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NOTES ON THE ESTIMATION OF THE MICRO ECONOMIC DETERMINANTS OF MIGRATION

T. Paul Schultz

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INTRODUCTION

Differences in labor earnings among individuals may indicate differences in skills, experience, and other productive traits. These differentials provide incentive to substitute in production lower paid skills for higher paid ones, and motivate individuals to acquire the higher paid skills. Differences in labor earnings among regions (and sectors) of an economy provide analogous incentive to modify the location of production to obtain lower cost labor, and conversely motivate workers to move where their skills are more highly valued. Migration, therefore, is commonly viewed as primarily a response to differential earnings opportunities in spatially distinct labor markets. Needless to add, much migration has occurred and will continue to take place for other, noneconomic, reasons, among which political, religious and other ideological motives have held sway at various times and places.*

From an economic point of view, general equilibrium models of interregional factor allocation have not yet been applied with noted suc-

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*Migration has not only been analyzed as a long-term human capital investment (Sjaastad, 1962), it has also been interpreted as a selective response of more energetic and adaptable individuals to the changing distribution of economic activity (Kuznets, 1964), and as the summation of presumably asymmetric "push and pull" factors associated with the individual and his environment (Lee, 1966). Yet all of these approaches posit an individual moving to where his future appears most attractive, or more formally, and tautologically, to where he maximizes the present (discounted) value of future streams of benefits minus costs (opportunity, direct and psychic), subject to his limited knowledge of the world and his preferences. Consumption benefits would also matter, not only in terms of the amenities of the environment but also the actual consumption effects of migration itself. Clearly upon retirement from the labor force, locational choice is likely to emphasize such environmental amenities and relative prices, and deemphasize labor market opportunities. Migration for retirement purposes must be relatively unimportant in developing countries given their age composition and income level.

cess to account for internal migration. Little progress has been made in distinguishing between the determinants of interregional derived demands for labor and labor supply responses of potential migrants. Therefore, I shall adopt a static, partial equilibrium approach to interpreting migration that, unfortunately, neglects the determinants of derived demand for labor, and interactions over time between interregional demands and supplies of labor. In this regard, the current framework for the study of migration is comparable to that used in much of the human capital and labor supply literature that treats individual behavior as a response to predetermined wage differentials, relative prices, and nonearned income.

The object of estimating a migration model is to learn what factors tend to influence individuals in their response to interregional differences in employment opportunities for persons with their bundle of skills. For example, the allocation of labor among regions may not be inefficient simply because the average level of wages in a region exceed that in another region unless of course the skills represented in the labor force in the two regions are comparable. Even in this extreme case, the relative distribution of labor earnings by skill group may differ across regions, and one skill group could be motivated to move in one direction and another skill group in another. Differences in aggregate wage or employment levels are difficult to interpret from the viewpoint of understanding migration or judging the efficiency of labor allocation in an economy. Disaggregation of the labor force into more homogeneous groups, according to skill classes that are relatively fixed for the individual, is an important step toward measuring labor market motivations for migration. The need for disaggregation may be

even more obvious in the study of internal migration in low income countries, in which it is widely assumed that differences in wages between regions and sectors signal serious, institutionally maintained, factor market distortions that may differ across skill groups.

Debate regarding development policy, and in particular the choice of appropriate means for expanding production and employment in rural and urban areas often turns on the assumed nature and relations among regional and sectoral labor markets. If wages are determined across both sectors by a rural subsistence wage in excess of labor's marginal product in agriculture, expansion of the urban sector is desirable at least until the "unlimited supplies" of rural labor are absorbed (Lewis, 1954; Fei and Ranis, 1961). If urban wages are institutionally maintained in excess of their market equilibrium level, migration to the urban areas may be regulated by urban unemployment that must perform the function of a market clearing "price" between sectors (Todaro, 1969; Harris and Todaro, 1970). If this model of labor markets accounts for urban/rural wage and unemployment differentials, then it may be more productive socially to expand employment opportunities in the rural sector, and thereby alleviate the urban unemployment problem. Finally, the competitive neoclassical two sector growth model would predict regional differentials in employment and wage conditions to emerge only to the extent needed to induce the level and composition of migration required by regional trends in demand and the location of natural resources. In this case, expansion of employment in either sector is desirable according to the level of local returns on the related investments. A disaggregated description of migration, the measurement of skill-specific wage and employment differences among regions, and the

estimation of migration response functions, should all provide information useful for discriminating among these alternative models of intersectoral development, and hence in choosing among their prescriptions for development strategy.

Research on labor markets in low income countries has only recently begun to apply the human capital framework to analyze survey and census data. The structure of wages and employment by age, sex, and educational attainment is available from only a handful of countries. These labor market data are fundamental building blocks for the analysis here of the determinants of migration, but also they are essential for investigations into the incidence and distribution of factor market distortions, the nature of unemployment, and the personal distribution of income. This paper has an elementary operational orientation; it consists of a collection of notes on conceptual, empirical, and statistical problems associated with the study of the responsiveness of migration to economic, social, and demographic conditioning variables.

By restricting myself to micro determinants of migration, I do not touch on the social repercussions of migration, and only briefly refer to general equilibrium models of migration and development. Consequently, I do not address the important but neglected task of measuring the elusive social externalities commonly attributed to rapid internal migration in low income countries.

The paper is ordered in the following manner. Section II explores bases for disaggregation in the study of labor markets and migration. The measurement of migration and its determinants is discussed in Section III, with the object of specifying variables that will clarify economic issues and avoid later estimation problems. A statistical

framework is developed in Section IV that lends itself to testing a variety of economic hypotheses with better statistical techniques than are common in the field.

II. DIFFERENCES IN INDIVIDUAL PRODUCTIVITY: METHODS OF STANDARDIZATION

Empirical study of migration frequently postulates an individual probability function for migration and estimates its parameters, occasionally from individual data on migrants and nonmigrants, or usually from aggregate data on the occurrence of gross origin to destination migration. Yet at the aggregate level, migration is important as a net reallocator of labor that presumably enhances factor productivity and reduces the disparity in rewards to comparable factors of production (Kuznets 1964, 1971). It remains unclear whether obtaining a satisfactory explanation of the micro determinants of gross migration will provide the most useful information for considering policy that seeks to cope with net migration; but my presumption is that it ultimately will (Theil, 1954; Grunfeld and Griliches, 1960). At least by focusing on gross migration or the individual probability of migration one starts with a coherent rationale for applying a reasonably well developed set of concepts regarding the determinants of household demand and investment in human capital to an important economic and social phenomenon (T.W.Schultz, 1961, 1972).

The study of migration has relied heavily on aggregate statistics; little empirical evidence has yet been derived from survey information on individuals, matching origin and destination characteristics, even though these individual data sources have recently been productively

exploited in estimating parameters to migration probability functions in low income countries (Hay, 1974, Barnum and Sabot, 1975). In this section, I first explore the requirements for aggregate data, stressing criteria for stratification to obtain relatively homogeneous components of the labor force. Second, I outline an approach to individual information on migration and interrelations among labor markets that relies upon indirect estimation of regional wage and employment functions that are imbedded in the migration function.

Aggregate Statistics on Migration

Gross migration rates are typically obtained from a single cross sectional survey or census that reports current residence of the respondent in conjection with residence in a specified earlier time period (e.g. five years ago). The number moving from each location to another specific location is expressed as a fraction of all those residing in the origin location in the earlier time period. Often such gross flows are only available from birthplace to current residence, but it may be comforting that in India and Venezuela the one-year and lifetime gross migration rates were highly correlated, and indeed they implied similar response elasticities when used to estimate gravity migration functions. (Levy and Wadycki, 1972a, Greenwood 1971a).

A net migration rate is an aggregate concept, or as Sidney Goldstein put it, there is no such thing as a "net migrant." Where population registries exist, or a complete matrix of gross migration flows are at hand, net flows can be calculated. The convention is to use the initial population of the region as the denominator for the net flow to arrive

at a net migration rate. Where all gross migration flows are not known, regional age and sex tabulations from two censuses may be compared, and cohort differences not explained by age and sex specific mortality rates can be residually attributed to net migration. For reasons stated above, I shall deal here only with regularities in and interpretations of the causes of gross migration.

