniques to control for unobserved heterogeneity at the level of a group of individuals. The fundamental characteristic which differentiates this methodology from our approach is that we assign, theoretically as well as empirically, a more prominent role to the mechanisms by which social interactions affect fertility behaviour.

The model of reproductive externalities outlined in Section 3 suggests a hierarchical structure underlying individual decision making. Namely, we observe the distribution of individual decisions on fertility choice, where individuals reside within households, are members of ethnic groups, and households cluster within neighbourhoods. Subsequently we account for two departures from i.i.d-based identification in a cross-section. First, individuals belonging to the same ethnic group are likely to be influenced by aggregate behaviour within the group, common cultural norms[20], and share characteristics that result from the observance of these norms. This in turn affects their fertility behaviour. Second, in neighbourhood cluster where households live in close proximity, their fertility behaviour is also likely to be influenced by interactions that occur *across* households, especially where households cluster based upon kinship.

Below we consider a number of critical issues that we need to address when seeking to make inference on the role of social interactions on fertility decisions. These are: the general problem of identification, spurious inference, identifying more than one channel of interaction, and conducting inference with a single cross-section

6.1 The Identification Problem

The observed data consists of (C, x, $\mathbf{z}$) where C is scalar outcome measuring children ever born (CEB), x is a categorical variable identifying ethnic group, $\mathbf{z}$ is a $k \times 1$ vector of characteristics recorded at the level of the individual, including educational attainment, age, and income. $\mathbf{u}$ denotes a vector of unobserved individual characteristics. A linear model of CEB which considers different manifestations of social interaction is written as

$$C = \alpha + \beta E(C|x) + E(\mathbf{z}|x)'\boldsymbol{\gamma} + \mathbf{z}'\boldsymbol{\eta} + \mathbf{u}, \tag{11}$$

[20] For example, cultural norms might in part determine the importance placed by different ethnic groups on having children, or on tribal and lineage considerations.

where α and β are unknown scalar parameters, and $\boldsymbol{\eta}$ and $\boldsymbol{\gamma}$ are, respectively, $k \times 1$ and $l \times 1$ parameter vectors, with $l \leq k$. $E(\mathbf{u}|x, \mathbf{z}) = x'\delta$.

The conditional mean of C given $(x, \mathbf{z})$ may be written as

$$E(C|x, \mathbf{z}) = \alpha + \beta E(C|x) + E(\mathbf{z}|x)'\boldsymbol{\gamma} + x'\delta + \mathbf{z}'\boldsymbol{\eta}. \tag{12}$$

Endogenous effects on individual fertility outcomes, in the sense that the mean children ever born (CEB) by ethnic group is a determinant of individual CEB[21] are present for $\beta \neq 0$. For $\boldsymbol{\gamma} \neq 0$ we observe a *contextual* effect whereby CEB varies with $E(\mathbf{z}|x)$, the mean characteristics by ethnicity. Focussing upon a single element of $\mathbf{z}$, say z_1 denoting education level, we are interested in capturing the effect of more highly-educated women in a population on fertility decisions *after* controlling for the level of education of the individual.[22] We would expect that conditional upon ethnicity, CEB would be lower for more highly educated women than others, such that $\eta_1 < 0$. In addition, the characteristics of these more highly educated women may filter through to influence CEB such that $\gamma_1 < 0$ orchestrating a transition in fertility.

Correlated effects operate through $\boldsymbol{\delta}$ and reflect the presence of common unobservable characteristics: these may range from factors such as the influence of the local religious clergy and/or tribal customs, to women's perceptions about the costs and benefits of childbearing, or to the advantages of obtaining an education in this society. [To the extent that these are not picked up by ethnicity].

As it stands (12) is not estimable given the endogenous regressor $E(C|x)$. In order to obtain an expression for $E(C|x)$ we marginalise both sides of (12) with respect to $\mathbf{z}$, giving

$$E(C|x) = \alpha + \beta E(C|x) + E(\mathbf{z}|x)'\boldsymbol{\gamma} + x'\delta + E(\mathbf{z}|x)'\boldsymbol{\eta}. \tag{13}$$

For $\beta \neq 1$ we may rewrite (13) as

$$E(C|x) = \alpha/(1-\beta) + E(\mathbf{z}|x)'(\boldsymbol{\gamma} + \boldsymbol{\eta})/(1-\beta) + x'\delta/(1-\beta). \tag{14}$$

The genesis of the identification problem derives from the simple observation that in (11) we specify a model for children ever born which is linear in a mean endogenous effect, $E(C|x)$, and a mean exogenous effect, $E(\mathbf{z}|x)$. It therefore follows that the reduced form representation of the conditional mean $E(C|x)$ will be a function of $E(\mathbf{z}|x)$. This is obviously central to the question of identification, namely we start with the intention of disentangling a mean group (ethnic) effect, in terms of the three components $E(C|x)$, $E(\mathbf{z}|x)$, and $E(u|x, \mathbf{z})$, and observe that, not surprisingly, the reduced form $E(C|x)$ is a function of $E(\mathbf{z}|x)$.

The observation that the mean endogenous effect is a function of the mean exogenous effect is of course wholly in keeping with the theoretical predictions of "contagion" theory (as in Dasgupta (2000)). Returning to our example of educated women, this theory would argue that in the transition to low fertility, increasing numbers of educated women in a society are the ones who act as 'tradition-breakers'

[21] Rather than simply *reflecting* individual actions.

[22] Ecological fallacy.

because they prompt societies to move from a high-fertility equilibrium to a low-fertility one. In the context of fertility behaviour in Kenya this would suggest that fertility decisions by less-educated women belonging to a particular ethnic group (and/or living in a certain region), would be influenced by more highly-educated women belonging to the same ethnic group (and/or living in the same region).

To determine exactly what is identified we insert (14) into (12) giving

$$E(C|x,\mathbf{z}) = \alpha/(1-\beta) + E(\mathbf{z}|x)'[(\boldsymbol{\gamma}+\beta\boldsymbol{\eta})/(1-\beta)] + x'\delta/(1-\beta) + \mathbf{z}'\boldsymbol{\eta}. \quad (15)$$

>From (15) we see that the composite parameters $\alpha/(1-\beta)$, $(\boldsymbol{\gamma}+\beta\boldsymbol{\eta})/(1-\beta), \delta/(1-\beta)$, together with $\boldsymbol{\eta}$ are identified conditional upon the regressors $[1, E(C|x), x, \mathbf{z}]$ being linearly independent in the population.

