# Environmental Security and Migration:
# The Role of Environmental Factors as Determinants of Migration Flows in Pakistan

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## 1. Introduction

This paper intends to investigate the linkages between the environment, income and migration. Little research has been carried out in this field so far, probably due to the limited empirical information available, and this study is intended as a preliminary first approach to the analysis of the environmental dimension of migration.

Thinking about the relationship between migration and the environment, two main questions seem to be relevant and will be addressed in the paper: in which way do the environment and migration interact? and what are the welfare and policy implications of this interaction?

The relationship between the environment and migration is twofold: environmental factors may influence the decision to migrate and migration in turn may impact the environment.

The environment has a deep economic value in both production and consumption. In rural developing economies, the environment is the fundamental source of livelihood; environmental resources are the primary factors of production in essential activities such as agriculture, horticulture, forestry, cattle raising, fishing, energy, and tourism. Exogenous shocks to the environment, such as flooding or drought, or the gradual degradation of natural resources associated with population pressure and human activities, such as deforestation or desertification, could lead to an impoverishment of rural areas and force people to move and seek better opportunities. In turn, mass immigration is likely to impose some pressure on the economy and the natural resource base in the regions of destination.

This paper investigates the extent to which environmental factors are determinants of migration in the South; the effect of migration on the environment is not explicitly analysed, and is left as topic for further research.

As a preliminary approach, the paper focuses on internal migration in a developing country, and explores the role that environmental factors play in inducing migration *within* that country. Certainly a less country-specific approach would be more interesting, but the lack of detailed empirical information to trace the migration history of individuals across macro-regions and to characterise the natural environment they live in, has narrowed our focus down to an individual country: Pakistan. Pakistan, for

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which individual socio-economic and demographic data on internal migration, as well as detailed climate and environmental information are available, is a rural developing economy showing considerable internal mobility and endowed with a fragile and diverse natural environment.

The structure of the paper is as follows:

Section 2 introduces the theoretical background to this research, drawing upon the economics literature on migration.

Sections 3 describes the specification and the estimation of the econometric model, which falls into the class of models defined by Maddala and Nelson (1975) as switching regression models with endogenous switching. The econometric model allows to estimate a migration decision function in two stages, accounting for the self-selection of migrants while investigating the role that climate and environmental factors may play on migrants' behaviour.

Section 4 describes the data set used and provides some descriptive evidence on migration in Pakistan. Results from some policy analysis on income and assets variables are illustrated.

Section 5 describes the results from the econometric estimation.

Section 6 addresses the policy implications of the main findings of this study, drawing further conclusions.

## 2. Theoretical background

Our analysis draws upon the economics literature on migration.

*Traditional economic theory* acknowledges the role of expected earning gaps as the primary determinant of migration, arguing that higher expected earnings in the region of destination would induce people to migrate. Higher expected earnings are traditionally explained by differentials in income and employment opportunities, and represent an individual expected positive net return from migration based on a cost-benefit calculation (Syaastad 1962, Todaro 1969).

In this framework potential migrants are assumed to make choices aimed to maximise the present value of net returns from migration. The individual's objective function reflects the earning differentials as well as the costs associated with migrating:

$$\text{(1)} \qquad PV(t) = \int_0^T [Y_{dt} - Y_{ot}]\, e^{-\rho t}\, dt - C_{do}$$

where $Y_d$ denotes earnings in the region of destination and $Y_o$ denotes earnings in the region of origin at time t, $C_{do}$ is the cost of moving from the region of origin to the region of destination, $\rho$ is the implicit discount rate and T represents the time over which the individual will remain active in the labour force. Migration occurs if the net present value of returns to migration is positive.

More recently a new stream of thoughts in economics has addressed individuals' migration as part of a household's strategy, stressing the role that households' dynamics and community's networks may play in inducing migration. The "*new economics of migration*" (Stark and Bloom 1985) views the migration decision as part of a household's risk-diversification strategy, whereby a household's gain from remittances could compensate for market failures in the sending regions. For example, credit and liquidity constraints to buy inputs to agriculture and other productive activities could be relaxed by the remittances received by the households in sending regions.

Based on these theoretical approaches, a few hypothesis about the role of environmental factors in inducing migration can be formulated (A. De Janvry et al., 1997).

Within the context of the *traditional economic theory*, the degradation of the environment due either to endogenous population pressure on natural resources or to external shocks, such as climatic events, would increase poverty, widen the expected earning gap, and therefore increase migration. Availability and access to natural resources affect welfare in two ways: directly, assuming that natural resources, such as water and forestry products, fulfil basic needs and enter directly the household's utility function, and indirectly, through their effects on income and labour opportunities. Income stemming from natural resources and labour employed in activities related to natural resource use would be negatively affected by the degradation of the environment, which would consequently increase the expected earning gap from migration.

Within the framework of the "*new economics of migration*", environmental uncertainty would increase the need for a household's risk diversification strategy, and remittances would compensate for environmental risk. Institutional failures to define people's entitlements on their environment contribute to higher uncertainty regarding the availability and accessibility to the natural resources, and would be a further incentive to migrate. However environmental changes leading to a lower profitability in agriculture would reduce the opportunity cost of market failures, thus reducing the ability of remittances to overcome market failures and the potential gain from migration.

Based on the net effects of these forces, we could therefore expect both a positive and a negative relation between the degradation of the environment and migration.