Age

A strong association between age and migration is universally noted; gross migration occurs more frequently among youth at the start of their economically independent lifetime than it does at progressively later ages.* The economist has rationalized this age pattern of migration rates in terms of the higher reward for migration while young, when the present discounted value of income increments in the destination is maximized (Sjaastad, 1962). But a few calculations would suggest that ten fewer years to retirement might not fully account for the many fold decrease in migration rates often observed among men between the age of 20 and the age of 30.** As with explaining the life cycle decline in

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*After retirement, labor market production attributes of a location are largely displaced by consumption attributes, contributing to a second post retirement wave of migration in some, generally affluent, societies. Here I am primarily concerned with the regional reallocation of labor up to the retirement age.

**Assume, for example, that a person enjoyed a constant certain dollar premium on his annual wage by migrating. With a 5 percent discount rate, these potential income streams would have a present value of about $16.40 if retirement were 35 years off, and $17.80 if 45 years off. If a nine percent differential explained a 50 percent reduction in migration rates between age 20 and 30, then a similar degree of responsiveness would be expected for migration between alternative destinations that exhibited nine percent differences in wage-employment opportunities. Such interregional responsiveness of migration is uncommon.

the share of own time invested in human capital (Ben Porath, 1967), there would seem to be an important, if difficult to document, role for rising cost in this age-migration pattern which might be called location-specific capital losses. Opportunity, direct and psychic costs are all likely to increase with age as vocationally specific experience and goods will become less readily transferred, and familial obligations and ancillary social relationships become less readily ruptured. Clearly all of these factors are modified by the ease of initial and return migration in a particular setting.

A cohort selectivity effect may also help to account for the pronounced concentration of migration among youth. Assuming that relevant attributes are distributed across a regional birth cohort, those for whom the expected returns from migration are highest and for whom the risks and challenges of migration are preferred will be the first to migrate as a viable opportunity arises, typically after leaving school. Subsequently, migrants are being drawn from a residual population of selectively changing character. It is hard to imagine migration across ages in a cross section, or over time in a cohort, as being generated by a constant stochastic process operating on a population of aging but otherwise unchanging composition. Yet this assumption is often implicit in empirical work on migration. Heckman and Willis (1976) have explored this problem for the study of reproduction, but it has not yet been adapted to the analysis of longitudinal information on migration, except in the mechanical short run prediction models where current migratory behavior is explained by past duration of residence. Many gaps in our understanding of migration may be concealed by the use of convenient cross sectional data by age, where longitudinal information on individuals and cohorts is called for. A seemingly neglected objective in migration

research is to develop satisfactory stochastic specifications of longitudinal migration models that can be estimated from time series. Progress along these lines could represent a major improvement over cross sectional analyses where differences across age groups at one point in time are assumed to measure differences cohorts expect to experience as they age.

Sex

Differences in migration rates between men and women are more varied across regions, countries, cultures and periods, as are the roles and relative economic opportunities of the sexes in contracting and expanding sectors of the economy. Men appear to predominate in the rural to urban migration documented thus far in Africa, India and Islamic countries, whereas women have on the whole led the exodus from agriculture in Northwestern Europe, areas of European Settlement, and Latin America. Given the variation in migration rates by age and sex, both are accepted bases for stratification in the demographic study of migration, where an objective is to discover beneath the diversity in overall migration rates greater constancy in component rates. Since life cycle differences in market wages of men and women are substantial, stratification by age and sex should also advance the economists desire to obtain more homogeneous groups, from the point of view of the present values of future labor market earnings.

Schooling

Within age and sex groups there remain substantial differences in life cycle earnings associated with schooling. It has been argued that these educational differences in wage rates arise from a combination of causes; statically, schooling is a useful proxy for productive skills that augment "efficiency units" of labor that a worker brings to a given task; dynamically, schooling reflects an "allocative efficiency" of the worker to deal with a changing productive environment (Welch, 1967; T. W. Schultz, 1975). Without repeating Welch's reasoning, it would seem to follow that if schooling affected allocative efficiency within a firm or a job, it should also exert a parallel effect on worker mobility and ability to decipher and efficiently respond by job search and migration to changing interregional and interfirm job opportunities.

A growing body of evidence from a variety of sources confirms this expectations that the better educated migrate more frequently and respond to smaller relative wage or income differences than do the less educated.* For example, Table 1 shows the monotonic relation between schooling and lifetime migration rates for both men and women in all but one coterminous state of Venezuela. As a first step toward clarifying the response of migration to wages across spacially distinct labor markets, comparisons should be conducted within groups that are as homo-

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*See, for example, Caldwell (1968, 1969), Lee (1970), Schwartz (1971), and DaVanzo (1972). In Venezuela circa 1961, lifetime migration rates increased in all 21 states, without exception, for men and for women, as educational attainment increased (across four classes) (Schultz, 1975, Table 1, p. 29).

Table 1

Percentage of Venezuelans 7 Years and Older in 1961, Not Currently Residing in Their State of Birth, by Sex and Educational Attainment: The Sum of Gross Lifetime Out-Migration

		Men				Women			
Code	State	No Schooling	Some Primary	Some Secondary	Some Higher	No Schooling	Some Primary	Some Secondary	Some Higher
01	Federal District	17.26	20.44	28.85	42.25	16.96	19.81	27.45	30.80
02	Anzoátegui	15.21	24.97	59.50	83.91	16.00	25.49	47.48	81.58
03	Apure	17.86	32.31	77.85	95.17	20.43	35.18	73.23	97.80
04	Aragua	22.18	28.80	52.67	83.22	25.75	29.45	45.88	72.00
05	Barinas	13.21	23.03	67.81	86.27	16.14	26.15	62.27	92.54
06	Bolívar	13.34	22.81	58.95	81.78	16.52	27.55	56.28	80.97
07	Carabobo	18.50	24.49	43.42	64.27	21.52	26.19	37.09	67.24
08	Cojedes	24.50	39.28	62.23	87.59	30.20	40.54	56.56	100.00
09	Falcón	29.34	37.20	56.69	79.35	27.80	30.46	44.11	59.59
10	Guárico	17.06	30.00	60.21	82.70	20.96	32.39	47.76	93.55
11	Lara	26.70	30.51	46.26	70.76	24.76	26.19	34.25	71.10
12	Mérida	19.57	36.04	65.57	74.51	23.20	37.73	51.14	66.80
13	Miranda	28.60	41.81	56.28	49.21	34.21	42.90	47.91	58.30
14	Monagas	18.72	34.63	63.67	85.90	22.03	34.97	50.21	90.70
15	Nueva Esparta*								
16	Portuguesa	10.92	22.75	57.26	83.33	13.86	25.64	50.00	84.06
17	Sucre	23.50	41.15	69.47	86.57	25.00	39.36	56.03	89.46
18	Táchira	16.82	29.95	62.35	84.46	22.71	32.19	48.68	89.95
19	Trujillo	28.77	40.73	67.62	85.50	29.77	39.31	54.47	91.63
20	Yaracuy	29.41	43.14	72.11	91.09	34.46	44.06	50.07	87.23
21	Zulia	5.25	9.78	29.92	42.13	4.86	9.32	27.29	48.07

*Neuva Esparta, a small island of 89,492 persons, is excluded from this study for a variety of reasons, as are the Amazon, Amacuro Delta and Federal Dependent Territories.

Source: T. P. Schultz, 1975.

geneous as possible with respect to education, sex and age.* This is not to deny the existence of substitution possibilities in production among age, sex, and educational groups in most contexts, but without initially holding constant for these basic attributes of labor force composition and productivity, differences in wage and employment conditions may only reflect compositional differences in the labor force across regions and will not have a bearing on incentives for migration. With more understanding of the migratory response of homogeneous groups, empirical estimation of "cross-wage effects" should be feasible, that is, how wages of one group affect the migratory behavior of another. Eventually, substitution possibilities in production across homogeneous groups should also be estimable and progress could be made in specifying regional derived demands for labor.

An obvious explanation for the lack of studies that disaggregate migration by age, sex and educational attainment, is the scarcity of associated employment and wage data for these economic and demographic divisions of the population. This gap is empirical research adds to the promise of investigations based on individual data files that contain the above minimum necessary information and generally much more valuable detail. One major, and as yet unresolved, problem in using individual records for the analysis of migration is "selectivity bias" or the inability to infer without bias from cross sections what opportun-

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*Since it is assumed that comparable labor is paid different wages in different sectors of the economy in many models of the development process, it is surprising how little firm evidence appears to exist on the quantitative importance of such "dual labor markets" and their institutionally maintained factor price distortions between rural and urban, craft and modern, informal and formal sectors of a low income economy.

ities the migrant has foregone at origin, and what opportunities the nonmigrant might have expected at destination, if he had migrated. On the other hand, some information on labor markets that might be useful in the study of migration are more likely to come from employers, such as quit, hire, fire and turnover rates, and others are infrequently available from surveys, such as the duration and frequency of unemployment and intensity of job search activities.