There are a number of ways to circumvent the identification problem. Within a linear framework the simplest yet probably the most restrictive method, is to impose zero restrictions. For example, Brock and Durlauf (2000) achieve identification by locating an individual level variable whose group level average can be ruled out a priori as a contextual effect[23]. *Expand on this in our case.* A more general approach, and the one used in this study, is to apply a link function to the conditional expectation $E(C|x,\mathbf{z})$. Namely, instead of assuming that this expectation is linear we write

$$E(C|x,\mathbf{z}) = F(\alpha + \beta E(C|x) + E(\mathbf{z}|x)'\boldsymbol{\gamma} + x'\delta + \mathbf{z}'\eta), \quad (16)$$

where $F(.)$ is a nonlinear monotonic transformation which maps the conditional mean from $\Re$ to the unit interval. This mapping achieves two things. First, the marginal effects are now not the estimated parameters. For example, the marginal effect of an increase in group level fertility

$$\frac{\partial F(.)}{\partial E(C|x)} = \phi(E(C|x/\sigma))\beta/\sigma,$$

depends on the level of mean fertility. We might expect that at both high and low levels of $E(C|x)$ this effect will be small, with the effect of social interaction highest for mid level values. As an example, consider the case of a binary discrete choice model, where for a given group of households, $E(C|x)$ is close to one. In this instance the marginal effect of a small increase in average fertility will be small since those remaining women without children are unlikely to respond to the fertility behaviour of others in the group. In figure * we present this relationship in the form of a reaction curve. By considering the intersection of the 45^0 line and the function $F() = \Pr(C_i = 1|\mathbf{z}, x)$ and $E(C|x)$, we see that unlike the linear model, the use of a link function allows for multiple equilibria.; and related, the magnitude of any change in the fertility level of the reference group will depend on the *level* of average fertility.

The introduction of the link function will also serve to eliminate, except in pathological case, Manski's reflection problem. Although the observation that the introduction of a non-linear transformation facilitates the identification of an otherwise

[23] Note that the existence of such variables will increase the precision of the estimates in a nonlinear setting.

unidentified model is not new[24], it is noteworthy that by introducing $F()$, we need not write the reduced form of (13) as (14). For example, with $F()$ either the logistic or standard normal cumulative distribution function, the problem is transformed to one of explaining the probability of having at least one child.

6.2 Empirical Identification: Spurious Inference on Social Interaction

The finding of a statistically significant interaction effect attributed to one or more manifestations of group (aggregate) behaviour, may be a result of an underspecification at the level of the individual unit.[25] The critical issue here is whether the mean values of the individual characteristics (constructed over appropriately defined groups) are endogenous to *unobserved* individual characteristics. A corollary of this is the question of how robust are any estimated group effects to different levels of control for within group variation (*Note*: expand relative to making inference on more than one group effect, and therefore different manifestations of underspecification. ...For example, the finding of a significant *aggregate* (exogenous) cluster effect attributable to the mean education of individuals, might be spurious if an individual characteristic which is both correlated with this average and a determinant for fertility is omitted. Similarly unobserved attributes of the cluster may also confound influence on the significance of interactions.[26]

Ginther, Haverman, and Wolfe (2000) in examining the robustness of inference on the effect of neighbourhod characteristics on different measures of children's attainment, explicitly consider the robustness of inference attributable to group effects. The focus of their analysis is the variation in both magnitude and significance of neighbourhood effects across a number of model specifications, differentiated by differing degrees of control for family characteristics. One noteworthy finding is that the closer the neighbourhood characteristic to the outcome measure the more robust is any inference on this effect to varying controls for family characteristics[27]. Now make distinction between endogenous and contextual effects. More specifically the authors find that a significant neighbourhood effect is observed as the set of family characteristics is reduced.

A problem of endogenous group formation (self-selection) is also a potential confounding effect. Consider the case where N individuals described by a vector $\mathbf{x}$ of characteristics are distributed over $J < N$ groups. An investigator seeks to make inference on the effect of one or more group level variables on fertility decisions. In considering the possibility of non-random selection into the J groups we first write

[24] For example, Heckman's selection model.

[25] Hauser( ) refers to this as a "contextual fallacy".

[26] As an example, Jalan and Ravallion (1997) identify positive externalities arising from average wealth. However, the critical issue is that in locating an aggregate effect it is necessary to ensure that such an effect is not a proxy for omitted non-geographic variables. Namely, an *aggregate* geographic effect might be spurious if a household attribute which is both correlated with average wealth (i.e. education) and a determinant for growth is omitted.

[27] A concern for this problem motivates the approach adopted by Guinnane, Moehling, and O'Grada (2001b)

$\mathbf{x} = \mathbf{x_s} \cup \mathbf{x}_{ns}$ where $\mathbf{x}_s = \mathbf{x}_{s1} \cup \mathbf{x}_{s2}$ ($\mathbf{x}_{ns}$) denotes the set of characteristics which are important (irrelevant) for selection. The partition on $\mathbf{x}_s$ reflects the distinction between selecting characteristics that are also determinants (redundant) for fertility decisions. In such a case attributing a statistically significant contextual effect to a process of social interaction is not possible unless all values of $\mathbf{x}_{s1}$ are controlled for. For example, if individuals sort themselves based upon an unobserved characteristic $x_p \in \mathbf{x}_{s1}$, which is also a determinant of fertility, then any subsequent group effect where the group is at least partially spatially defined, may be acting as a proxy for this unobserved effect (see Grimlich (.)).

Now expand discussion in terms of multiple levels of social interaction, and therefore potential for selection biases at these different levels. It is important to understand here that individuals do not self-select into these groupings. They do not self-select at the level of the household. At the level of the cluster there is self-selection insofar as individuals locate in a cluster due to their ethnicity, and ethnicity is important for fertility. But we can control for this by also conditioning our analysis on ethnicity.

6.3 Immutability and Ordering (incomplete)

The discussion of multiple types of social interaction in section 5, concerns, in a more general sense, the issue of the appropriate ordering within a cross-section. Namely, although the form of ordering in a time series is both singular[28] and immutable, within a cross-section there may exist more than one ordering, and in addition, the relative importance of these orderings over time. In this study we have entertained three possible orderings: (i) dependence exists within the household;[29] (ii) dependence exists across individuals that reside in a cluster of households; and (iii) that dependence exists across individuals within the same ethnic group. In this context the issue of immutability concerns the fact that with a single observation per individual we are strictly not able to make inference as to the permanence of any interaction effects. However, although similar problems of inference based on a single cross-section relate to whether or not an estimated individual effect represents a steady state relationship, or some form of transition, it is possible to argue that: in the case of social interaction effects due to fertility behaviour, the relevance of the three orderings, household, the cluster, and the ethnic group, is unlikely to change; and that any observed aggregate effects are unlikely to be change over time periods of five to ten years (?)

7 NonLinear Models of Fertility Behaviour

Although departures from the linear model are numerous, economic theory is, in general, relatively impotent in informing choice as to the most appropriate non-

[28] With of course a large number of different processes used to represent dependence across a set of time ordered observations.