## 3. The Econometric Model: Specification and Estimation

In most of the empirical economic work on migration, which draws upon the economics literature previously illustrated, the migration decision function captures income opportunities, risk elements expressed by measures of unemployment and remittances, costs elements expressed by distance functions, and community networks variables to represent the information function: usually this migration decision function is applied to migration flows, given the lack of adequate detailed information on individual migrants.

This study instead relies upon micro-data, which contains cross-country socio-economic, environmental and demographic information drawn from a survey on a sample of individuals all over Pakistan. Migrants are defined as those individual who moved from their place of birth, and any socio-economic variable on migrants, including income variables, is observed *after* migration has occurred.

Exploiting this data set, we try to understand the choice mechanism behind individuals' migration, accounting for the potential role played by environmental factors.

In particular, by estimating the returns to migration, we explicitly address the issue of self-selection of migrants. The concept of self-selection is based on the notion that economic agents choose among competing alternatives on the basis of incremental expected returns: as a result, the agent who makes choices tends not to be randomly distributed within the population as a whole. Consequently there is inherent “selectivity bias” in data which report relative returns to competing alternatives: in the case of migration, a “selectivity bias” may arise by comparing incomes under the two options of migrating versus not-migrating, under the assumption that the choice to migrate is part of an optimising strategy for households or individuals.

This paper attempts to address the linkages between the environment, income and migration explicitly accounting for the migrants’ self-selection from the population and for the endogenous nature of income with respect to migration.

The econometric model adopted falls in the class of *switching regression models with endogenous switching*.

The “selectivity” modelling has been originally applied to studies of migration and income by Nakosteen and Zimmer (1980), following its application mainly to studies of participation in the labour force (Heckman 1974, 1979, Nelson 1977), of the effects of union on wages (Lee 1978), of tenure choice and demand for housing (Trost 1977, Lee and Trost 1978, Rosen 1979).

Based on Nakosteen and Zimmer specification, the model consists of two income equations, which explain respectively income for migrants and for non-migrants, as well as one *criterion function*, which describes the dichotomous decision to migrate. The sample observations are thought of as falling into one of the two mutually exclusive regimes, with the migration decision equation serving as an endogenous selectivity criterion which determines the appropriate regime, i.e. migrant versus non-migrant.

Our sample observations will be used to estimate the parameters of the migration decision function and income equations. Provided that consistent estimates of the income equations can be obtained, then fitted values from the income equations will be used to estimate the parameters of the migration decision function.

Drawing upon the traditional economic theory approach, as previously suggested, we can assume that at any point in time each individual *i* will choose to migrate if the percentage gain in moving exceeds the associated costs, i.e. if the net returns from migrating are positive.

Individuals will thus choose to migrate if:

(2) $$(Y_{mi} - Y_{ni})/ Y_{ni} > B_i$$

where $B_i$ represents direct and indirect costs, as a proportion of income, incurred by individual *i* in moving, and $Y_{mi}$ ,$Y_{ni}$ represent income of individual *i* respectively after and before migrating.

We assume as well that the proportionate costs may be represented as a function of a vector of individual’s and household’s characteristics (X), a vector of attributes of the regions of origin or destination, mainly environmental characteristics (E), and a random disturbance term:

(3) $$B_i= g ( X_i, E_i) + \varepsilon_i$$

Regional and environmental characteristics are included in (3) to reflect the indirect costs, or the opportunity cost of moving from areas which may provide favourable climate conditions and environmental security, through easier access to natural resources, as well as the benefits of migrating towards areas with more favourable environmental conditions.

From (2) and (3), the migration decision criterion can be expressed as a function of gains in income as well as individuals', households' and regional environmental characteristics.

The criterion function is modelled as a linear combination of these variables which jointly explain the individual's propensity to migrate:

(4) $$M_i^* = \alpha_0 + \alpha_1 [(Y_{mi} - Y_{ni})/ Y_{ni}] + \alpha_2 X_i + \alpha_3 E_i - \varepsilon_I$$

Individual *i* chooses to migrate if:

(5) $$M_i^* > 0$$

and does not migrate if

(6) $$M_i^* \leq 0$$

The model is completed by specifying income equations for migrants and non-migrants respectively:

(7) $$Y_{mi} = \beta_{m0} + \beta_{m1} X_i + \beta_{m2} E_i + \varepsilon_{mi}$$

(8) $$Y_{ni} = \beta_{n0} + \beta_{n1} X_i + \beta_{n2} E_i + \varepsilon_{ni}$$

where the explanatory variables are again represented by a vector of individual's characteristics (X), and a vector of attributes of the regions of origin (E), mainly climate variables. Both vectors X and E in the income equations do not entirely consist of the same variables appearing in the criterion function: in fact the individual characteristics which relate to the household's structure and the environmental variables which are included in the migration decision function are not included in the income equations. The individual's characteristics and the regional attributes included in the income equations are those variables which are thought of having a direct impact on income which is different from their impact on the decision to migrate. The economic rational which supports the exclusion restrictions allows us to identify the system of equations of the structural model.

The basic structural form of the model is therefore expressed by the criterion function and the two income equations, respectively equations (4), (7) and (8).

The endogenous variables are $M_i^*$, $Y_{mi}$ and $Y_{ni}$.