Individual Statistics on Migration

Individual information on current and past residence, current employment and earnings status, permits one to dispense with the crude assumption underlying most aggregate analyses of migration--that the potential migrant occupies a representative position in the aggregate distribution of characteristics that are thought to determine his probability of migrating. Even the seemingly weaker assumption that the migrant retains his relative position in the size distribution of wages, etc. as he shifts from origin to destination need not be realistic.

This procedure is likely to overstate the realizable gains for a typical rural-urban migrant in most low income countries. On average, migrants are positively selected, under most circumstances, and they therefore exhibit above average education and earnings when compared with populations at origin. Conversely, it does not seem implausible that, without experience at destination which is typically a more urban

and skill intensive sector of the economy than at origin, migrants suffer at least a temporary disadvantage upon arrival in the destination job market when compared with other workers having the same educational qualifications, age, and sex.

On the other hand, the reverse pattern may arise due to a negative selectivity of migration. Tolley's (1970) study of recent U.S. experience suggests that the least educated are displaced from agriculture by the competitive pressures of allocating efficiently the continuous stream of improved new inputs and techniques. Conversely, in developing areas where the agricultural sector has exhibited relatively little change in inputs or techniques, rewards for educated skills and innovative and entrepreneurial talents are probably greater in urban than in rural activities. Positive selectivity among rural-urban migrants is consequently common. Negative selectivity in migration may also arise in low income countries. Lipton (1976) shows evidence of a bimodal distribution of migrants from rural Indian villages with lower class landless being displaced short distances by agricultural changes ,whereas higher class youth being sent long distances to acquire education and better jobs. Both negative and positive selectivity are seen in these disparate groups of Indian migrants. Fragmentary evidence on interregional migration in low income areas leads me to expect that, as in Venezuela (Table 1), the positive selectivity of migration outweighs the negative, given the evolving distribution of opportunities and returns to education in the urban and rural sectors of most developing areas. A shift in development priorities that reduced the bias toward urban interests, and introduced a stream of new inputs and techniques into modernizing agriculture could, of course,

change this selective pattern of migration in the future.

Individual data can be used to reduce some of these sources of aggregation bias, but forms of "selectivity bias" will persist. I assume here that they are of a second order of magnitude.* My goal is to estimate real wage and employment opportunities that a migrant could anticipate encountering in each region of a country, explicitly allowing for job opportunities to improve with duration of residence. Opportunities also probably differ according to the migrant's region of origin, since quality of schooling and relevance of vocational skills would differ across regions and consequently benefit or handicap some migrants more than others. Estimated real wage and employment rates could be multiplied to obtain average real earnings at origin and destination, and the discounted sum of these earnings streams could then become arguments in a migration decision function (Sjaastad, 1962). But attitudes toward unemployment and risk could perhaps be better understood if both of these arguments, the wage and the employment probability, entered separately in migration function.** If both the

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*There are at least two sources of selectivity bias that are not readily eliminated from such an empirical exercise. First, persons who migrate are different from those who do not, for no other reason than that they nonrandomly chose to migrate. Stratifying by age, sex, and educational attainment reduces the differences between migrants and nonmigrants, but is not likely to eliminate it completely. Probably there remains some positive selectivity, and therefore, the fortunes of migrants are better than nonmigrants might reasonably expect to have were they to migrate. Second, those persons observed in the labor force are not a random sample of all persons of that age, sex, and educational attainment group. They might be recipients of higher wage offers than those not in the labor force, and therefore this exercise would attribute to all potential migrants (potential participants and nonparticipants) an upward biased wage offe

**Urban unemployment may play a role governing the rate of rural-urban migration, where urban wages are inflexible downward and urban jobs must be rationed (Todaro, 1969). The Todaro assumption warrents more explicit empirical testing than it has received. The expected income (utility) hypothesis invoked to allow the evaluation and calculation of expected present values implies restrictive behavioral assumptions that need not be imposed in modeling migration.

wage and employment functions are estimated in semi-logarithmic form, their sum is the logarithm of "expected income." Consequently, it is straightforward to test whether the "expected income" hypothesis is strictly consistent with observed migration behavior. It seems desirable, therefore, to explore empirically how migrants trade-off the wage level against the probability of obtaining a job at destination, and where data are sufficiently rich, how this tradeoff changes over various time horizons.

PARALLEL SPECIFICATION OF REGIONAL EMPLOYMENT AND WAGE FUNCTIONS

Rather than estimate a single semi-logarithmic earnings function as elaborated by Mincer (1974), there is reason in the study of migration and labor markets in general to estimate both a real wage rate function and an hours (or weeks) worked function for each regional labor market. Both of these wage and employment functions are treated as reduced forms, where both dependent variables are expressed in logarithms and the same right-hand-side variables appear in each equation. In certain circumstances, the employment function might be viewed as a labor supply function, but a more complex interpretation is probably justified in which time not working may be devoted to job search or odd jobs in the informal sector.

Though the specification of these functions might depend on the institutional setting in a particular country, as well as the available data, a hypothetical example illustrates how I might initially explore labor market data. The two labor market functions would be estimated over k individuals separately within each sex and education group (j) in

each region (i) of a country, as follows:

$$\ln W_{ijk} = \alpha_{ij0} + \alpha_{ij1}A_{ijk} + \alpha_{ij2}A^2_{ijk} + \alpha_{ij3}X_{ijk} + \alpha_{ik4}X^2_{ijk} + \sum_{m=5}^{n} \alpha_{ijm}R_{ikm} \quad (1)$$

$$\ln L_{ijk} = \delta_{ij0} + \delta_{ij1}A_{ijk} + \delta_{ij2}A^2_{ijk} + \delta_{ij3}X_{ijk} + \delta_{ik4}X^2_{ijk} + \sum_{m=5}^{n} \delta_{ijm}R_{ijmk} \quad (2)$$

where W and L are the real wage rate and the units of time worked, respectively, A and A^2 are calendar age and age squared (or some transform such as years since end of schooling, or preferably actual years of work experience), X and X^2 are proposed to capture the nonlinear effect of years of experience in the destination region i, in its quadratic form) and the R's are n-4 origin region dummy variables representing the quality of schooling, perhaps. Parsimony in specifying and parameterizing such wage and employment functions would, of course, depend on the extent and form of data at hand. Hierarchcal F ratio tests could be applied to test for coefficient equality across origin regions, or even education and sex groups, in an effort to reduce the number of parameters estimated. Having adopted this parallel semi-log specification, the relative effects of any right-hand-side variable on total expected earnings is directly obtained by summing the respective parameter estimates, i.e. $\alpha_{ij.} + \delta_{ij.}$.

The purpose of estimating these wage and employment functions by

migratory status is to obtain predicted values for the labor market conditions in all regions. These predicted values conditional on the individual's age,sex, education, etc. should be relevant to the decision whether he migrates from his origin region to the specified potential destination region. If individual migration decisions are independent of each other, the mean proportion migrating or gross migration rate is a maximum likelihood estimator of the migration probability. Such rates could be obtained from aggregate data sources as before, or by tabulation of a survey or census. But if these rates are based on small enough subpopulations, their instability may necessitate the use of a more efficient estimation procedure that weighs observations accordingly. If individual data are used directly, the dependent variable in the migration function becomes dichotomous. The form of a statistical model that might be useful for estimating the migration function itself is discussed in section IV.

The empirical exercise proposed above requires a considerable amount of work and it has not, to my knowledge, been performed in a low income country.* The intermediate products pertaining to the regional distribution of wage and employment opportunities would be informative, adding substantially to our understanding of the sources of personal income inequality that are rooted to regional factor market differences. Also, I would hazard the guess that, the second stage of analysis directed to explaining migration would yield quite different migration

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*I received after writing this paper a study by DaVanzo (1976) that performs a similar exercise with U.S. data, but she proceeds much further in refining issues relating to the husband's and wife's joint interest in family migration.

response parameters than those we are accustomed to in aggregate studies. The next section deals with the empirical specification of the migration probability function.