[29] Note that given we do not observe a separate set of observations for each individual within a household, and instead observe a comparable set of household attributes (i.e. number of other wives, size of household), ...

linear form. However, in this particular context we may narrow the set of options to the following: multiple index models choice models; single index models such as ordered response; and single index models using a count model. Although all models incorporate probability models with masses of probability at non-negative integer values, the Poisson model, in imposes less structure than the ordinal response model, and therefore represents a natural starting point.

The Poisson distribution for the number of children ever born $y = 0, 1, 2, \ldots$, and for intensity parameter μ, is given by

$$\Pr[Y = y] = \frac{e^{-\mu}\mu^y}{y!}, \quad y = 0, 1, 2, \ldots$$

The principal problem with this specification derives from an equidispersion dispersion characteristic such that $E[Y] = Var[Y] = \mu$. As a result, in certain instances this restriction will result in a misspecification. For example, in many count processes the variance often exceeds the mean (overdispersion), as a result of the excess zeros problem. One manifestation of this is that a Poisson density predicts the probability of a zero count to be considerably less than observed. In the particular context of modelling the number of children ever born to a woman, an excess zeros problem may, in part, originate as a result of women in the sample who cannot have children, and for whom there are no reliable indicators of the infertile state.

In order to circumvent these restrictions a class of *zero-inflated models* have been proposed, where the vernacular *inflation* is used to denote the fact that the probability mass at zero exceeds that allowed under a standard parametric family of distributions. This could apply to both the Poisson and the Negative Binomial model. Both these models allow for excess zeros in count models by assuming that the population is characterised by two regimes: a) an always zero regime; and b) a zero or non-zero regime. The generic form of these models is given by

$$Y_i \sim \left\{ \begin{array}{ll} 0 & \text{with probability } p_i \\ \Delta(\mu_i) & \text{with probability } 1 - p_i \end{array} \right\},$$

where Δ denotes the kernel density. In both cases a mixture distribution is comprised of an always zero regime, and a sometimes zero, with respective probabilities p and $1 - p$. NB represents a natural extension of the (nested) Poisson in the sense of allowing for cross-section heterogeneity through the modelling of an individual unobserved effect, say ϖ_i; the first two moments of the NB model are $E[Y] = \mu$ and $Var(Y) = \mu(1 + \alpha\mu)$, where α is var(ϖ_i)? Subsequently we simply present the Zero Inflated Negative Binomial (ZINB) model.

The conditional and unconditional pdf for the non-degenerate component of the ZINB model is given by

$$\begin{aligned} f(y_i|\varpi_i) &= e^{-\mu_i\varpi_i}(\mu_i\varpi_i)^{y_i}/y_i! \\ f(y_i) &= \int_0^\infty [e^{-\mu_i\varpi_i}(\mu_i\varpi_i)^{y_i}/y_i!]g(\varpi_i)d\varpi_i \end{aligned} \qquad (17)$$

For convenience, namely to ensure a closed form expression for (17), a gamma distribution is chosen for ϖ_i. The conditional mean is now given by $\ln\theta_i = \ln\mu_i + \ln\varpi_i$.

$$Y_i \sim \left\{ \begin{array}{ll} 0 & \text{with probability } p_i \\ \text{NegBin}(\mu_i, \alpha) & \text{with probability } 1 - p_i \end{array} \right\}$$

where we parameterise p_i using a probit link function..

In summary we utilise a ZINB model, where the inflation sub-model addresses the excess zeros component; the negative binomial component allows for excess dispersion above and beyond excess zeros. The model also incorporates standard errors that are adjusted for a departure from iid errors due to the a random component at the level of the cluster.

8 Data and characteristics of DHS survey

Reflecting the population breakdown in the country as a whole, our sample, taken from the Kenyan Demographic and Health Survey (KDHS)[30], has data on the Kalenjin, the Kikuyu, Luhya, Luo, Kamba, Kisii, Mijikenda/Swahili and Meru/Embu.[31] The Kenya DHS adopted a two-stage stratified sampling approach that selected households located within primary sampling units (PSU) or sampling clusters. A sample of households are then selected within each PSU[32]. These clusters are identical to the complete enumeration of sample clusters which took place as part of the 1977 National Demographic Survey. The sample points themselves are identical to those chosen in the sampling frame maintained by the Kenyan Central Bureau of Statistics. In the 35 of Kenya's 42 districts that were included in the survey, there were 536 cluster lists compiled - 444 rural clusters and 92 urban clusters, of which 530 were non-empty clusters[33]. There was also an implicit stratification introduced by ordering the clusters geographically within a hierarchy of administrative units in order to identify their location within the district and province (DHS and Macro International, 1999: 179-182). A complete list of all households in each cluster was recorded between November 1997 and February 1998. From the remaining 530 clusters, a systematic sample was drawn of, on average, 22 households in urban clusters and 17 households in rural clusters. This formed a total of 9465 households. In these households, all women age 15-49 were targeted for interview. Response rates varied by province from approximately 88% to 99% (for more details see KDHS, 1998 p.180). In the data used in the present study however we consider individual-level data only for the 7800 women who did respond.

[30]The survey contains interview data for 7800 women aged 15-49 and includes both ever-married and never-married women. It contains women from all of Kenya's large ethnic groups and covers a wide geographical area, omitting only the areas of extremely low population density in the North. Geographically. Kenya is divided into 7 provinces which are further subdivided into 47 districts. The Kenya DHS covered 42 of Kenya's districts; 35 were sampled, 7 were not. 17 districts were oversampled.

[31]Our study excludes the Maasai, a pastoral group living in the Kenyan Rift Valley, and other tribes such as the Galla and Somalis, who live in the north-east.

[32]This type of cluster-based sampling is generally based on the existence of a large number of clusters, and that within each cluster there are a relatively small number of units - here observations.

[33]6 of the clusters could not be included in the survey due to inaccessibility (DHS and Macro International 1999: 180).

In addition to the geographical stratification of data by cluster and household, it is also possible to stratify these data by ethnicity. As also discussed in section 2, the major Kenyan ethnic groups (covering 88% of the population) are Kikuyu, Luo, Luhya, Kamba, Kalenjin, Kisii and Mijikenda/Swahili. The Kikuyu is the largest, with 17.9% of the population, while Mijikenda/Swahili is the smallest, with 5.0%. The representation of each group in the sample is similar to its representation in the whole population. Table 3 depicts the total number of cases under study grouped according to region and ethnicity. The largest number of women included in the sample live in the Rift Valley region, while the smallest number of women sampled live in Nairobi. The nature of the sample is therefore particularly useful for analysing behaviour in rural Kenya Looking at the distribution by ethnic group, the largest sample was drawn from the Kalenjin group, while the smallest was drawn from the Meru/Embu group[34].