$M_i^*$ indicates the individual's *i* marginal propensity to migrate. We do not observe $M_i^*$, but only the effective migration decision:

$$M_i = 1 \text{ if } M_i^* > 0$$

$$M_i = 0 \text{ if } M_i^* \leq 0$$

As previously mentioned, we observe migration after it has occurred, therefore we observe the destination wage of migrants and the origin wage of non migrants:

$$Y = Y_m \text{ when } M_i = 1$$

$$Y = Y_n \text{ when } M_i = 0$$

Since $(Y_{mi} - Y_{ni}) / Y_{ni}$ is approximated by $(\log Y_{mi} - \log Y_{ni})$, $(\log Y_{mi} - \log Y_{ni})$ is inserted in the migration decision function (4). This approximation simplifies the estimation procedure and remains consistent with the migration decision model. Therefore the model to be estimated becomes:

(4b) $$M_i^* = \alpha_0 + \alpha_1 [\log Y_{mi} - \log Y_{ni}] + \alpha_2 X_i + \alpha_3 E_i - \varepsilon_I$$

(7b) $$\log Y_{mi} = \beta_{m0} + \beta_{m1} X_i + \beta_{m2} E_i + \varepsilon_{mi}$$

(8b) $$\log Y_{ni} = \beta_{n0} + \beta_{n1} X_i + \beta_{n2} E_i + \varepsilon_{ni}$$

Since the observed dependent variable in the migration decision equation is a binary variable the parameters of the explanatory variables could be estimated by maximum likelihood probit techniques. The income equations could be estimated by OLS and the resulted fitted values of log-income variables could be inserted into the migration decision function to obtain consistent estimates of the decision equation. However OLS would be inappropriate to estimate the income equations since it would not reflect the presence of self-selection in migration.

If we assume self-selection in migration, the conditional means of the income disturbances terms in the income equations are non-zero and not constant for all the sample observations. Based on the conditional formula for the truncated normal distribution, they can be expressed as:

(9) $$E(\varepsilon_{mi} \mid M_i = 1) = \sigma_{me^*} [-f(\Psi_i) / F(\Psi_i)]$$

(10) $$E(\varepsilon_{ni} \mid M_i = 0) = \sigma_{ne^*} [f(\Psi_i) / 1 - F(\Psi_i)]$$

where $\sigma_{me^*}$, $\sigma_{ne^*}$ and $\psi_I$ are defined below, and $f(.)$ and $F(.)$ are respectively the standard normal density and cumulative distribution functions.

The argument $\Psi_i$ in (9) and (10) is obtained as follows. Substituting (7b) and (8b) in (4b) we obtain the reduced form of the migration decision equation:

(11) $$M_i^* = \gamma_0 + \gamma_2 X^1_i + \gamma_3 E^1_i - \varepsilon_i^*$$

where the vectors $X^1$ and $E^1$ consist of all the exogenous variables in the model.

If we assume that the disturbance term is normally distributed with unit variance, equation (11) may be estimated by maximum likelihood probit methods. Define:

$$\Psi_i = \gamma_0 + \gamma_2 X^1_i + \gamma_3 E^1_i$$

The probit estimation yields fitted values of $\Psi_i$, denoted $\overline{\Psi}_i$, which are to be used as estimates of the arguments of the standard normal density and distribution functions in (9) and (10). The coefficients $\sigma_{me*}$ and $\sigma_{ne*}$ in (9) and (10) are elements of the covariance matrix of the disturbances: $COV\ [\varepsilon_m\ \varepsilon_n\ \ \varepsilon*]$.

Expressions (9) and (10) summarise the selectivity bias which would result from the OLS estimation of the income equations; if we performed OLS estimates of the income equations they would be inconsistent and would lead to biased estimates of returns to migration.

In more detail, the suggested procedure to get consistent estimates of the model is to correct the income equations by incorporating the appropriate "selectivity variables", and to add error terms with zero mean (Lee, 1978). A two stage estimation procedure is then employed to estimate all the parameters in the model.

The corrected income equations can be written as:

$$\text{(12)} \qquad \log Y_{mi} = \beta_{m0} + \beta_{m1} X_i + \beta_{m2} E_i + \sigma_{me*} [-f(\Psi_i)/ F(\Psi_i)] + \eta_{mi}$$

$$\text{(13)} \qquad \log Y_{ni} = \beta_{n0} + \beta_{n1} X_i + \beta_{n2} E_i + \sigma_{ne*} [f(\Psi_i)/ 1\text{-}F(\Psi_i)] + \eta_{ni}$$

where

$$E(\eta_{mi} \mid M_i = 1) = 0$$

and

$$E(\eta_{ni} \mid M_i = 0) = 0$$

In stage 1, the reduced form decision equation (11) is estimated using probit techniques. Fitted values obtained from the probit estimation of (11), denoted $\overline{\Psi}$, are used to construct the variables $\overline{u}_{mi}$ and $\overline{u}_{mi}$ s.t.

$$\overline{u}_{mi} = [-f(\overline{\Psi}_i)/ F(\overline{\Psi}_i)]$$

and

$$\overline{u}_{ni} = [f(\overline{\Psi}_i)/ 1- F(\overline{\Psi}_i)]$$

In stage 2, $\overline{u}_{mi}$ and $\overline{u}_{ni}$ are inserted into the appropriate income equations (12) and (13) and these are estimated by OLS.

