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Population and Agricultural Development Models: The Promise of the Third Generation

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The first- and second-generation economic-demographic models concentrated on the consequences of population growth. These were judged negative in the former, or possibly having some positive Kuznetsian effects in the latter. The proposed third-generation model examines conjointly both consequences and determinants of population growth, and analyzes them at the level of the agricultural household. In such a model the effects of population growth on agricultural development cannot be determined *a priori* but become the subject of empirical investigation.

Great reverence is due to the Rev. Malthus by the practitioners of the art of development-demographic modelling (henceforth D-D modelling). He certainly did not earn this place for the vulgarized views attributed to him, viz. that population growth is checked by limited food supplies. In fact Malthus was the first D-D modeller in the systems-simulation sense of the term. Moreover, he is still unsurpassed in the sense that his system, which ties together individual, family and aggregate economic and demographic change, has yet to be captured by the existing formal D-D models of the first and second generations. It remains instead a challenge for the third-generation D-D models which are now being conceptualized.

The primary function of a D-D model is to signal (and hopefully measure) the *indirect* effects of changes in the social, economic and demographic environment. No D-D model is needed where only direct effects are involved—in order to make projections of population and its age and sex distributions, or in order to construct a development plan and explore its implications for the levels of per capita income. The usefulness of D-D modelling arises when policy-makers are interested in the *interactions* and the *spillover effects* of the policy control variables they command. To what extent may the policies intended to increase agricultural productivity affect demographic variables, such as family size and its structure, population growth or rural-urban migration? In which ways may family planning expenditures affect economic variables, such as the level of education, family income and its distribution, and their aggregates? Is social mobility likely to interact with fertility, and if so which is the precise mechanism—education, income, employment?

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THE EARLY AND LATTER-DAY MALTHUS

Malthus was especially interested in the interactions-aspect of D-D modelling, or, in the modern parlance, in the consequences that go from population to development and the determinats which make the connection from development to population. The model was fully developed sequentially through the several editions of the *Essay on Population,* and especially between the first [15] and the second [12].

The emphasis in the first edition of the *Essay* is on the consequences of population growth. The formulation of the argument is rather elliptic; still it adumbrates the development of the full model to come later. The sequence is inexorable: the postulated "fixity of passion" leads to an intrinsic tendency of population to increase. The ensuing pressure on limited land results in lower labour productivity forcing consumption below the subsistence point. The main checks to population are "positive" which include war, disease, hunger, and

> . . . The vices of mankind [which] are active and able ministers of depopulation. They are the precursors in the great army of destruction; and often finish the dreadful work themselves. But should they fail in this war of extermination, sickly seasons, epidemics, pestilence and plague advance in terrific array, and sweep off their thousands and ten thousands. Should success be still incomplete; [*sic*] gigantic inevitable famine stalks in the rear, and with one mighty blow, levels the population with the food of the world. [15; pp. 139-140]

There exist two temporary relief valves in the first edition. First, increases in land area due to colonization, or land improvements through the accumulation of capital, can temporarily prevent the erosion of the levels of living. This is a preview of the Ricardian principle of diminishing returns (and of Malthus's later foray [13] into rent), complete with the afterthoughts of Ricardo on technological change and capital deepening. The second relief mechanism is the "preventive" check, which is abstinence from sexual relations, accomplished either by delay of marriage or by continence within marriage. These two exceptions, however, did not do much to allay the portrayal of Malthus as a prophet of doom. The former operated on food supplies based not on the bounty but on the meanness of nature. The latter operated on population through human deprivation by the strong assumption that it could never be activated without the threat of misery. Therein lie the origins of the dilemma as seen by the early-day Malthus: better living conditions lead to rapid population increases which outstrip the food supplies until either the positive or the preventive check comes into operation and an equilibrium population is restored.

A careful reading of the second edition of the *Essay* [12] and of Malthus's later works [14] on population makes the dilemma more apparent than real. The emphasis is shifted on the preventive checks, more specifically the "moral restraint" that determines the "prolificness of marriages" and the "earliness of marriages".