According to the DHS data, a rural woman has on average about 5.2 children compared to fertility among urban women at 3.1 children. . Fertility differentials by the level of education show that illiterate women bear on average 5.8 children compared to 3.5 children for women with secondary school education (DHS 1998, p. xvii). To what extent does the sample reveal demographic differences between ethnic groups? For women aged 40-49, the mean CEB varies from 5.91 for Kikuyu to 7.56 for Luo. The differences in fertility by ethnic group are clearly very large, and are evident whether we are examining actual completed fertility (CEB), ideal number of children desired, or unwanted fertility. Table 5 shows the mean CEB grouped by region and by ethnicity for various age cohorts in the sample. CEB varies from a low of 1.7 in Nairobi/Central to a high of 3.3 in Nyanza. This pattern is also seen by region for differing age cohorts. The Kikuyu, Kalenjin, Luhya and the Luo follow similar patterns for all age groups. For example, CEB is low among the Kikuyu (in the Nairobi region), and high amongst the Luo (in the Nyanza region).

There are three-quarters of women and men in the sample either who want to limit births or to space them.**Table** $**$ shows the stated ideal number of children desired by women in the sample. This is lowest in Nairobi/Central compared to Nyanza, western and coast regions. It varies from a low of 2.95 to a high of 4.36 in Coast. This pattern is also seen by region for differing age cohorts, except for the Coast region (discussed below). All ethnic groups depict relatively similar behaviour except for Miji/Swahili (in the Coast) who depict very high ideal numbers, and the Kikuyu who are very low.

Table $**$depicts unwanted fertility in the sample measured as the total number of CEB less the ideal number of children desired for women aged 40-49 years who have largely completed their fertility. This is lowest in the Central region (-0.5) and highest in the Coast region (-1.7). In all regions, women are having greater numbers of children than they desire, except among women in the Coast region where it is the reverse. All ethnic groups are having greater numbers of children than they desire, except among Miji/Swahili, where it is the reverse. For the age group 40-49,

[34] It is important to understand here that individuals do not self-select into these groupings. They do not self-select at the level of the household. At the level of the cluster there is selection insofar as individuals locate in a cluster due to their ethnicity, however this is exogenous to fertility behaviour.

unwanted fertility varies from 0.1 in the Coast region to 2.4 in the Eastern region.

The DHS data show that knowledge of family planning in Kenya is very high: 98% of women and 99% of men were able to name at least one modern method of contraception. There are 39% of women who use contraception and the most widely used methods are contraceptive injectables, the pill, female sterilisation and periodic abstinence. Contraceptive use does however vary greatly by region: while there are 61% of women in the Central province who use contraception, only 22% of women in the Coast province do so likewise. Only 23% of women with no education use contraception compared to 57% of women with secondary education. Both government and private medical sources provide access to contraceptives.

8.1 Channels of Message Transmission: Group and Variable Selection

In light of the characteristics of the ethnic groups, we postulate that social interactions occur at multiple levels - at the level of the cluster, the household and across ethnicity. The key channels of message transmission at the cluster-level would be those occasioned by learning effects at the cluster-level, which, given the differential pattern of clustering by extended families, is likely to differ across ethnic groups For example, the current level of CEB may be influenced by history or past fertility behaviour. Current CEB may also be influenced by expectations about CEB. The area of residence – e.g. the ridge may be a possible influence. The diffusion of contraceptive technology which though uniform across the cluster, may be another possible influence. In this case, access to the media (for example radio messages about lower fertility on the Voice of Kenya) represents an additional potential influence CEB. However, fertility at this level is also dependent upon access to electricity and water on the assumption that if they are badly provided, CEB will be greater given the existence of a direct fertility motive for children to help with these water and fuel collection tasks.

At the household-level, the channels of message transmission are diverse. Household structure is relevant: over 30% of households in the sample were those in which there was more than one wife. Polygyny can have two effects on fertility which may work in opposite directions: first, it might raise CEB due to the greater help afforded with child-care. Alternatively, it may reduce fertility as information about contraception may be more discussed among co-residents in the household. Both age-grading and hierarchy would tend to make households more patrilineal with the consequences for lower female autonomy implying greater CEB. If family planning was discussed with neighbour and friends, the influence on fertility will be great, and often more important than the influence of the immediate family. The extended family may also influence CEB by helping with child-care. However, it is important that this set of potential interactions need to be countenanced by other household-level attributes for example, rooms for sleeping, roof quality and floor quality which can be used as indicators of income, the presence of consumer durables such as access to radio, TV, telephone, and bicycle which have implications for both income, for water collection times, and for media access.

In justifying the selection of the ZINB as a model of fertility behaviour we now consider the selection of the various groups as the mechanism for mediating multiple social interactions, and for each group, the specific form of the endogenous and exogenous effects[35]. The group effects included in the model are attributed to the household, to the ethnic group, and to the village cluster.

Individual-level Effects

The choice of variables to control for individual level effects is in keeping with a long lineage of economic models of fertility decisions. These variables are age of the woman measured in years and an age-squared variable accounting the non-linearity associated with age-related variables. This controls for older women having, on average, more children than younger ones. The education of the woman is included and measured as the highest level of education attained, separating out primary, secondary, and higher education effects. The influence of the media was measured as whether the woman listened to the radio at least once a week. This variable was included on the assumption that greater information about contraceptive technology would be available to the woman if she listened to the radio, as messages about this are routinely broadcast on the national radio channel, the 'Voice of Kenya' in English, Swahili and the vernaculars. A binary variable recorded how long the woman had lived in the community. If she had lived in the same community since 1993 then this variable took the value 0; if she had recorded in the interim period and had therefore lived in at least two communities, then this variable took the value 1. This variable was included on the assumption that if a woman has resided in the community for a longer period, then she was more likely to have formed stronger networks in the cluster, which in turn may influence her fertility behaviour.

Household-level Effects: mean effects

A number of mean-level effects were created at the level of the household. One measure of interaction is a measure of polygyny: there were 30% of households who had more than one wife living in the household. It is expected that households which had more than one wife would have lower fertility due to help provided with child-care. In addition a mean level variable measured whether or not family planning had been discussed with friends and neighbours. This form of interaction is important, for example, if a woman was likely to discuss family planning with friends and neighbours, here decision-making is more likely to be influenced by them. For example, other demographic studies of poor societies have found that this role played by friends and neighbours is important for either lowering or raising fertility (see, for example, Iyer (2002)). The number of usual residents in the household, where usual residents excludes the number of children-ever-born to women, was also included as a mean effect. The rationale for the inclusion of this variate is that if other household members help with child care, then this considerably alters the benefits and costs of child bearing to parents. Where kin help with care, or indeed as with other African societies where 'fosterage' is common, other residents have an important bearing on a woman's total fertility. Household-level effects for the three levels of highest education attained - primary, secondary and higher education - were also included in the model.

[35] Note: there are empirical reasons why we might want to slice the data by region. It is mainly due to government policy in Kenya which has targeted married women of reproductive age in regions.