Estimates obtained by this procedure can be shown to be consistent.

We must note, however, that the standard errors obtained by OLS are underestimated, due to the fact OLS assumes that $\overline{u}_{mi}$ and $\overline{u}_{ni}$ are true variables, while they are estimates. Unbiased estimates could be obtained by correcting appropriately the OLS variance-covariance matrix (Greene, 1993).

The fitted income values obtained by estimating the two corrected income equations will then be used to estimate by MLE the migration decision function in (4b).

A thorough description of econometric models of self-selection is found in Maddala (1985).

## 4. Data and Descriptive Statistics

The data source for the socio-economic, environmental and demographic data on the Pakistan population is the Pakistan Integrated Household Survey: a cross-country multi-stage sampling survey conducted in Pakistan by the World Bank as part of the Living Standard of Measurement Studies (LSMS). The survey was conducted in 1991 at the individual and household level and is based on a multi-stage stratified sampling procedure.

The sample covers:

- *four provinces*: Punjab, Sindh, North Western Frontier Provinces (NWFP), Balochistan
- *three main domains*: self-representing cities, urban areas, rural areas
- and applies to *4800 households* drawn from *300 Primary Sampling Units* (extracted by province and domain) throughout the country.

Few territories are excluded from the sample, corresponding to the exclusion of 4% of the total population of Pakistan.

The climate data for that same year has been provided by the Pakistan Meteorological Department. The data includes the monthly and annual amount of precipitation, as well as the average, maximum and minimum temperature. The climate data is available for 41 meteorological stations spread all over the country; by mapping the meteorological station across the country we geographically link the climate information with the districts where people live in. Each meteorological station covers the area of several districts.

The environmental information available refers to the accessibility and availability of sources of water and wood, expressed as a function of the time needed to fetch water and collect firewood by each household.

In our sample the migrant status refers to individuals, and migration is observed *after* it has occurred; in the descriptive and econometric analysis we will refer to migrants as to those who actually live in a place different from where they were born.

It may be argued that this is a too broad definition of migration. For some individuals in fact we observe several migration steps and we should trace their full migration history, focusing on their last migration. However this information is available for too few individuals and, in order to exploit the full sample, we are forced to use the previous broad definition of migrants.

With regard to income variables, exploiting the survey information two income variables are constructed, to reflect the nature of the source of income: one variable is per capita income stemming from natural resources (hereafter *natural income*), the other variable defines per capita income stemming from all other sources (hereafter *other income*).

Natural income aggregates measures of income stemming from selling products related to agricultural, forestry and cattle raising activities; when income is expressed in kind, market prices in the district where people live are used to express income in monetary terms.

The same procedure applies to the measures constructed to value individual's property assets, whereby we identify a measure of per capita assets on natural resources, mainly land and cattle, and a per capita measure comprehensive of any other asset.

As previously noted, migrants are defined as individuals who moved from their original birth place. The country shows a very high internal mobility: 34.94 % of individuals in the sample moved from the place they were originally born. The migration history of individuals indicates several migration steps for each individual and shows a gradual redistribution of the sample from rural to urban areas, with 74.6% of the available sample originally born in rural areas and only 39.2% still living in rural areas.

Immigration is catalysed by two provinces: Punjab and Sindh, the most fertile lands, which attract immigrants even from abroad, mainly India, and show a high internal mobility. Most of migration occurs within provinces: only 35.5% of migrants moved across provinces (Table 1).

**Table 1. Regional distribution of migrants**

| | ***Place of living*** | | | | |
|---|---|---|---|---|---|
| ***Place of birth*** | **Punjab** | **Sindh** | **NWFP** | **Baluch.** | Total |
| **Punjab** | **2963** | 203 | 34 | 15 | **3215** |
| **Sindh** | 61 | **536** | 12 | 28 | **637** |
| **NWFP** | 152 | 152 | **865** | 10 | 1179 |
| **Baluchistan** | 17 | 35 | 1 | **130** | 183 |
| **Other Pakistan** | 39 | 22 | 46 | 22 | 129 |
| **India** | 968 | 467 | 5 | 8 | 1448 |
| **Bangladesh** | 24 | 20 | 0 | 0 | 44 |
| **Afghanistan** | 5 | 2 | 12 | 22 | 41 |
| **Other Cs.** | 23 | 18 | 2 | 2 | 45 |
| Total | **4252** | **1455** | 977 | 237 | 6921 |

As shown in Table 2, people abandon their birth place when they are relatively young: 75% of migrants left their birth place when they were younger than 21, and only 5% were more than 39 years old.

Interestingly, according to the survey results work and land availability seem to be the most important reasons for migration (Table 3).

**Table 2. Age distribution of migrants**

| *Percentiles* | *Age when left birth place* |
|---|---|
| 10% | 4 |
| 25% | 11 |
| 50% | 17 |
| 75% | 21 |
| 90% | 30 |
| 95% | 39 |
| 99% | 56 |

**Table 3. Reasons for Migrating**

| **Reasons for moving** | **Percentage** |
|---|---|
| | |
| **Work** | **37.76** |
| School | 0.96 |
| **Land availability** | **17.87** |
| Marriage | 1.45 |
| Other family reasons | 13.87 |
| War | 14.50 |
| Others | 13.58 |

The human capital of those who migrate, measured by schooling, is poor, and even poorer than the human capital of the people who do not migrate; only 37.4% of migrants are literate, vs. 40.43 % of non migrants, and only 44.1% has been in school, vs. 47.45% of non migrants.