> . . . The effects of this check on man are more complicated. Impelled to the increase of his species by an equally powerful instinct, reason interrupts his career, and asks him whether he may not bring beings into the world for whom he cannot provide the means of *support.* [12, p. 6]

> . . . The preventive check, as far as it is voluntary, is peculiar to man, and arises from the distinctive superiority in his reasoning faculties which enables him to calculate distant consequences. [12, p. 12]

This may sound like "reason" overriding the "passion between the sexes", that was postulated earlier, which would jettison the natural law of increase in population. Its replacement by the "tendency of the *lower classes* to reproduce too much" saves the day. The preventive check is considered more important for the "cultured classes", as opposed to the "labouring classes", for "civilized life", as opposed to "savage life", for "Modern Europe", as opposed to "the ancient times and the uncultivated parts of the world". The theory of the demographic transition is thus anticipated. And the literature on the socioeconomic determinants of population growth is launched, complete with the importance of education, the status of women, and the "social capillarity thesis" and replete with policy measures for curbing the reproductive tendency.

The earlier Malthus is well known as the doomsayer of publicist fame. He was a political pamphleteer who began the whole exercise of the *Essay on Population* [15] as an attack on the poor laws of the day. His argument was used throughout the nineteenth century to demonstrate the futility of every major reform in the socioeconomic field. He was so successful in this role that the latter Malthus [12] with the streak of social reformer has gone almost entirely unnoticed.[1]

Another insight from Malthus's work which has not been fully appreciated is the importance of the family unit. In Malthus's D-D modelling, aggregate economic and demographic changes are tied together at the family level. Improvement in economic conditions leads to the formulation of families at an increased rate. Abstinence is associated with the delay of marriage. The lower classes have higher fertility within marriage. A theme of this paper is that the family element which Malthus introduced wili come into focus with the third generation of D-D models.

FIRST- AND SECOND-GENERATION D-D MODELS

Since Malthus the art of D-D modelling has flourished. The early models were informal, but starting in the late 1950s a large number of formal simulation models have become available. There is no need to review here the considerable literature

[1] For a welcome exception, to which this paper owes multiple debts, see Birdsall, Fei, Kuznets, Ranis and Schultz [2]. Coale [6] considers Malthus's "moral restraint" (of the upper classes) tantamount to the contemporary spread of birth control. This, along with the importance of the delay in marriage which Coale's studies of European history emphasize, places again the spotlight on the more subtle Malthusian determinants of population growth.

since that task has been ably performed by others.[2] A few comments on what is the norm in such modelling and where the exceptions lie will be sufficient to introduce the discussion of the task left to the third-generation models.

The first-generation D-D models draw on the early Malthus and focus exclusively on the consequences of population growth. As a rule they share Malthus's pessimism and they assess negatively the consequences of population growth. The analytical apparatus for reaching this conclusion is relatively simple with two basic alternatives. A Harrod-Domar type of production function makes the rate of output growth a function of the rate of savings and investment. Population growth is assumed to decrease the rate of savings and investment, either absolutely or relatively by shifting resources into "population investment" (e.g. schools, hospitals) that has longer gestation periods. This leads to lower rates of growth and therefore to a race between output generation and population growth. Alternatively, one can specify a general production function in land, labour and capital, given the level of technology, which is homogeneous of degree one. In this case output per worker can be expressed as a monotonically increasing function of capital per worker. Increasing the rate of growth of employment relative to the rate of growth of the capital stock decreases the amount of capital per worker. This decreases output per worker compared to what it would have otherwise been. The implicit assumption is that the rate of growth of capital stock and of the stock of land (and technology) are independent of the rate of growth of employment. This assumption was to be dropped with the second-generation D-D models. More generally, the second generation recognizes that although the consequences of population growth may be negative, they cannot be so *ex hypothesi*. Societies have built-in brakes and shock absorbers which arrest the speed and cushion the fall. But one must search inside the machinery, through a number of intricate parts, in order to discover those instruments. They cannot be observed by simply looking at the external configuration of the social vehicle. The second-generation models, as a result, examine more closely the indirect effects and the interactions that go from the change in income and productivity back onto population growth and distribution.