III. Empirical Specification and Economic Hypotheses

Since migration requires resources and time to realize a new set of employment and consumption opportunities, it is often treated as an investment opportunity. For ranking and choosing among investments, it is appealing to summarize the associated costs and returns over time as an internal rate of return or present (discounted) value. But the traditional problems of thus ranking physical capital investments are at least as severe when these summary approaches are applied to human capital investments, particularly migration.

The gestation period of a human capital investment can be a crucial feature in its attractiveness, and yet plays no distinct role in the above summary measures. The importance of time phasing of inputs and outputs can be attributed to imperfections in the human capital market that largely necessitate self financing, and the inability of investors to diversify commitments to reduce risk, since only one choice of migration destination can be pursued at a time. These features of migration help to explain the prevalence of "stepwise" patterns of migration noted since the Industrial Revolution (Ravenstein, 1885), widespread networks of relatives and extended family that facilitate and mobilize capital for migration in some societies. and the relative infrequency of return migration where substantial costs of relocation and job search are incurred initially by migrants.

Risk is a dominant element in the migration decision, for which measures are imperfect and possibly misleading. There is not only the risk of pecuniary failure, that would weaken the incentive to any investor, there is also the uncertainty of how fundamental changes in the migrant's mode of life and opportunities will change his values and family attachments. Both risks might restrict a youthful migrant's access to family savings, though I suspect the altruistic obligations that characterize the family assure that the extended family is the primary source of monetized investment funds used in migration. Changes in lifestyle might reasonably be disquieting to the migrant's elders, but the ability to bequeath these locational "benefits" to heirs makes migration unusual as a clear source of intergenerational externalities. Whatever summary measure of gain or return is associated with migration, it will be a very partial measure of the expected psychic, pecuniary and opportunity costs and benefits, appropriately adjusted for risk.

Relative or Absolute Differences in Earnings

There is no unambiguous logic known to me that implies migration responds to either the difference or the ratio of earnings. It is simple to show, however, that this specification choice could depend on whether direct costs or opportunity costs of time are the primary deterrent to migration (DaVanzo, 1972). Neglecting consumption benefits from migration, the present value of migrating from region i to j can be expressed:

$$V_{ij} = \sum_{t=1}^{n} (W_{jt}-W_{it})/(1+r)^t - C_{ij} - P_{ij} - T_{ij}W_{il} \qquad (1)$$

where W_{jt} and W_{it} are the earnings opportunities available to the potential migrant in period t in region j and i, respectively, n is the retirement age

minus the migrant's current age, r is a constant discount rate, and C_{ij}, P_{ij} and T_{ij} are the direct, psychic, and time costs, respectively, of migrating from i to j, all of which are assumed to be incurred in the initial period. Time costs are valued, in this example, at the initial period origin wage.

For simplicity it is assumed that regional wages do not vary over time and age, t=1,...n; the internal rate of return, r*, is then defined as that discount rate that equalizes the present value of current costs and annuity benefits.

$$C_{ij} + P_{ij} + T_{ij}W_i = (W_j - W_i)/(r^*(1-r^*)^{-n}) \qquad (2)$$

Abstracting from the finiteness of the working life by letting n approach ∞,

$$r^* = (W_j - W_i)/(C_{ij}+P_{ij}+T_{ij}W_i). \qquad (3)$$

If migration costs were only opportunity costs of foregone earnings during the period of relocation and job search, $C_{ij} = P_{ij} = 0$,

$$r^* = (1/T_{ij})\left(\frac{W_j}{W_i} - 1\right), \qquad (4)$$

the migration function might have as its arguments the ratio of wages minus one, and the reciprocal of the time units foregone by migration.

However, if direct and psychic costs were the only costs of migration, and they were unrelated to origin or destination wages, i.e., $T_{ij}=0$, then the absolute difference in earnings might be an argument in the migration decision function as well the reciprocal of the direct costs:

$$r^* = (1/(C_{ij}+P_{ij}))(W_j - W_i). \qquad (5)$$

In both cases, the internal rate of return is expressed as a product of the arguments representing the cost and benefit components; actual specifications of these terms would, of course, depend on the nature of available data, but the rationale for a logarithmic specification of the migration decision function is clear in both (4) and (5).

The proxy usually available for costs is that of distance from i to j, which leaves much to be desired. And though direct costs, C_{ij} and P_{ij}, is probably a well-behaved monotonic function of distance, the link to opportunity costs, $T_{ij}W_{il}$, is unclear. To approximate regional differences in T_{ij} one needs added information on job turnover and an explicit model of how jobs are allocated.

Private Internal Rates of Return to Migration

In contrast with the literature estimating earnings functions (Mincer, 1974), estimated parameter values associated with a migration function do not obviously tell one, even approximately, the internal rate of return to migration. But at a more descriptive level the relative standard devision (of the logarithms) of earnings across regions indicates the average magnitude of gains available to migrants in terms of time costs. Recall that the time costs in equation (4) determining the internal rate of return reflects the years of foregone earnings, valued at origin real wages, expended to progress to the destination real wage level; T_{ij} is then not a period of total unemployment, but more accurately a discounted integral of time unemployed (actual $W_t = 0$) and "underemployed" ($W_t < W_j$), during which the migrant gradually closes the gap between his earnings and the "equilibrium" level received by long term (λ year) resident at destination:

$$T_{ij} = \int_{t=0}^{\lambda} (W_j - W_t)\ (1+\gamma)^{-t}\ dt, \qquad (6)$$

where γ is a rate of time preference.

In these simplified terms, interregional relative variation in wages within education, sex, and age groups is one measure of disequilibrium returns available to migrants.* For example, Tables 2, 3, and 4 present

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*Many additional productive attributes of a labor force might differ across

comparative statistics on wages and migration across regions for the United States and Venezuela. As observed earlier, migration notably increases with educational attainment. Despite the tendency for interpersonal relative variation in earnings to increase with educational attainment,* the inter-regional relative variation in earnings diminishes. For example, males with some primary schooling in Venezuela report an interregional relative variation in wages of .22 in 1961 (Table 3). With a log normal distribution of regional wages, a representative potential migrant residing in a state with an average level of wages would find about 16 percent of the alternative regions offering him a wage at least 22 percent greater than he currently receives. For males with some secondary schooling, a similar fraction of alternative regions would yield at least a twelve percent gain, and for those with some higher education, a comparably common gain would be less than ten percent. If the time costs needed to obtain these destination average earnings streams were equivalent to one year, these percentage gains would also be approximately internal rates of return.**

The empirical regularity of declining relative returns to migration

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regions and explain interregional earnings differentials. As noted in the discussion of estimating wage and employment functions, other variables such as ability or quality of schooling belong in these reduced form equations. The hazard of controlling for other characteristics is that they will be, to a greater degree, endogenous and hence bias other estimates, or that they become so collinear with each other that individual parameters and their statistical significance lose reliability.

*For the U. S. see Mincer (1974) and Schultz (1971). Evidence from other countries is widely scattered with some exceptions being found within narrow advanced specialities, for example, in Netherlands. But across general educational classes with no less than five years working experience, the tendency for relative variance to increase with education seems common.

**One might expect that regions with very different wages would also tend to be separated by greater distances, or have other countervailing factors responsible for some portion of the wage gap. Another approach to estimating internal rates of return from wage relatives might be to seek to explain this relative variation, and regard the standard deviation of the residual in such a model as a measure of unexplained regional variation that might warrant interregional migration. The residual in this wage model might then be entered as an argument in a migration decision function.