This evidence seems to be in contrast with the evidence found in the literature of relatively high human capital of people who migrate across regional borders.

Looking at income variables (Table 4), migrants appear to be poorer than people who did not migrate, and relatively more homogenous: their mean income, even when decomposed by source of income, is lower, and more equally distributed. Only migrants who migrate across provinces show a relatively higher mean income, possibly indicating that richer people can bear the costs of migrating across provinces, or that higher income differentials pull migration across provinces.

Two measures of income inequality are computed: the Gini coefficient of income distribution and the coefficient of variation of income. They both show very high inequalities in the distribution of income, although the inequalities are lower in the group of migrants. This evidence may support the theory of relative-deprivation, which argues that the perception of relative deprivation in the region of origin, characterised by high income inequalities, would induce migrants to leave.

Decomposing the income distribution coefficients by source of income, we observe that income stemming from natural resources is inequality increasing.

When we replicate the analysis for the variables on the values of property assets, we observe the same result: migrants show lower mean asset values than non migrants, and the assets are more equally distributed. The value of property assets on natural resources, mainly land and cattle owned by the household, are inequality increasing, and they contribute by 84.4% to overall assets inequalities (Table 5). This evidence is less striking if we consider that in Sindh and Punjab farming still struggles over a feudal system, where over 90% of farmers own very small plots, smaller than 10 hectares.

**Table 4. Descriptive statistics on** *natural* **and** ***other income****

| **Income variables** | **All households** | **Individuals providing mig. Inf.** | **Migrants** | **Non migrants** |
|---|---|---|---|---|
| **Mean *natural* income** | 34680 | 35918 | **35765** | **36001** |
| **Mean *other* income** | 60999 | 61857 | **59776** | **62980** |
| **Coeff. var. *natural* income** | 21.625 | 21.846 | 18.080 | 23.610 |
| **Coeff. var. *other* income** | 4.637 | 4.551 | 1.966 | 5.375 |
| **Gini *Natural* Income** | .825 | .792 | **.575** | **.713** |
| **Gini *Other* Income** | .733 | .693 | **.431** | **.616** |
| **#obs** | 24532 | 19823 | 6928 | 12895 |

*income is expressed in local currency

**Table 5. Gini decomposition by sources of property values**

| | **Assets on Natural Resources** | **Assets on Other Sources** |
|---|---|---|
| Concentration coefficient of assets (if >1 inequality increasing) | **1.007** | **.838** |
| Source of assets contribution to overall assets inequality | **.844** | **.136** |

## 5. Empirical Model and Results

The data used in the estimation of the model has been described in the previous section. It is important to stress that the data source is a survey, and that the survey was conducted using a multi-stage stratified sampling procedure, covering 4800 households drawn from 300 primary sampling units (PSUs) and 88 strata throughout the country. By using this sampling procedure, the sample observations are not randomly selected, and sampling weights have been incorporated in the data to correct for the fact that the stratified sampling procedure does not give all households in the country an equal chance of being selected.

To correct for bias in the estimates, our estimation procedure accounts for the fact that the survey used a multi-stage sampling procedure and for clustering within the sample.

The use of the Pakistan Integrated Household Survey however provides a very large data sample, and allows us to exploit the asymptotic property of the estimators.

**5.1 The Empirical Model**

The structural model that we use can be specified as follows:

(14)

$$M_i^* = \alpha_0 + \alpha_1 [\log Y_{mi} - \log Y_{ni}] + \alpha_2 AGE_i + \alpha_3 AGEsq_i + \alpha_4 LIT_i + \alpha_5 SEXM_i + \alpha_6 SON_i + \alpha_7 SINGLE_i + \alpha_8 GINILV_i + \alpha_9 WATERBR_i + \alpha_{10} WOODBR_i - \varepsilon_i$$

(15)

$$\log Y_{mi} = \beta_{m0} + \beta_{m1} AGE_i + \beta_{m2} LIT_i + \beta_{m3} SEXM_i + \beta_{m4} TPRPLV_i + \beta_{m5} SDPRPLV_i + \beta_{m6} AVTMPLV_i + \varepsilon_{mi}$$

(16)

$$\log Y_{ni} = \beta_{n0} + \beta_{n1} AGE_i + \beta_{n2} LIT_i + \beta_{n3} SEXM_i + \beta_{n4} TPRPLV_i + \beta_{n5} SDPRPLV_i + \beta_{n6} AVTMPLV_i + \varepsilon_{ni}$$

where (14) is the migration decision function and (15) and (16) are the income equations respectively for migrants and non-migrants.

In the migration decision function, AGE, AGEsq, LIT, SEXM, SON and SINGLE define individuals' characteristics and the role of individuals within their household. AGE and AGEsq represent respectively the age of each individual and its squared value; LIT is a dummy which identifies literacy, constructed as the ability to both read and write. SEXM is a dummy variable for males. SON is a dummy for the son of the head of the household, and SINGLE is a dummy which applies to non-married individuals.