By looking into the feedback effects the second-generation models have incorporated certain of the characteristics that can become the underpinnings of Kuzentsian modern economic growth, i.e. of sustained population growth without lowering the level of income. Among these characteristics that may offset the initially dampening effect of population growth are: (i) the stimulus that population

[2] Among the recent reviewers Faruqee (in [13]) provides a discussion and a summary table of 13 formal simulation D-D models contrasting their various characteristics. Sanderson [17] has presented a detailed evaluation of five formal models which have a separate specification of the agricultural sector (BACHUE, TEMPO II, FAO, Simon, Kelley-Williamson-Cheetham). The criterion is the technical adequacy of the equation structure of the model, i.e. meaningfulness, plausibility and correctness. Finally, Robinson and Schutjer [16], in discussing agricultural surplus, present a review of certain informal D-D models that deal with agriculture and especially of Ranis-Fei and Boserup.

growth provides to demand; (ii) the increase in market size with the attendant economies of scale; (iii) the improvement of the labour force by providing better-trained workers;[3] and (iv) the encouragement of technological change, especially in agriculture. In connection with agricultural technology, Boserup [4] "stands Malthus on his head" by suggesting that it is not population that adapts to the limited quantities of land. It is instead agricultural technology and land use (as well as off-farm employment opportunities) that adapt to the existing agricultural population. She sees the shifts from primitive, slash-burn, agriculture to short-fallow rotation and ultimately to settled, annual cultivation as responses of society to population pressure.

THE THIRD-GENERATION-IN-BEING D-D MODELS

Going from demography to development, i.e. studying the consequences of population growth, is only one loop in D-D modelling. The second represents the determinants of population growth, i.e. going from development to population. Malthus incorporated it in his informal D-D model by postulating the "fixity of passion" (early version) or the propensity of lower classes to over-reproduce (later version). Closing this loop remains the task that will be hopefully tackled in the third-generation D-D models.

The literature on the determinants of population growth has also been aptly summarized to make its repetition here redundant [3; 19]. A brief description of the important links will help explain the failure so far to incorporate the determinants into D-D modelling and may help in circumscribing the task left to the third-generation models.

The impact of development on population was first formalized in the study of the demographic transition. The literature by now had identified a large set of *intermediate variables* which have an impact on the fertility behaviour of the household. They can be classified as physiological factors, health and nutrition factors, cultural factors, institutions and tastes and socio-economic factors. Next there is the *scientific blackbox* which refers to the explanation of changes in attitudes and motivations towards the family and its size. In contrast to the intermediate variables which refer to the observable world, attitudes and motivations are largely unobservable phenomena. In the process of scientific explanation they contribute grist to the mill through which the observed "facts" are put in order to grind out predictions for the future. The predictions in this specific case refer to the fertility rate.

The formulation of the determinants of fertility so far is not congruent with the modelling of the consequences side discussed above. First, the consequences refer to the impact of population growth—rather than fertility—on development. Consistency can be restored by entering two new parameters, the mortality rate (or

[3] Leibenstein [11] especially has emphasized this effect.

life expectancy in general) and the age structure of the population. Both these parameters are to a certain extent exogenously determined from the previous demographic history of the population. Fertility rate, mortality rate and the age distribution of the population determine together the birth rate and through that the rate of increase in population which feeds into the development block.

The second inconsistency between the determinants and the consequences sides arises from the fact that the intermediate variables and the analysis of motivation refer to families in their broadest sense while the consequences side is in terms of aggregate populations or their subsets. This problem can be handled by analyzing the consequences of population growth at the family level. It is this insight of the latter-version Malthus–the linking of the demographic attributes of the family to the development process–that constitutes the missing link for complete D-D modelling.

Economic theory has until recently overlooked the analytical importance of the family.[4] Yet the family is the *nexus* of three important decisions, demographic, production and consumption, which constitute the three components of behavioural analysis. The family is the locus of the major demographic decisions–to marry, to have another child, to migrate, to take in a relative, to encourage the aged kin to remain, to provide education. These decisions are reflected in the age structure of the family, its size and its type–nuclear, consanguineous, stem, joint and so on. The family's institutional specification has important economic connotations.