Household-level Effects: Controls

A number of household level variables were included to control for income and other characteristics. One notable problem here us that in the DHS no direct questions on income were asked of survey respondents. Utilising a number of questions asked about household quality, access to infrastructure, and the ownership of consumer durables, it was possible to construct a number of indicators which control for the economic status of households. First, the quality of both the flooring of the home and the quality of the roof were used in the model. The quality of roof construction was measured on the following (increasing quality) scale: iron (mabati), tiles, grass or thatch, and other material. The quality of the floor was measured using (decreasing quality) scale: mud, dung or sand, wood planks, tiles or polished wood, and cement. Other indicators of the quality of housing infrastructure were whether or not it had a toilet, and the number of rooms for sleeping.

The status of the household may also be proxied by ownership of consumer durables. Such items provide a relatively good measure of income given that the purchase of consumer durables is not subject to short-run variability, and as such is more representative of the longer-term status of the household. The variables that were used are whether or not the household owns a radio, a television, a telephone, and a bicycle. Note however, that ownership of a radio and a television could also be seen as indicative of the household's access to the mass media. Ownership of a bicycle is important for access to fuel and water.[36]

Cluster-level mean effects

In order to capture social interactions at the level of the cluster, a number of mean cluster variables were created. These variables represent endogenous and exogenous effects, as well as controls for the attributes of the cluster. Mean children ever born by cluster was included as a measure of endogenous effects, and was also interacted with an ethnic dummy to allow for interactions to differ across ethnic groups. A number of measures were also created to capture exogenous effects. Mean-level cluster effects for education measured up to the highest level of education attained (primary, secondary and higher) were constructed. For the number of usual residents mean-level cluster effects for whether or not family planning was discussed with others such as neighbours and friends was included in the model.

Cluster-level mean attributes

The construction of measures of cluster *attributes*, as opposed to characteristics of cluster members is critical if we are to reduce the likellihood of spurious inference. (Give example here - see Ginther). For example, based upon the work of Dasgupta (1993), better access to water and fuel reduces the demand for child labour to collect them, and that this is turn reduces the demand for children, and hence the fertility rate (Iyer (2002); Aggarwala, Netanyahu, and Romano (2001)). In Kenya in 1973, only 15% of the population in rural areas was served by piped water points so there was considerable time spent by families transporting drinking water. Moreover, any drinkingw water collected from rivers or ponds was also untreated. Although this situation has changed considerably in recent decades with the promotion of self-

[36] For example, other demographic studies have found that onwership of a bicycle considerably reduces the time spent collecting water for a households' daily requirements (Iyer 2002).

help groups in rural areas to provide access to potable water, in order to take the effect of such basic infrastructure access into account, mean-level cluster effects were created for access to fuel and water. Access to fuel at the cluster level was measured by a mean-level effect for access to electricity. Access to water infrastructure at the cluster-level was measured by three variables: (i) whether access to water was located in the residence (either piped into the residence or a well was located in the residence); (ii) whether access to water was obtained from a publicly-provided source, either a public tap or a public well; (iii) whether water was obtained by collecting it from a river, stream, pond or lake; and (iv) whether rainwater was relied upon as the chief source of water. Another cluster-level attribute included was whether or not a radio was listened to at least once a week.

9 Results[37]

The results of the zero-inflated negative binomial model are shown in Table 10. The dependent variable in the model is that total number of children ever born (CEB). We note that although the model contains a large number of variables based upon cluster aggregates, standard errors are calculated using the Huber (1967) method to adjust for any residual intra-cluster correlation.

Province-level variables

All six of the province level variables were significant at the 5% level, and exerted a negative effect on CEB, relative to the base category, the 'western' province. The coefficients ranged in value from 0.05 in the Rift Valley to 0.14 in Nairobi. This suggests that the broad region in which people live seems to matter for fertility. But given that the size of the province is very large, it is difficult to draw interpretative conclusions from these variables.

Cluster-level mean effects

As discussed in section 7.1, the cluster–level variables are divided into cluster-level social interaction terms, and variables measuring the effect of cluster-level attributes. We first consider the effects of the cluster-level social interaction terms. The endogenous effects for each of the ethnic groups, as measured by the difference between mean CEB for a particular ethnicity and individual CEB[38] are all insignificant. The mean group educational level effect attained by each ethnic group was significant for a number of ethnic groups. For example, at the 10% level, the mean education effects were important for the Kalenjin and the Kamba. For Kenya as a whole, the Kalenjin have, on average lower rates of schooling attainment, even though the average rates of education among them in the sample are similar to other groups such as the Kamba. Yet these levels are still below the Kikuyu, for example. This might suggest that groups which have lower levels of education, on average, are also more likely to be influenced by social interactions derived from the

[37] Note that actual reported coefficients in Table 10, not being marginal effects, cannot be used to report the actual effect on the number of children ever born. Such estimates will be provided in the next revision, and will replace the *.

[38] This is consistent with an underlying representation of the social utility function as conformist. See Bernheim (1994).

better-educated members of their ethnic groups.

Cluster-level attributes

A number of cluster-level attributes were very significant. For example, if the cluster had access to the mass media, measured by mean access to radios, then this exerted a negative effect on fertility: the likelihood of having an extra child was reduced by about * children. In addition electricity access in the cluster had a negative impact on fertility. Infrastructure variables,with respect to water resources, were also very significant. Relative to depending on rainwater, if the cluster had access to a river, pond or stream fertility was lower, on average, by * child. If the cluster had access to piped water, this reduced fertility by on average * child; and if the cluster had access to water from a public source such as a public well, then this also reduced fertility by about * children[39]. These findings on fuel and water infrastructure are extremely significant in that they suggest that better access to fuel and water infrastructure at the level of the cluster are important for fertility reduction in this society.

Household-level mean effects

At the level of the household a number of social interaction effects were significant. The size of the extended family exterted a negative influence on fertility. This effect is inconsistent with expectations that the extended family would exert a positive impact on account of the help that they also afford with child care. In the sample there were nearly 30% of households in which there was more than one wife resident. Households which had more than one wife resident were likely to experience lower fertility. At first glance, this finding might be surprising given that we would expect that households in which polygyny was practiced are likely to be households in which there is additional help with child-care. But it could equally be the case that these are also households in which family planning is better discussed, or in which second marriages were undertaken by men due to the lack of progeny from the first marriage. Although we have no way of testing which of these explanations account for this finding, this particular finding is not inconsistent with other studies of polygyny and fertility which have shown that polygynous marriages are not always more fertile than monogamous ones (Obermeyer (1992)).

Discussion of family planning with friends and neighbours decreased fertility among the Kenyan women in the sample, on average by about * children. This finding is consistent with more recent evidence in the demographic literature on other societies such as India, which suggests that the role of others coresident in the household might have profound consequences for demographic behaviour; and that women in developing societies may actively discuss contraception, thereby encouraging others to use it and lower fertility (Iyer (2002)).