Age, and its squared value, are included in the migration decision equation to test the usual finding that age has a positive but decreasing influence on the propensity to migrate. The role that human capital, expressed by literacy, may play on the migration decision is more ambiguous: in the literature there is general consensus on the fact that people who migrate across borders have a relatively high human capital, which allows them to face the transaction costs of migrating and the adjustment costs in the region of destination. In the context of a household's risk diversification strategy those who migrate are assumed to be the most productive elements in the households, possibly those showing higher returns to education. However, there is some ambiguity on the human capital endowment of people who migrate internally, since they face comparatively lower transaction and adjustment costs; the descriptive empirical evidence on Pakistan suggests a relatively poor human capital of internal migrants.

Based on that evidence, we could expect a negative sign on the estimated coefficient of the "literacy" dummy.

The estimated coefficient on the dummy variable on sex, taking on a unit value for males, is expected to show a positive coefficient, reflecting higher mobility of the productive adult males within the household, and the stronger effect of household ties for females, particularly mothers. The dummy variables for being son of the household's head and for not being married are included to understand some of the dynamics of the migration choice within the household. Consistent with the new household economics theory, we would expect adult individuals, with some household's ties and responsibilities, to migrate and try to compensate for market failures in the regions of origin sending remittances to their households. Therefore we would expect single people not to have a positive influence on the probability of migration. The coefficient on the dummy for being son of the household's head is expected to have a negative sign, given the evidence found in the literature on adults migrants showing higher returns to migration.

GINILV, WATERBR and WOODBR represent some wealth-related and environmental characteristics respectively in the region of destination and origin of migration, and are included in the migration decision function to address the potential costs associated with migration.

GINILV is the Gini coefficient of distribution of property assets in the district where individuals live, or migrated to, whereby WATERBR and WOODBR indicate easy access and availability of water and forests' wood in the districts where people were born.

In order to represent opportunity costs or benefits associated with migration and the environment we use attributes of both the regions of origin and destination of people who did migrate, although we are aware that this may create some definitional problems. To provide a measure of potential sources of wealth which may trigger or push migration, we use in fact a coefficient of concentration of property assets, mainly land and cattle, in the district where people migrated to; using the same coefficient as a push factor, i.e. the concentration of land and cattle in the region of origin, would provide an easier interpretation, and would be more consistent with the choice mechanism of the model. However, lack of sufficient information on the regions of origin of migrants has forced us to use an indicator of wealth in the destination regions. Supported by the theory of relative deprivation of migrants, we expect that a higher concentration of property assets in potential regions of destination would disincentive migration towards those regions: we therefore expect the estimated coefficient on the Gini coefficient on property assets in the destination regions to show a negative sign. Although it could be argued that migrants may affect the distribution of property assets, we want to point out that we assume that the Gini coefficient on land and cattle is not endogenous.

Easy access to sources of water and forests' wood are included in the migration decision equation to represent the opportunity cost of moving from areas which provide some "environmental security", through the availability and accessibility to natural sources of livelihood. Based on the traditional economic theory, we formulated the hypothesis that environmental degradation, either directly or indirectly, i.e. through income-related opportunities, would increase poverty, widen the expected earning gap and induce migration. Within this framework, easy access to sources of water and firewood are thought of having a direct impact on the migration decision, and are excluded from the income equations. The exclusion restrictions are justified by the fact that the access to sources of water and firewood is not considered to have a direct income effect: income is mainly influenced by climate factors, affecting in particular agricultural income. Wood and water are a source of livelihood and directly fulfil basic needs, not necessarily acting through income. Higher availability and easier access to sources of water and forests' wood would provide an incentive not to migrate. We would therefore expect a negative sign on the estimated coefficients of both variables.

Exclusion restrictions apply as well to those individual's characteristics which define the individual's role within the household, which are thought of entering directly the migration decision function.

Exclusion restrictions on both individuals' characteristics and regional attributes allow us to identify the system of equations, as well as to avoid problems of collinearity in the second stage of the estimation.

The income equations thus include only exogenous variables that are thought to exert an impact on earnings distinct from their impact on the decision to migrate.

In the income equations dummies on age, literacy and sex are used to control for individuals' characteristics; the remaining explanatory variables are climate variables which characterise districts where people live in. TPRPLV indicates the total amount of annual precipitation, SDPRPLV is the intra-annual standard deviation of precipitation, and AVTMPLV is the average monthly temperature in the district where people live. We regress both the aggregate measure of per capita income, and the per capita measure of income stemming from the use of natural and other sources on the individuals' characteristics and climate variables.

Estimated coefficients on climate variables are expected to be highly significant, particularly when used to explain income stemming from natural resources. The intra-annual variance of precipitation, identified as one of the main causes of desertification and as one of the climate manifestations which mostly affect productivity in agriculture, is expected to have a negative effect on income. Average monthly temperature and total amount of precipitation are expected to have a positive effect on income from natural resources, although extremes in temperature and precipitation may seriously and negatively affect natural income. Income generated from sources different from agriculture or pastoralism may as well be affected by climate factors, although in abstract it would not be easy to identify the direction of this impact.

### 5.2 Econometric Results

Maximum likelihood estimates of the reduced form decision equation are illustrated in Table 6.

Overall the reduced form decision equation is statistically significant.

The estimated coefficients in general are individually statistically significant and show the expected sign: the estimated coefficient on age is statistically significant and has a positive but decreasing impact on the likelihood of migrating, being son of the head of the household or being single have a highly significant negative influence on the likelihood of migration. Estimated coefficients on sex and human capital show a positive sign but they are not statistically significant. All the estimated coefficients on the regional characteristics and the environmental variables are highly significant and reveal the expected signs.