Table 2

Level and Variation in Male Incomes and 5 Year Migration Rates
Age 25-29 in the United States 1960, among divisions
(Arithmetic Weighted)

	White		Nonwhite	
Expected Family income ($/yr) by Years of Education	Means	Standard Deviation	Means	Standard Deviation
0 - 4 years	1859	520	1553	630
5 - 7 years	3138	598	2122	637
8 years	3871	576	2440	575
9 - 11 years	4440	460	2733	536
12 years	5175	393	3413	663
13 - 15 years	4980	325	3479	766
16+ years	5880	337	4341	497
Gross Migration Rate 1955-1960 by Years of Education				
0 - 4 years	8.64	11.2	6.02	8.83
5 - 7 years	11.6	13.4	8.37	10.9
8 years	14.0	14.0	11.1	15.4
9 - 12 years	15.3	13.3	12.6	15.6
12 years	17.8	13.9	16.9	18.5
13 - 15 years	24.5	17.4	21.7	23.8
16+ years	37.1	26.9	30.6	30.2

Source: DaVanzo, 1972, table 9

Table 3

Levels and Variation in Male Wage and Lifetime Migration Rates in Venezuela in 1961 among Coterminous States

	Arithmetic		Logarithmic	
Monthly Average Wage Rates	Means	Standard Deviation	Means	Standard Deviation
No Schooling	368	145	5.84	.345
Some Primary	558	118	6.30	.220
Some Secondary	1629	201	7.39	.120
Some Higher	6119	530	8.71	.096
Lifetime Average Migration Rates				
No Schooling	1.03	2.26	-1.43	1.74
Some Primary	1.61	3.39	-.808	1.56
Some Secondary	3.03	6.57	-.083	1.48
Some Higher	4.04	8.62	.140	1.57
Nonmigration Rates				
No Schooling	80.4	6.63	4.38	.082
Some Primary	69,7	8.51	4.24	.121
Some Secondary	42.4	12.3	3.71	.276
Some Higher	23.7	15.4	2.97	.590

Source: Schultz, 1975, table 4.

Table 4

Levels and Variation in Female Wage and Lifetime Migration Rates in Venezuela in 1961 among Coterminous States

	Arithmetic		Logarithmic	
Monthly Average Wage Rates	Means	Standard Deviation	Means	Standard Deviation
No Schooling	251	79.7	5.48	.297
Some Primary	347	47.2	5.84	.143
Some Secondary	912	79.2	6.81	.085
Some Higher	1574	138.	7.36	.084
Lifetime Average Migration Rates				
No Schooling	1.17	2.69	-1.52	1.93
Some Primary	1.63	3.70	-1.03	1.74
Some Secondary	2.63	5.62	-.434	1.65
Some Higher	6.30	12.7	.496	1.61
Nonmigration Rates				
No Schooling	77.8	7.08	4.35	.091
Some Primary	69.0	8.23	4.23	.117
Some Secondary	51.9	10.8	3.93	.221
Some Higher	22.6	17.7	2.90	.807

Source: Derived from Venezuelan Census of 1961 according to methods reported in Schultz, 1975.

with educational attainment in both countries confirms the notion that there are important earnings differences across individuals in the market for human capital. Yet it is still consistent with the working hypothesis that individuals, within their capital constraints, equalize the return they require from alternative human capital investments. In a normal long run equilibrium, the marginal rate of return to human capital is thought to diminish for an individual as the quantity invested is increased. Though this relationship is not necessarily observed in a reduced form earnings function estimated across individuals (Becker, 1975), it is noted in many countries that estimated "returns" to schooling are lower for higher levels of education.*

The magnitude of returns to migration diminish by 72 percent for both men and women in Venezuela, from those with no schooling to those with some higher schooling; the approximate decline in returns to migration between the extreme education classes of males age 25-29 in the U.S. is about 80 percent for whites and 71 percent for nonwhites.** But the puzzle remains of why the educated migrate more frequently although they appear thereby to derive smaller rates of returns on their time investments. At least two hypotheses warrant study: the enhanced ability of better educated to process information and thus reduce either the risk premium required to undertake migration or the time required to make the change of jobs, or both, or the increased access to investable funds among the better educated which, perhaps because of family background, encourages them to invest more in human capital formation, lowering the marginal return they find acceptable.

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*There are many exceptions, however. It has been suggested that where institutionally inflexible supply bottlenecks have created a scarcity of the highly trained and demand conditions have expanded rapidly, such as in contemporary Brazil, earnings disparities have widened and large rents raise the returns to higher education.

**In the study by DaVanzo (1972) the standard deviation of the logarithms of earnings is not reported; the approximation used here is simply the ratio of the arithmetic standard deviation to the arithmetic mean.

Expected Income Hypothesis

In the Harris-Todaro (1970) model of migration, it is assumed that potential migrants behave as though they maximized their expected earnings, defined as the product of their expected wage rate, and their preceived probability of finding employment, expressed over time and discounted to present values. In determining who gets the available urban jobs, it is assumed that all job seekers have an equal chance, and consequently, expected employment in each period is one minus the average unemployment probability. Stiglitz (1972) shows that the same expression holds for the expected urban wage in the absence of urban growth for either the queuing model, in which individuals are hired in the order of urban arrival, or the random selection-poisson model, in which individuals are hired irrespective of their arrival times.

In a migration function in which the explanatory variables are expressed in logarithmic form, the expected earnings hypothesis implies that the coefficients on the logarithm of the wage rate and on the logarithm of the employment rate should be identical.* This is, of course, a severe empirical test of the expected income hypothesis. Nonetheless, the adequacy of the data or model may be questioned if the destination employment rate coefficient is not positively and significantly associated with migration.

On the other hand, a number of factors might explain a tendency for the coefficient on the employment rate to exceed the coefficient on the wage rate. Fields (1975) has identified several such factors, in explaining why the large gap between urban and rural wages has not contributed to even greater urban unemployment. First, a rural resident may have some positive probability of obtaining an urban job without first migrating to the city and incurring

* Replacing the wage and employment variable with its product, an F or likelihood ratio test can be performed to test the restriction of coefficient equality on the two variables. Regression studies of migration, though often in double log specification, consider the unemployment rate and not the employment rate, as implied for this simple test of the Harris-Todaro formation.

opportunity and real costs in job search. Second, "unemployed" urban workers may find low paying jobs in the traditional urban sector, which do not bar them from searching for a better job, but which reduce the opportunity costs of effective job search and lower the rate of urban open unemployment. Third, turnover of urban jobs can affect the equilibrium level of unemployment, as can modified forms of queuing or preferential treatment in hiring. Risk aversion, which is neglected in the expected income model, may also play a role if migrants emphasize more heavily the probability of employment than the expected wage rate in the modern sector when employed. All of these modifications to the expected wage hypothesis imply that the empirically estimated migration tradeoff between the employment probability and the expected urban wage rate at destination will exceed unity.

Uncertainty, Job Turnover and Allocation

The strict Harris-Todaro expected income formulation neglects information on the period of job turnover or the duration of unemployment or the manner in which the job seeker responds to uncertainty in the labor market. Where more information is available on the functioning of regional labor markets more satisfactory and rigorous testing of models of migration should be possible. Fields and Hosek (1975) have proposed a framework for interpreting turnover that characterizes the job allocation mechanism as a first order Markov process, where the probability of being hired if unemployed and fired if employed are expected to be constant over time. Applying this model to migration, the expected earnings gained from migration is a function of $W[P_{ue}/(r+P_{ue} + P_{eu})](1+r)/r$, rather than as in the Harris-Todaro (1970) model $W(1-U)/r$, where r is the discount rate, W the real wage gain in urban compared with rural employment, U the urban unemployment rate, and P_{eu} and P_{ue} are the probabilities of being fired if

employed and of being hired if unemployed during the reference period, respectively. Clearly, the two formulations are the same when the current employment state does not influence the probability of next period employment, i.e. $P_{ue} = 1 - P_{eu} = P_{ee}$. Proxies for these probabilities are drawn by Fields (1976) from monthly "layoffs" and "new hires" for SMSAs in an application of the framework to intermetropolitan US migration. Empirical approximations for these concepts in low income countries are not likely to be found in standard data sources, but the formulation could be a guide for future data generating efforts aimed at understanding the determinants of migration.

Asymmetry of Origin and Destination Conditions.

Additional considerations suggest that the treatment of employment conditions in origin and destination regions may be asymmetric. Just as the potential migrant may anticipate that he would encounter more than the average unemployment rate of destination, as a new arrival in the city, he may equally well discount origin unemployment, given his existing job, established contacts and family ties. Consequently, origin employment coefficients would tend to be distinctly smaller than destination employment coefficients. This appears to be implicit in the Harris-Todaro (1970) formulation where rural employment probabilities are ignored or assumed equal to one.