In a market economy most of the production decisions take place outside the household, in the business firm. Exception is a good portion of agricultural production that takes place at the family farm-firm. The conventional economic accounting system has focused on market production and has overlooked another important component of production that is carried within the household. This includes subsistence production activities and maintenance services, such as cooking, cleaning, fuel gathering, medical services, care of the elderly and childcare.

Finally the family is the unit where the household budget is administered and the consumption decisions take place. It is responsible for the distribution of leisure among family members, for the distribution of nutrition, and also for the composition of family expenditure among different commodities.

General D-D modelling requires that the conventional economic framework is broadened to accommodate the household. This can be done in two steps. First, the demographic behaviour of the household has to become an integral part of economic analysis. Second, the economic behaviour of the household has to be redefined to include both market and on-market activities. This calls for data collection on the basis of the "full expenditure-income" system. Scattered data on the three components of family behaviour exist to a varying degree for different countries. The

[4] The same, happily, cannot be said for the sociologists' approach to demography. For example, see Freedom [9].

problem is that such data, having been collected for different purposes, cannot be mapped consistently into households or groups of households. Birdsall *et al.* [2] have proposed an accounting system that can be implemented uniformly for collecting data at the family unit for a generalized economic-demographic analysis.

THE FAO THIRD-GENERATION D-D MODELLING PROJECT

Project INT/76/P18 of the Food and Agriculture Organization which is funded by UNFPA and directed by the author has collected data from the Philippines (and is in the process of surveying also two other countries) in order to build a D-D model that includes both determinants and consequences of population growth. The model has been described elsewhere [18]. Certain crucial characteristics and the general research strategy will be mentioned here.

The project surveys the agricultural household because there, *par excellence*, coincide the demographic, production and consumption decisions. Moreover, since agricultural households in developing countries are responsible for three-quarters of the world's annual population increase, modelling the farm household can yield important insights into the determinants and consequences of population growth. The data collection consists of carrying out three surveys at each household: a household composition and demographic survey, with fertility questionnaires for all women in the household who are of reproductive age; a farm management survey; and a consumption-expenditure survey.

The analysis of the data combines the use of demographic and economic tools. First the demographic analysis is carried out for different groups of households (e.g. owners, tenants, poverty group, etc.) with the purpose of constructing model (marital) fertility and nuptiality schedules [5; 7; 8]. The deviations of individual households from the model schedules are interpreted as deterministic and are attributed, through analysis-of-variance techniques, to specific intermediate variables that are household attributes. Secondly, the groups of households identified in the demographic analysis as having different fertility behaviour are also analyzed in an integrated framework of consumption and production behaviour [10]. By the use of the profit function and the linear expenditure system the economic behaviour of the household becomes a function of exogenous variables such as prices and fixed factors of production. The estimated parameters of the production and consumption functions can be used to indicate whether households with different demographic behaviour have also differences in their economic behaviour and to what extent the demographic characteristics of the household affect the household's level of full expenditure-income and its distribution.

Several variants of this analysis can be pursued with the data collected. The important feature remains that the basic framework developed serves to analyze jointly the demographic, production and consumption decisions of the household. In this manner the loop is closed in the study of the determinants and consequences of population growth. As a result the two-way interactions in D-D modelling can be studied in a general system.

CONCLUDING REMARKS

The main feature of the third-generation D-D modelling outlined in this paper is the integrated analysis of the demographic, production and consumption behaviour of the household. The demographic literature has provided the tools for analyzing (marital) fertility and nuptiality within distinct socioeconomic groups. The "new economics of the household" [1] has paved the way for analyzing production and consumption behaviour at the household level, especially by making operational the concept of the "full expenditure-income". The lack of consistent statistical data is remaining an obstacle for integrating economic-demographic behaviour at the household level. Traditionally the unit for data collection is either the individual or the aggregate (region, country), and family behaviour, as a result, has not been examined in an integrated system.

The agricultural household, as a rule, is characterized by a simultaneous triple-decision-making process that determines the size of the family, the production function and the consumption function. The collection of family-farm data on family history, farm management and income and expenditure will provide the statistical information for an integrated analysis of the determinants and consequences of population growth as specified at the family level. This is indeed the level where population growth occurs.

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