In the following step of the estimation, fitted values from the reduced form probit model are used to construct selectivity variables, one for the group of migrants and the other for non-migrants, to be appended to the corresponding income equations.

OLS estimates of the corrected income equations for migrants and non-migrants are presented respectively in Table 7 and Table 8.

We estimate *aggregate income* equations separately from *natural* and *other income* equations both for migrants and non-migrants, mainly in order to capture the climate variables effect on natural income.

The most interesting results can be summarised as follows:

- the estimated coefficients on climate variables are highly statistically significant and show the expected sign in influencing income from natural resources for both the migrants and non-migrants group
- literacy is the only individual characteristic which is consistently significant in explaining income across the two groups. It is interesting to observe that literacy has a positive effect on *aggregate* and *other income,* whereas it has a negative effect on *natural income*. This may be due either to the fact that education has a higher opportunity costs for households living off agricultural and pastoralism activities, particularly in environmentally vulnerable and fragile areas, or to the fact that labour in agriculture requires little schooling education
- the selectivity bias is highly significant only in the non-migrants income equations: this result supports the hypothesis of self-selection, at least as it pertains to non-migrants. The positive sign of the selection bias on aggregate income may be interpreted in support of the hypothesis that non-migrants in the population choose not to migrate because they cannot foresee more favourable returns elsewhere. This hypothesis is consistent with the empirical evidence previously presented showing lower mean income of migrants with respect to non-migrants in Pakistan. The negative self-selection effect on natural income may indeed support the hypothesis that non-migrants fail in not perceiving better opportunities from natural income elsewhere.

It is important to notice that the combined effect of the two selectivity variables on aggregate income is positive, although the combined effect on natural income is negative.

The last stage of our estimation entails the probit estimation of the structural form of the migration decision equation, which includes the fitted income values. Results of the estimation are presented in Table9.

The migration decision equation overall is statistically significant.

The migration decision is estimated in various stages including individually and separately the three different measures of expected returns.

The estimated coefficient on the expected returns to migration catalyses our interest: when the measure of aggregate income is used, the estimated coefficient on expected net gains in aggregate income is significant at the 90% level and shows that aggregate income triggers migration. Only expected gains from natural income do not result to have a positive influence on the likelihood of migration.

In the overall picture provided by the estimation of the model and by the descriptive empirical evidence on the data sample this finding is consistent with the story of people moving from rural to urban areas: degraded environments induce people to migrate from their regions of origin, migrating from rural to urban environments and engaging in different production activities. Migrants seem to be driven mainly by expected gains in sources of income not related to natural resources, possibly aiming at non-agricultural production activities to diversify risk and compensate for environmental uncertainty.

Estimated coefficients on the regional variables are highly significant and influence the likelihood of migration according to our expectations: higher availability and better accessibility to sources of water and forest wood in the regions of origin deter emigration, and high inequalities in the distribution of property assets, mainly on land

and cattle, in the potential regions of destination disincentive migration to those regions.

Our results show that factors other than income seem to be highly significant in explaining migration: the *access* to natural sources of income, through direct access to natural resources, or through property assets or “entitlements” to the use of natural resources, appear to be a key factor  influencing mobility.

**Table 6. Probit Estimation of the Reduced Form Decision Equation**
**Probit Analysis using Multi-Stage Stratified Sampling Procedures**

| *Independent variables* | *Marginal Effects* | *Individual t-statistics* |
|---|---|---|
| Constant | -5.823 *** | -3.649 |
| **Individual Characteristics** | | |
| Age | .022 *** | 5.421 |
| Age Squared | - .001 *** | -5.401 |
| Sex: male | .021 | 0.520 |
| Literate | .041 | 1.012 |
| Son of the head of household | - .385 *** | -8.811 |
| Single | - .452 *** | -9.449 |
| **Climate and Regional Characteristics at Destination** | | |
| Concentration of *Property Assets* | -2.424 *** | -3.836 |
| Total annual precipitation | .004 *** | 3.019 |
| Inter-annual σ of precipitation | - .031*** | -2.213 |
| Average monthly temperature | .196 *** | 3.075 |
| **Environmental variables at origin** | | |
| Easy Access to water in region of origin | - .0005 *** | -2.490 |
| Easy Access to wood in region of origin | - .0014 *** | -4.595 |
| # of observations | **18269** | |
| # of strata | **51** | |
| # of Primary Sampling Us | **300** | |
| F-test (12, 238) | **66.66** | |