As an illiquid investment in the productivity of the human agent, migration is undoubtedly limited by imperfections in capital markets. The income or wealth of the potential migrant or his family is likely to augment his supply of investable funds, and contribute to lowering the return he requires to migrate. This investable-funds effect of origin wage variables would offset, to some degree, the origin wage's restricting effect on out-migration. Origin wage variables may be expected to receive, therefore, a

somewhat smaller (negative) coefficient in absolute value than will the destination wage (positive).*

Another common characterization of migration involves the selectivity with which migrants are drawn from their origin population. Lee (1966) concludes that when the opportunities of the destination region fuel the migration process, migrants are positively selected, which could imply for our purposes that better educated migrants should be relatively more responsive to destination variables. Conversely, when deterioration in origin conditions stimulates outmigration, a negative selectivity arises according to Lee, which suggests relatively greater weight should be associated with origin conditions in the migration of less educated groups. To my knowledge this selectivity hypothesis has not often been directly documented; testing for the asymmetry or origin and destination effects by education level is a start, though it does not do justice to the subtle dynamic considerations that may be important in Lee's interpretation of historical evidence. Yet we would expect the positively selected highly educated migrant stream to respond more sensitively to destination effects,if Lee's reasoning is applicable.

Urban-Rural Sectors

The comparability of real wage rates and employment opportunities in urban and rural subsectors is hard to achieve with existing data from low income countries. Employment levels are reportedly high in rural-agricultural regions, and lower in urban-industrial regions. Yet it is commonly assumed that the majority of self-employed workers in agriculture are less fully employed throughout the year than such unrefined census data indicate (Turnham, 1971). Moreover, the greater frequency of unmonetized payments in kind and lower prices of food and shelter in the rural sector understate real rural wage rates in comparison

*This argument is elaborated by DaVanzo (1972) and tested against US inter-divisional gross migration flows. Greenwood (1971b, p. 259) found rural origin income effects were even positive on Indian migration to cities. I expected to find in Venezuela that the capital market constraint would be most frequently binding in the case of the migration of the least educated. Therefore, the ratio of destination to origin wage coefficients should be greatest for this group. This result was confirmed (Schultz, 1975).

with urban. The prices of manufactured goods are, on the other hand, somewhat cheaper in urban than in rural areas. Without relative price indices and confidence in the comparability of employment data in urban and rural sectors, wage and employment equations might be usefully estimated for both urban and rural sectors of each region. Migration should also be distinguished by rural and urban subareas within a region if feasible.

School Enrollment Rates and Other Factors

Stratification of the migrant population by sex and educational attainment is essential to quantify the diverse effects of schooling on migratory behavior and to recognize explicitly the heterogeneity of labor. In addition, educational opportunities of a location are often reported by migrants as an important reason for moving, either for their own access to improved schools or for their children's access (Nelson, 1970). Consequently, school enrollment rates may be considered as a measure of the region's provision of public sector services. Public housing, health and other services may also influence destination choice of migrants, though evidence of such effects is as yet impressionistic.

Military service, in many countries, shifts youth about the country, with lasting effects on their subsequent mobility. Migration of youth is similarly bound to obtaining higher education. And once the educational goal is achieved return migration requires a decisive break with established routines. All of these factors have not yet been explicitly incorporated into econometric studies of migration though dissaggregation by educational attainment provides a starting point for this analysis.

The Rate of Natural Population Increase

One potentially important determinant of migration that is exogenous from the individual's point of view but may be somewhat amenable to social policy is the difference between regional birth and death rates. Regional differences in this rate of natural increase of the population stimulate migration to the extent that these differences do not correspond with regional employment growth. Population growth has often been greater in rural areas than in urban areas, and these rural areas have also experienced frequently slower growth in derived demands for labor. Consequently, both supply and demand shifts have contributed to the disequilibrium among regional labor markets. The partial equilibrium framework adopted here interprets employment conditions as motivating individuals to migrate, but does not attempt to determine how these conditions were produced by shifts in regional derived demands for labor and regional differences in natural increase in supplies of labor. Kuznets in his introductory essay to Population Redistribution and Economic Growth, U. S. 1870-1950, concludes that "the effects of population increase are far less important than those of structural changes in the economy's productive system" (1964, xxv). But in understanding contemporary migration in developing countries, regional differences in population increase may no longer be secondary to changes in the structure of production (Schultz, 1969, 1975). Exploration of population growth effects on migration would seem to require a broader general equilibrium approach to internal migration and development.

Can Migration and Destination Be Independent?

Before turning in the next section to a statistical framework for the study of migration determinants, the limitations of the dependent variable and the ambiguous meaning of regional population size require discussion. The dependent variable is the probability of migration from region i to region j, P_{ij}, or given independence of individual movement, a consistent estimator of this probability is the gross migration rate.*

The longer the period over which migration is observed, the more serious are various measurement problems. Differential mortality among migrants and nonmigrants can probably be neglected except perhaps for lifetime migration rates. The importance of repeat and return migration varies greatly from setting to setting. Information on birthplace, which is the starting point for lifetime migration data, may not be the place of permanent residence, particularly where regional units are small and municipal hospitals provide maternity services for dispersed populations. More serious, however, is the measurement error introduced by the passage of time over which concurrent employment and wage conditions may be inadequately measured.

Differences in the population size of regions make it difficult to infer with confidence what factors cause regional rates of migration to vary. This will be evident later when we search for a rationale for the gravity formulation for the study of migration. The normalization of migration to a probability or a gross rate seems unavoidable. Having specified an individual migration probability function, no more difficulty attaches to aggregating over individuals to obtain a gross regional migration rate than is encountered in deriving aggregate relations

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*Some studies of gross migration rates appear to use in the denominator the population currently resident in the j^{th} state. See for example, Levy and Wadycki, 1972a.

in other areas of discrete consumer choice.*

Although origin and destination population size have long been interpreted as determinants of migration flows (Carey, 1858-59) in the literature using the gravity model, this presumption is not without its pitfalls. For example, many "gravity" studies account for past migration in terms of current population size variables.** Since migrants are counted in current destination populations and excluded from current origin populations, a positive and negative definitional correlation (bias) is introduced that distorts any time ordered association between migration and population size variables. This bias can be particularly serious when migration is measured over substantial periods, and in settings where migration is "efficient" or flows are predominantly in one direction.*** By redefining population size variables ex ante, as the number of persons born in the region, this definitional bias can be removed (Schultz, 1975) but there remains another, more subtle, bias that arises from the persistence of interregional patterns of development and population growth.

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*The case can be made for weighting aggregate observations according to the size of the origin population to increase efficiency in estimation. The differences in origin size are viewed as affecting the variance of the observed regional migration rate, which is itself sampled from a particular time period. Larger regions should exhibit less sampling variation in gross migration rates over time, other things being equal, and therefore are weighted more heavily in a generalized least squares estimation procedure. In practice, one multiplies in the linear case all variables by the origin population size (or the denominator in the dependent variable rate). Since the appropriate weighting scheme differs between the gravity and logistic models, unweighted estimates also are attractive (Cox, 1970, p. 106-7). This entails only a modest loss of efficiency given the large sample sizes, and should not introduce bias (Theil, 1969).

**This would appear to be the procedure followed by Beals, et al. 1967; Greenwood, 1969b, 1971; Levy and Wadycky 1972a, 1974; and Sahota, 1968, among others.

***Migration is called "efficient" if the net migration flow from one point to another is large relative to the sum of the gross migration flows occuring in both directions. In low income countries, migration tends to be more efficient (unidirectional), particularly among the less educated. See related discussions by Lee, 1970; Sjaastad, 1962, Schwartz, 1971.

Frequently populous regions are so populated because they contained early centers of commerce, industrialization, and urbanization, and subsequently attracted a net inflow of migrants. When one observes migrants continuing to gravitate toward more populous regions, at least in most low income countries today, this may not be due to the larger numbers of persons in the destination regions, as implied by the gravity model, but only a persisting reflection of the omitted or imperfectly measured economic variables pertaining to regional growth that continue to influence migration.* The regions with large populations once had the prerequisites to amass a large population, and these advantages appear to be eroded slowly, if at all, by the development process. Caution must be exercised, therefore, in interpreting the coefficient on the destination population size variable for it may reflect a "size effect" or the effect of many omitted regionally persistent variables. An improved dynamic approach to migration flows over time and across regions will be required to disentangle this ambiguity.**

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*In several studies the prior stock of migrants has been considered as a determinant of current migration, using single equation estimation techniques. The effect of this variable is rationalized in terms of information flows or the effects of friends and family on migrant destination choice. But in this case, even more clearly than with population size variables, the prior migrant stock is an endogenous variable, and by not treating it with simultaneous equation techniques, the migration equation is seriously biased. Not surprisingly, the prior migrant stock explains very well current migration flows, in both the US and Venezuela. See Nelson, 1959; Greenwood, 1969a and Levy and Wadycki, 1973.