Household-level attributes

Household-level social effects need to be mediated by the effect of the household-level attributes. As discussed in section 7.1, a number of household-level attributes are used as controls. In general we would expect that income would be negatively correlated with fertility, and this hypothesis was borne out by income indicators used in the model. For example, if the woman belonged to a household which had an iron

[39] Relative to clusters in which rainwater was relied upon to provide basic water needs.

roof or a tiled roof (relative to the base of straw or thatch), then the woman had, on average, lower fertility. This finding is unsurprising as roofing quality is a strong indicator of income in a rural household. None of the floor quality variables were, however, significant. Access to a toilet facility, another indicator of income, was also significant. Two variables included in the model which could be construed both as income indicators and as controls for media access: radio and television ownership. As expected, radio ownership exerted a negative impact on fertility, suggesting that messages transmitted by the Voice of Kenya were effective, although this variable was only significant at the 10% level. Ownership of a telephone increased fertility and this seems unusual. Another income indicator - rooms for sleeping - also depicted negative effects on fertility, as might be expected.

Individual-level effects

The age of the woman depicted the expected relationship with fertility: older women, on average, have higher fertility than younger women. Primary education exerted a positive effect on fertility consistent with other studies that a few years of education merely weakens existing taboos (such as not practising abstinence upon attaining grandmother status), and that this accounts for an initial increase fertility. Numerous demographic studies on this issue, argue that it is only secondary and higher education that reduces fertility. However at the individual level, the other education variables were not significant, probably on account of the fact that the effect of education is captured in the social interaction terms at the cluster level. The social interaction terms for children ever born by ethnic group, again measured based upon an underlying conformist social utility function was highly significant for all the ethnic groups. One particularly striking result is the observation that although for all ethnic groups with the exception of the Kikiyu, the estimated endogenous effects were in the range 0.186-0.229, for the Kikiyu, this effect was considerably greater (0.314). In examining Table 2 we note that in relative terms the Kikiyu have a highly evolved sense of ethnic identity, and that for this group, households are generally comprised of groups of individuals which are related by blood and marriage (the *mbari*). As a result one might expect a greater tendency for fertility decisions to reflect ethnic group norms.

After extracting that component of variation in CEB due to the effect of mean ethnic group fertility behaviour, an ethnic group dummy variable was included to capture a composite of unobserved ethnic attributes: an ethnicity effect, relative to the Luo - the base category - was significant for most groups. The only exception was the Meru/Embu group which showed a positive effect on fertility. One explanation for this effect of being Meru/Embu is that this group live in the North and East of Kenya, and , depict more traditional norms about marriage and fertility. For all other groups however, the effect of ethnicity was to lower CEB. A dummy variable that controlled for urban and rural residence showed that CEB was lower, on average, if the woman lived in an urban area.

The inflation sub-model (used to estimate the probability that a woman has zero children due to being infertile), was estimated using two predictors. First, we used a cut-off age of thirty eight (*ageConstraint*), to capture the effects of age, and in addition, the answer to the question of $ideal\ family\ size$. The variable

$IdealFS\_zero$ scores one if a woman responds with zero to the question, $What\ is\ your\ ideal\ family\ size$. The null hypothesis that all the parameters in were jointly equal to zero was firmly rejected.

10 Conclusion and policy relevance of research

Both economists and demographers are interested in analysing the causes behind high fertility especially in some developing societies in which fertility rates are considerably in excess of replacement level. In the debate about whether it is individual economic circumstances that influences fertility behaviour, or whether there are factors within the wider society that have implications for fertility, the role of social interactions has been observed to matter.This paper has also examined the importance of social interactions, in the context of fertility behaviour in Kenya but has stressed the importance of the multiplicity of social interactions for fertility bahaviour in Kenya.

Strategic complementarities in fertility decisions implies that a couple's fertility decisions may be dependent on the actions of others in the vicinity or in the society more widely.The mechanisms through which these complementarities occur are through strategic interactions. In this paper we argue that it is possibly to identify the channels through which these interactions occur, and that they are plural rather than singular in nature. We argue that these channels operate at the household, cluster and ethnic level. This is an important finding of the research because it suggests that by identifying the multiplicity of these channels, we have a better basis upon which to attempt to influence policy. More significantly, the existence of multiple channels of social interaction imply that an analyst attempting to isolate these pathways, needs to be cautious about the possibility of erroneous inference.

The key conclusion of the paper is that in order to influence fertility in Kenya, we need to be aware of the importance of both local and global interactions in the form of ethnicity and geography. The key finding is that once the influence of a 'global' form of interaction - ethnicity - is included, the influence of a more 'local' form of interaction - geographical clusters - becomes insignificant. This implies that we need to be cautious when specifying the channels of social interaction and in drawing inferences from them.

From a policy perspective, the analysis conducted here suggests that in Kenya, we will need to target the demand for children via influencing people's desires about fertility. For example, educating women is important as higher educated women depict lower fertility. On the other hand, the role of the media through promoting knowledge about family planning is critical in order to influence 'ideas' about lower fertility norms. Economic characteristics are important, and measures of income are significant determinants of fertility. If high fertility is a consequence of the demand for child labour to collect water and fuel infrastructure, then targeting access to piped water in the home and electricity is critical. But it is important also to recognise that economic characteristics interact with norms so that, for example, raising education levels for women of all ethnicities will be significant for fertility declines.

Ethnicity is significant for fertility to the extent that norms of behaviour among members of the same ethnic group, may coincide. This implies that ethnic group leaders can be targeted to influence norms. Geography in the form of localised cluster interactions, is an important kind of social interaction that influences fertility behaviour in Kenya, *but only when ethnicity is omitted from the model.* When we control for ethnicity, the local effect disappears. The key message that emerges from this study therefore is that since fertility in this sample is influenced both by 'local' interactions and by 'global' norms, from a policy perspective, a specifically targeted intervention in an area of high fertility, or towards specific groups in society, arguably will be more effective than a'one size fits all' approach to population policy. Therefore, both theoretically and empirically, if we are interested in reducing fertility in poor societies such as Kenya, or indeed drawing lessons for other developing societies more widely, we think it apposite to sound a word of caution: *Social interactions matter, but multiple interactions matter even more.* Failure to recognise their importance and interdependence will lead only to misspecifications, and more worryingly for population policy in poor societies, the problem of spurious inference.

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Table 1: Trends in Kenya's Demographic Indicators: 1948-98

Indicator	1948 Census	1962 Census	1969 Census	1979 Census	1989 Census	1977 Census	1998 DMS Sample
Population (millions)	5.4	8.6	10.9	16.1	21.4	29	n.a.
Population growth rate (% per annum)	2.5	3.0	3.3	3.8	3.4*	3.0	n.a.
Crude birth rate	50	50	50	52	48	35	34.6
Total fertility rate	6.0	6.8	7.6	7.9	6.7	4.8	4.7
Crude death rate	25	20	17	14	10	10	n.a.
Infant mortality rate	184	n.a.	118	104	66	66	70.7
Child mortality rate	n.a.	219	190	157	125	108	105.2
Life expectancy (yrs)	35	44	49	54	57	55	n.a.
Contraceptive prevalance rate	n.a.	n.a.	n.a.	7.0	26.9	39	39

n.a. = not available
*

Source: Compiled from Ayayi and Kekovole, 1998, p. 117; National Council for Population and Development (NCPD), Central Bureau of Statistics (CBZ), Kenya and Macro International (MI), 1999.

Table 2: Characte

Kalenjin	
	- on average, less educated than other groups w
	- smallest unit of territorial composition is the
Kamba	
	- high literacy and are involved in inter-territor
	- skilled craftsman and agriculturists
Kikiyu	
	- a highly evolved sense of ethnic identity and t
	- the best-educated of all groups and are also tl
	- fathers have a less dominant role for decision-
	- relations between extended family are strong;

Table 3: Distribution of the Sample by Region and Ethnicity

	Region							
	Nairobi	Central	Coast	Eastern	Ny'nza	Rift V'ly	West'n	ALL
Ethnicity								
Kalenjin	4	1	1	3	5	1272	30	1316
	(1.0)	(0.1)	(0.1)	(0.3)	(0.4)	(67.6)	(3.6)	(18.1)
Kamba	80	7	84	672	2	10	0	855
	(20.7)	(0.9)	(10.0)	(57.3)	(0.1)	(0.5)	(0.0)	(11.7)
Kikuyu	154	741	34	22	3	298	3	1255
	(39.9)	(94.6)	(4.0)	(1.9)	(0.2)	(15.8)	(0.4)	(17.2)
Kisii	13	3	2	2	559	64	2	645
	(3.4)	(0.4)	(0.2)	(0.2)	(40.7)	(3.4)	(0.2)	(8.9)
Luhya	61	10	37	7	52	179	771	1117
	(15.8)	(1.3)	(4.4)	(0.6)	(3.8)	(9.5)	(91.6)	(15.3)
Luo	58	10	48	4	749	55	35	959
	(15.0)	(1.3)	(5.7)	(0.3)	(54.6)	(2.9)	(4.2)	(13.2)
Meru/Embu	16	9	10	460	3	5	0	503
	(4.1)	(1.1)	(1.2)	(39.2)	(0.2)	(0.3)	(0.0)	(6.9)
Miji/Swa	0	2	628	2	0	0	1	633
	(0.0)	(0.3)	(74.4)	(0.2)	(0.0)	(0.0)	(0.1)	(8.7)
ALL	386	783	844	1172	1373	1883	842	7283
	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)

Table 4: Distribution of the Sample by Region and Ethnicity

%	Region							ALL
	Nairobi	Central	Coast	Eastern	Ny'nza	Rift V'ly	West'n	
Ethnicity								
Kalenjin	0.3	0.1	0.1	0.2	0.4	96.7	2.3	100.0
Kamba	9.4	0.8	9.8	78.6	0.2	1.2	0.0	100.0
Kikuyu	12.3	59.0	2.7	1.8	0.2	23.7	0.2	100.0
Kisii	2.0	0.5	0.3	0.3	86.7	9.9	0.3	100.0
Luhya	5.5	0.9	3.3	0.6	4.7	16.0	69.0	100.0
Luo	6.0	1.0	5.0	0.4	78.1	5.7	3.6	100.0
Meru/Embu	3.2	1.8	2.0	91.5	0.6	1.0	0.0	100.0
Miji/Swa	0.0	0.3	99.2	0.3	0.0	0.0	0.2	100.0
ALL	5.3	10.8	11.6	16.1	18.9	25.9	11.6	100.0

Table 5: CEB by Region and Ethnicity

	Region							
	Nairobi	Central	Coast	Eastern	Ny'nza	Rift V'ly	West'n	μ^E_{CEB}
Ethnicity								
Kalenjin	1.750	8.000	9.000	0.333	4.600	3.303	2.933	3.296
Kamba	1.688	3.714	2.619	2.842	2.000	3.800	-	2.729
Kikuyu	1.682	2.498	1.735	2.091	2.000	2.983	5.333	2.491
Kisii	1.308	1.667	4.000	0.000	2.716	2.625	8.500	2.687
Luhya	1.967	2.100	2.135	3.000	3.538	3.352	3.272	3.176
Luo	1.862	3.100	1.958	2.500	3.745	3.091	3.114	3.469
Meru/Embu	0.438	2.667	1.600	2.880	1.333	0.800	-	2.744
Miji/Swa	-	0.500	3.078	1.500	-	-	1.000	3.062
μ^R_{CEB}	1.692	2.512	2.865	2.829	3.310	3.224	3.271	2.983
σ^R_{CEB}	1.833	2.405	2.840	2.816	3.232	3.048	3.168	-

Table 6: CEB by Region and Ethnicity for Various Age Groups

CEB	Age Group (years)								
	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-59	ALL
Region									
Nairobi	0.11	0.93	1.81	2.38	3.51	3.95	5.12	4.49	1.69
Central	0.17	1.03	1.93	3.28	4.38	5.63	6.33	5.92	2.51
Coast	0.31	1.28	2.57	3.87	5.17	6.34	6.78	6.53	2.86
Eastern	0.15	1.20	2.61	4.02	5.00	6.31	6.75	6.51	2.83
Nyanza	0.24	1.46	3.19	4.99	5.97	7.32	7.59	7.46	3.31‘
Rift Valley	0.27	1.38	3.12	4.54	5.90	6.95	7.71	7.25	3.22
Western	0.20	1.44	3.00	4.82	6.09	7.13	7.35	7.23	3.27
Ethnicity									
Kalenjin	0.27	1.39	3.36	4.90	6.12	7.27	7.80	7.48	3.30
Kamba	0.17	1.21	2.62	3.95	4.88	6.14	6.60	6.34	2.73
Kikuyu	0.18	1.00	1.93	3.27	4.38	5.60	6.34	5.91	2.49
Kisii	0.09	1.15	2.89	4.20	5.49	6.67	7.67	6.99	2.69
Luhya	0.21	1.40	2.93	4.58	5.70	6.91	7.39	7.10	3.18
Luo	0.36	1.67	3.11	4.85	6.25	7.51	7.60	7.56	3.47
Meru/Embu	0.10	1.05	2.41	3.64	4.90	6.25	6.84	6.52	2.74
Miji/Swa	0.30	1.35	2.80	4.24	5.38	6.60	6.77	6.68	3.06
ALL Regions/Ethnicities	0.22	1.29	2.75	4.22	5.44	6.61	7.11	6.83	2.98