**One way to test this hypothesis concerning the appropriate interpretation of destination population size effects is to pool a time series of cross-sections on interregional migration. The disturbance in the estimated migration equation could then be partitioned into a region specific and random component using the procedure first proposed by Balestra and Nerlove (1966). My expectation is that this more appropriate dynamic estimation approach would "wash out" the effect of both destination and origin population size variables. It would also, in all likelihood, reduce the magnitude of coefficients on other variables that are highly serially correlated overtime in the cross section. See Schultz, 1973.

IV. A Statistical Model

My objective is to specify a set of relationships that describe how the mutually exclusive and exhaustive probabilities of migration, including the outcome of not migrating, depend on a set of conditioning variables. One model for such a phenomena is the polytomous logistic or log linear model as applied in bioassay for a number of years (Mantel, 1966; Cox, 1970) and more recently in economics (McFadden, 1968; Theil, 1969; Nerlove and Press, 1973). In particular the application of Domencich and McFadden (1976) to the study of consumer choice among urban transporatation modes is analogous to the problem analyzed here. They provide a theoretical basis for studying individual choice among discrete alternatives within the traditional framework of economic rationality and utility maximization. Differences among individuals in tastes or utility functions are posited in a stochastic form, providing an economic link between observed discrete choices individuals make and attributes of the alternatives and observable traits of individual decisionmakers.

An individual is confronted with n alternative locations in which to reside, including his origin location (e.g. birthplace) denoted by subscript i. The probability that he resides in location j in a specific time period is assumed to depend on a vector of weighted personal and regional characteristics, Z_{ij}, as follows:

$$P_{ij} = \frac{e^{Z_{ij}}}{\sum_{j=1}^{n} e^{Z_{ij}}}, \quad \begin{matrix} i=1,\ldots,n \\ j=1,111,n \end{matrix} \qquad (1)$$

where for each region of origin, probabilities sum to one:

$$1 = \sum_{j=1}^{n} P_{ij} \qquad i=1,\ldots,n. \qquad (2)$$

The odds ratio of any two probabilities implied by this specification is independent of the characteristics of other (hence, irrelevant) locations. Though this lack of differential substitutability or complementarity between alternatives may appear to be a shortcoming of the polytomous logistic model, this functional specification provides a flexible and symmetric way to treat multiple choice situations and implies a plausible, if not ideal, characterization of the determination of interregional migration.*

A possible specification of Z_{ij} would be a linear function in natural logarithms** of (1) the pertinent characteristics of the origin and destination regions, X_i and X_j, (2) the average distance between persons in the two regions, D_{ij}, and (3) individual traits associated with susceptability

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* For example, one suspects that changes in the employment opportunities in Baltimore influence the relative numbers of persons from Philadelphia migrating to Washington, D. C. vis a vis New York City. The cross substitution effect of Baltimore is probably greater on the Washington flow of migrants than on the New York City flow. On the other hand, changes in opportunities in Seattle might leave these specific flows relatively unchanged. How the spatial organization of locations or the geographic spread of information about locations affects patterns of migration is frequently discussed in the literature, but this complication has not yet been resolved in a convincing and empirically tractable way. Levy and Wadycki (1974a) have recently attempted, in the context of a gravity model of migration, to operationalize Stouffer's (1940) concept of "intervening opportunities" as a determinant of interregional migration. In most low income countries there are relatively few urban centers of growth with clear rural migration watersheds. Complex heterogeneous interregional migration flows with substantial cross substitution effects may be less of a problem, therefore, for the type of analysis proposed here.

** The logarithmic form of Z_{ij} is preferred for several reasons. First, the expected wage hypothesis later tested posits multiplicative interaction between wage rates and employment rates which is readily translated into parameter restrictions on the logarithmic variables. Second, if opportunity costs are the major costs of migration, the ratio of expected incomes in two regions approximates the return to migration between these regions (DaVanzo, 1972). Third, the empirical literature on migration has generally fit double log linear equations permitting more nearly direct comparisons. Finally, the logarithmic form of Z_{ij} explained more of the variance than other forms I tried, such as a linear form.

to migration, Y_i. Where theoretical guidance on scaling of Ys is limited and the effect of a trait, such as education, is thought to operate in conjunction with the Xs and D_{ij}, stratification of the population according to these traits is a reasonable research strategy. Homogeneity restrictions on parameter estimates across groups defined by such variables as age, sex, and educational attainment may then be tested.

$$Z_{ij} = \alpha + \sum_{k=1}^{K} \beta_k \ln X_{ki} + \sum_{k=1}^{K} \gamma_k \ln X_{kj} + \delta \ln D_{ij} \qquad \begin{matrix} i=1,\ldots,n \\ j=1,\ldots,n \end{matrix} \qquad (3)$$

where α, δ and β_k, γ_k for $k=1,\ldots,K$ are the $2K + 2$ parameters of the migration probability function for each strata of the population. Restrictions may be considered to reduce the number of independent parameters for estimation. First, however, this framework may be elaborated to allow for structural differences that exist between the processes determining whether a potential migrant leaves his origin location, and if he does migrate, where he relocates.

The above "uniform" specification of migration as a single integrated decision process provides one way for considering migration probabilities, P_{ij}, where $i \neq j$, but neglects complications that might arise with nonmigration, namely the occurrence of P_{ii}.*

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*There is first a problem of measurement. If all regions contain the same area and populations, the nonmigrant probabilities might be treated simply as an adding up constraint, implied by equation (2). But if regions differ in size, relatively larger ones would encompass a relatively larger share of all changes in residence within their own boundaries, augmenting the frequency of measured nonmigration. One anticipates, therefore, that N_i origin initial population (or perhaps jobs or area), would be positively correlated with nonmigration as a consequence of measurement conventions, other things being equal. It should be noted, however, that since unobserved socioeconomic determinants of migration may also be correlated with such a "size" variable, the measurement effect alluded to here may be swamped by other correlated past and concurrent variables. In analysis of Venezuelan migration data it was found that the parameter estimate for the regions "size" was not negative, as anticipated, but positive and sometimes statistically significant at conventional levels.

A general "two stage" view of migration might assume all response parameters in the process determining nonmigration are distinct, indicated by asterisks:

$$Z_{ii} = \alpha^* + \sum_{k=1}^{K} (\beta_k^* + \gamma_k^*) \ln X_{ki} \qquad i = 1,\ldots,n \tag{4}$$

whereas the Z_{ij} for $i \neq j$ are still determined according to equation (3).

Another modification to the migration model may be denoted the "symmetry hypothesis", in which origin and destination conditions are thought to exert equal but opposite effects (elasticities) on the probability of migration, namely $\beta_k = -\gamma_k$, $k = 1,\ldots,K$. It follows that only the ratio of origin to destination conditions then matter:

$$Z_{ij} = \alpha + \sum_{k=1}^{K} \beta_k \ln (X_{ki}/X_{kj}) + \delta \ln D_{ij} \qquad \begin{matrix} i = 1,\ldots,n \\ j = 1,\ldots,n \\ i \neq j \end{matrix} \tag{5}$$

$$Z_{ii} = \alpha^* \qquad i = 1,\ldots,n \tag{6}$$

Clearly, certain factors may be symmetric and others not; these may be tested as restrictions on the estimated parameters.

Estimation

The uniform polytomous logistic model of migration, summarized in equations (1), (2) and (3), can be estimated by maximum likelihood techniques based on individual or grouped data. It has been shown that when the likelihood function for this model converges to a maximum it will be a unique maximum (McFadden 1968; Nerlove and Press, 1973). Information on migration frequencies can also be obtained from tabulations of large surveys or censuses. For those cells in which the expected migration probability is greater than zero and less than one, the polytomous logistic model can be estimated by ordinary least squares.

In order to impose the n adding up constraints in equation (2), it is convenient to express the migration probabilities as ratios. The nonmigrant probability, P_{ii}, can be used as the normalizing factor. Taking logarithms of these probability or odds ratios, one obtains the estimation equation that is linear in parameters:

$$\ln (P_{ij}/P_{ii}) = Z_{ij} - Z_{ii} \qquad \begin{matrix} i = 1,\ldots,n \\ j = 1,\ldots,n \\ i \neq j \end{matrix} \qquad (7)$$

which becomes for the "uniform model":

$$\ln (P_{ij}/P_{ii}) = \sum_{k=1}^{K} \gamma_k \ln (X_{kj}/X_{ki}) + \delta \ln D_{ij} \qquad (8)$$

Thus, aggregate estimates of the uniform model provide no direct information on α (no intercept) or β's (origin effects), and rationalize a "symmetric" treatment of origin and destination conditions as ratios.

When nonmigration is not restricted to be a response to the parameter vector allocating migrants among destinations, the "two-step" model can be estimated.

$$\ln (P_{ij}/P_{ii}) = (\alpha - \alpha^*) + \sum_{k=1}^{K} (\beta_k - \beta_k^* - \gamma_k^*) \ln X_{ki}$$

$$+ \sum_{k=1}^{K} \gamma_k \ln X_{kj} + \delta \ln D_{ij} \qquad (9)$$

Estimates of equation (9) permit a test of the hypothesis earlier advanced that migration should be approached as two separate decisions -- whether and where to migrate. Where one finds that the regression coefficients of $\ln X_{ki}$ are of approximately equal absolute value, but opposite sign, to the coefficients of $\ln X_{kj}$, one could impose the restriction of symmetry, replacing the origin and destination variables with their ratio as in equation (5). However, F tests of coefficients equality (Fisher, 1971), or likelihood ratio tests for minimum likelihood estimators,would not actually test whether both $\beta_k = \beta_k^*$ and $\gamma_k = \gamma_k^*$, but only test whether $(\beta_k - \beta_k^* - \gamma_k^*) = \gamma_k$. However, incremental tests could be calculated for the hypothesis that $\alpha = \alpha^*$.

The "symmetry hypothesis" is implied, as observed above, by the uniform polytomous logistic model. Moreover, the only change in the aggregate estimation equation (8) when a distinct nonmigration parameterization is assumed with symmetry is the addition of an intercept term, $\alpha - \alpha^*$. Should this intercept be negative, a tendency exists for nonmigration to occur more frequently than predicted by the uniform model of migration. The existence of an "inertia" (negative) or "wanderlust" (positive) effect would seem to be a suggestive distinction between the uniform and two-stage migration formulations.

Nested tree decision models may also be constructed that are consistent with the logit formulation but seem particularly well suited to the study of migration as a segmented process. McFadden (1977) has shown that in such cases it is possible to apply a moderate cost stepwise estimation procedure, estimating by stages the conditional probabilities proceeding from the final stage to the initial stage. In the case of migration, polytomous logit estimates are first estimated for the decision of destination conditional on migrating, and then second stage estimates are obtained by fitting a binary logit model for whether migration or nonmigration occurs. The performance of the uniform and the nested tree decision models can then be compared in terms of likelihood ratios to determine goodness of statistical fit.

The Gravity Model of Migration

Most empirical research on migration has applied some modification of the "social interactions" (Cary, 1858-59) or "gravity-type" model of interregional migration. Similarities and differences between the polytomous logistic and the "gravity" model should therefore be noted. The gravity framework presumes that aggregate gross flows of migration from one location to another are directly proportional to the population in the origin and destination, and inversely proportional to the distance between regions, and perhaps conditional on other attributes of origin and destination, measured as differences or ratios.

$$M_{ij} = N_i P_{ij} = \frac{N_i^{g_1} N_j^{g_2}}{D_{ij}^{g_3}} Z(.) \quad \begin{matrix} i=1,\ldots,n \\ j=1,\ldots,n \\ i \neq j \end{matrix} \qquad (10)$$

where M_{ij} is the gross aggregate number of migrants going from i to j, N_i and N_j are the number of persons initially residing in region i and j, Z(.) is a migration function of other attributes of region i and j including an intercept, and g_1, g_2, and g_3 are parameters.

Frequently g_1 is restricted to one and the gravity model is rearranged to obtain an estimation equation where the dependent variable is the gross migration rate.*

*An exception is Sahota's (1968) study of Brazilian migration that relies largely on double log regressions using as his dependent variable gross lifetime migration flows among the Brazilian states as recorded in the 1950 Census. Though he interprets his findings in terms of individual responsiveness of migration to a host of variables, it is not clear how he can relate his estimates to the micro economic behavioral model posited at the outset of his investigation. Sahota's specification also contradicts the classical assumption of homoscedastic disturbances in the regression equation, and since the origin population size tends to be correlated with other determinants of migration, bias as well as loss of efficiency occurs (Schultz, 1969). For these reasons no parallels are sought between his study of Brazilian migration circa 1950 and my investigation of Venezuelan migration (1975) as of 1961. Greenwood (1969b) also analyzes gross flows in Egypt.

$$\ln P_{ij} = a + \sum_{k=1}^{K} b_k \ln X_{ki} + \sum_{k=1}^{K} c_k \ln X_{ij} + d \ln D_{ij} \qquad \begin{matrix} i=1,\ldots,n \\ j=1,\ldots,n \\ i \neq j \end{matrix} \qquad (11)$$

where a, b_k, c_k, and d, are analogous to the logistic parameters obtained by least squares, and N_i and N_j may be contained in the vector of regional attributes X_{ki} and X_{kj}. In this formulation the parameters obtained from equation (11) can be interpreted in terms of an individual migration probability model, although predicted "probabilities" may exceed one.

In addition, the gravity model assumes that migration varies in proportion to the size of destination population, in other words, that the elasticity of migration with respect to destination population size is constant; some studies also restrict this elasticity to one.* It is hard to derive from behavioral assumptions this responsiveness of migration to destination population size, although this is attempted by Niedercorn and Bechdolt (1969). It is difficul to devise an appropriate test for this normalization procedure as implied by the gravity model, because serial correlation over time in the unexplained component of migration (i.e. the disturbance) is likely to yield high and misleading correlation between initial population size and current migration in a single cross section.

Finally, the gravity model does not make use of the information contained in the relative frequency of nonmigration, P_{ii}; the n adding up constraints that are incorporated into the logistic model by means of equation (2) imply residual estimates of P_{ii} for the gravity model, but to my knowledge

*See Greenwood 1971(b) or in arithmetic form Vanderkamp, 1971. Most applications, however, estimate g_2 independently, and generally obtain positive values of less than one (Beals, et. al., 1967; Levy and Wadycki, 1972ab, 1974). But as noted later, there are problems in interpreting these estimates.

these have not been reported before.*

It may be noted that the gravity formulation, as estimated by equation (11), could yield similar estimates to the logistic model (as in equation (8)), if the P_{ii} were the same magnitude for all i (i=1,...,n), and the same characteristics were specified in the vector of determinants, X_k. In the limit, as the unit of time diminished over which migration is measured, the P_{ii}'s approach one, and differences between these two model specifications would tend to diminish. The observed good "fit" of migration data to the gravity model would tentatively suggest that the logistic will also provide a better fit to data when determinant characteristics are expressed, as here, in logarithms, rather than in conventional units.

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* The coefficient of determination (R^2) is not immediately useful for comparing the fit of the logistic and "gravity" models of migration, since their dependent variables differ. The logistic estimates of equation (3) or (8) can be readily converted into predicted values for all P_{ij} and these compared with the n^2 observed values. Similarly, estimates of the gravity model obtained from equation (11), and the implied estimates for P_{ii}. i=1,...n, (though not necessarily values on the zero to one interval) can be compared with observed gross migration rates. Since both models are derived from logarithmic estimation equations, a plausible criterion for fit might be the mean squared relative error.

V. Conclusion

This paper has reviewed several conceptual, empirical and statistical problems with the framework commonly applied in the empirical study of internal migration in low income countries. Some of the specification problems discussed are sufficiently serious that available parameter estimates are not particularly helpful, either in considering policies or in understanding underlying individual behavior. A priority in this field would therefore seem to be to move toward a somewhat more satisfactory statistical and empirical specification of the migration function that would then be applied more uniformly across countries. Much richer characterizations of the institutional operation of labor markets will be required, and demands will grow for new and better data. A promising route for obtaining these multidimensional data is the household survey representing all national labor markets. The optimal degree of aggregation for final estimation, however, may not be the individual or family. But the strong presumption of this author is that the closer one gets to the individual decision unit, the less serious will be many of the problems discussed here.

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