Table 7: Mean Education (Years) by Ethnicity

	Region							
Ed. Level	Nairobi	Central	Coast	Eastern	Ny'nza	Rift V'ly	West'n	μ^E_{CEB}
Ethnicity								
Kalenjin	13.5	0.0	7.0	7.3	7.0	6.5	7.0	6.5
Kamba	9.2	4.9	6.9	6.7	8.5	6.6	-	6.9
Kikuyu	9.5	7.9	9.6	8.7	7.7	7.4	6.7	8.1
Kisii	10.5	6.0	5.5	12.0	6.8	6.7	6.0	6.9
Luhya	8.7	6.8	8.4	9.6	6.0	6.0	7.1	7.0
Luo	8.7	6.7	8.2	8.8	5.9	6.9	8.1	6.3
Meru/Embu	8.9	8.2	7.2	6.5	10.0	8.6	-	6.6
Miji/Swa	-	11.0	5.1	4.0	-	-	6.0	4.2
μ_{ED}	9.2	7.8	5.1	6.7	6.3	6.6	7.1	6.7

Table 8: CEB and Educa

	Nairobi		Central		Coast	
	CEB	Educ.	CEB	Educ.	CEB	Educ.
Ethnicity						
Kalenjin	1.750	13.5	8.000	0.0	9.000	7.0
Kamba	1.688	9.2	3.714	4.9	2.619	6.9
Kikuyu	1.682	9.5	2.498	7.9	1.735	9.6
Kisii	1.308	10.5	1.667	6.0	4.000	5.5
Luhya	1.967	8.7	2.100	6.8	2.135	8.4

Table 9: Inference Template

Models estimated on CEBT	*Model 1*	*Model 2*	*Model 3*
Province-level variables			
Nairobi	X	X	X
Central	X	X	X
Coast	X	X	X
Eastern	X	X	X
Nyanza	X	X	X
Rift_Valley	X	X	X
Cluster-level variables			
Education	X	X	X
Children ever born (Kalenjin)	X	X	X
Children ever born (Kamba)	X	X	X
Children ever born (Kikuyu)	X	X	X
Children ever born (Kisii)	X	X	X
Children ever born (Meru-embu)	X	X	X
Children ever born (Mijikanda-Swahili)	X	X	X
Children ever born (Luhya)	X	X	X
media access (radio)	X	X	X
Discussed FP with friends etc.	X	X	X
elec. in HH	X	X	X
water (nat. source)	X	X	X
water (piped into HH)	X	X	X
water (public source)	X	X	X
Household-level variables			
Education (primary)		X	X
Education (secondary)		X	X
Education (higher)		X	X
Number of other wives		X	X
Discussed FP with friends		X	X
total HH size - CEB		X	X
iron roof		X	X
tiled roof		X	X
other roof*		X	X
wood floor		X	X
tiled floor		X	X
cement floor‡		X	X
toilet facility		X	X
has radio		X	X
has TV		X	X
has telephone		X	X
has bicycle		X	X
rooms (sleep)		X	X

Inference Template: continued

Models estimated on CEB			
	Model 1	*Model 2*	*Model 3*
Indiviual level variables			
Age			X
Current Age^2			X
Education (primary)			X
Education (secondary)			X
Education (higher)			X
Listens to radio			X
Resident since 1993			X
Kalenjin			X
Kamba			X
Kikuyu			X
Kisii			X
Luhya			X
Meru-embu			X
Mijikanda-Swahili			X
const			X

† base = rain water; *Base is thatch; ‡ Base is sand/mud

Table 10: Children Ever Born: Zero-Inflated Negative Binomial

Cluster Level Variables		
Models estimated on CEB	Model C	
	Coef.	Pr > $\|z\|$
Province-level variables		
Nairobi	-0.141	0.000
Central	-0.057	0.062
Coast	-0.134	0.000
Eastern	-0.106	0.007
Nyanza	-0.079	0.013
Rift_Valley	-0.053	0.022
Cluster-level variables		
children ever born (Kalenjin)	-0.004	0.974
children ever born (Kamba)	0.0171	0.234
children ever born (Kikuyu)	-0.028	0.257
children ever born (Kisii)	0.029	0.274
children ever born (Meru-embu)	0.007	0.822
children ever born (Mijikanda-Swahili)	0.009	0.694
children ever born (Luhya)	-0.019	0.124
children ever born (Luo)	-0.007	0.699
Education (Kalenjin)	-0.482	0.067
Education (Kamba)	-1.358	0.054
Education (Kikuyu)	0.138	0.793
Education (Kisii)	-0.363	0.587
Education (Meru-embu)	0.570	0.154
Education (Mijikanda-Swahili)	0.200	0.915
Education (Luhya)	-0.030	0.915
media accesss (radio)	-0.234	0.000
discussed FP with friends etc.	-0.045	0.334
elec. in HH	-0.053	0.074
water (nat. source)	-1.157	0.000
water (piped into HH)	-1.059	0.000
water (public source)†	-1.194	0.000

....continued

Models estimated on CEBT	Coef.	Pr > $\|z\|$
Household-level variables		
Number of other wives	-0.166	0.000
Discussed FP with friends etc.	-0.044	0.000
total HH size - CEB	-0.458	0.000
iron roof	-0.058	0.000
tiled roof	-0.097	0.043
other roof*	-0.067	0.368
wood floor	0.019	0.624
tiled floor	0.210	0.668
cement floor‡	-0.012	0.341
toilet facility	-0.005	0.000
has radio	-0.016	0.099
has TV	0.004	0.801
has telephone	0.063	0.038
has bicycle	-0.017	0.113
rooms (sleep)	-0.010	0.022
Indiviual level variables		
Age	0.234	0.000
Current age^2	-0.003	0.000
Education (primary)	0.052	0.000
Education (secondary)	-0.018	0.236
Education (higher)	-0.066	0.130
Listens to radio	0.006	0.206
Resident since 1993	0.022	0.132
Children ever born (Kalenjin)	0.186	0.000
Children ever born (Kamba)	0.203	0.000
Children ever born (Kikuyu)	0.314	0.001
Children ever born (Kisii)	0.197	0.000
Children ever born (Luhya)	0.217	0.000
Children ever born (Meru-embu)	0.229	0.000
Children ever born (Mijikanda-Swahili)	0.204	0.000
Kalenjin	-0.118	0.001
Kamba	-0.220	0.000
Kikuyu	-0.368	0.000
Kisii	-0.261	0.000
Luhya	-0.190	0.000
Meru-embu	0.279	0.000
Mijikanda-Swahili	-0.162	0.001
urban	-0.040	0.047
ideal number of children	-0.002	0.344
Inflation Model		
Age Constraint	-0.320	0.000
Ideal FS zero	-0.162	0.530
Constant	-18.044	0.000
$\alpha =$	3.54e-09	0.563