* significant at 90% ** significant at 95% *** significant at 99%

**Table 7. Second stage estimates: Migrants Income Equation**
**OLS estimation**

| | Log of migrants *aggregate income* as dependent variable | | Log of migrants *natural income* as dependent variable | | Log of migrants *other income* as dependent variable | |
|---|---|---|---|---|---|---|
| *Independent variables* | *Coeff.* | *t-stat.* | *coeff.* | *t-stat.* | *Coeff.* | *t-stat.* |
| Constant | **7.449*** ** | 6.281 | **-11.5*** ** | -3.228 | **10.73*** ** | 8.180 |
| **Individual Characteristics** | | | | | | |
| Age | **- .001** | -.069 | **-.001** | -.137 | **-.001** | -.721 |
| Sex: male | **-.045** | -1.08 | **.267*** ** | 2.137 | **-.110*** ** | -2.388 |
| Literate | **.553*** ** | 12.723 | **- .867*** ** | -6.667 | **.826*** ** | 17.207 |
| **Climate Characteristics in place of living** | | | | | | |
| Total annual precipitation | **.003*** ** | 2.640 | **.011*** ** | 3.616 | **.001** | .615 |
| Inter-annual σ of precipitation | **-.026*** ** | -2.829 | **-.097*** ** | -3.470 | **-.006** | -.537 |
| Average monthly temperature | **.115*** ** | 2.451 | **.572*** ** | 4.070 | **-.042** | -.807 |
| **Selectivity Bias** | **.000008** | .214 | **.00008** | .690 | **.0000007** | -.002 |
| # of observations | 5280 | | 5280 | | 5272 | |
| F-test | 26.69 | | 9.75 | | 57.27 | |
| R- squared | .0342 | | .0128 | | .071 | |

* significant at 90% ** significant at 95% *** significant at 99%

- t-stat. values are slightly biased

**Table 8. Second stage estimates: Non-Migrants Income Equation**
**OLS estimation**

| | Log of non-migrants *aggregate income* as dependent variable | | Log of non-migrants *natural income* as dependent variable | | Log of non-migrants *other income* as dependent variable | |
|---|---|---|---|---|---|---|
| *Independent variables* | *Coeff.* | *t-stat.* | *coeff.* | *t-stat.* | *coeff.* | *t-stat.* |
| Constant | **11.2*** ** | 23.188 | **-13.3*** ** | -10.028 | **14.5*** ** | 27.058 |
| **Individual Characteristics** | | | | | | |
| Age | **-.008*** ** | -7.01 | **.031*** ** | 10.541 | **-.014*** ** | -11.691 |
| Sex: male | **-.054** ** | -1.867 | **.326*** ** | 4.147 | **-.136*** ** | -4.277 |
| Literate | **.654 *** ** | 21.604 | **-1.37*** ** | -16.381 | **.934*** ** | 27.645 |
| **Climate Characteristics in place of living** | | | | | | |
| Total annual precipitation | **-.00015** | -.353 | **.011*** ** | 9.709 | **-.002*** ** | -4.920 |
| Inter-annual σ of precipitation | **-.0041** | -.946 | **-.075*** ** | -6.255 | **.011*** ** | 2.259 |
| Average monthly temperature | **-.0367** ** | -1.896 | **.640*** ** | 11.994 | **-.185*** ** | -8.555 |
| **Selectivity Bias** | **1.02*** ** | 6.624 | **-6.78*** ** | -15.959 | **2.23*** ** | 27.058 |
| # of observations | 12975 | | 12975 | | 12957 | |
| F-test | 100.19 | | 112.10 | | 195.23 | |
| R-squared | .0513 | | .0571 | | .0955 | |

* significant at 90% ** significant at 95% *** significant at 99%

- t-stat. values are slightly biased

**Table 9. Probit Estimation of the Structural Form Decision Equation**
**Probit Analysis using Multi-Stage Stratified Sampling Procedures**

| ***Independent variables*** | ***Marginal Effects*** | ***Individual t-statistics*** |
|---|---|---|
| Constant | **-.383***** | -3.35 |
| **Estimated net returns to migration ♦** | | |
| Net gains in *aggregate income* | **.00003 *** | 1.485 |
| Net gains in *natural income* | **-.000005 *** | -1.487 |
| Net gains in *other income* | **.000014*** | 1.488 |
| **Individual Characteristics** | | |
| Age | **.0211***** | 5.154 |
| Age Squared | **-.0002 ***** | -5.047 |
| Sex: male | **.0165** | 0.424 |
| Literate | **.0476** | 1.187 |
| Son of the head of household | **-.363***** | -8.468 |
| Single | **-.458***** | -9.836 |
| **Regional Characteristics** | | |
| Concentration of Property Assets at destination | **- 3.29***** | -5.816 |
| Easy Access to water in region of origin | **-.0007***** | -3.225 |
| Easy Access to wood in region of origin | **-.001***** | -4.663 |
| # of observations | 18269 | |
| # of strata | 51 | |
| # of Primary Sampling Units | 300 | |
| F-test | 73.92 | |

* significant at 90% ** significant at 95% *** significant at 99%

♦ The table shows the estimated coefficients on the three different measures of expected net returns to migration, which are included as regressors in the estimation of the migration decision individually and separately

## 6. Policy Implications and Conclusions

Consistent with the traditional economic theory on migration, the results from the model estimation suggest that environmental factors influence the likelihood of migration through direct and indirect effects.

D*irectly*, because availability and easy access to natural resources in the regions of origin seem to deter emigration; i*ndirectly,* because climate factors significantly influence income variables, and estimated net gains on aggregate income trigger migration. Furthermore, high inequalities in the distribution of property assets, mainly on land and cattle, in potential regions of destination of migration provide a disincentive to migrate. High concentration of property assets is likely to reduce income opportunities for potential migrants, representing a barrier to the access to sources of income and new production activities.

Consistent with the new household economics theory, the dynamics of the individual's migration choice seems to be part of a household's risk diversification strategy; migrants seem as well to compensate for environmental uncertainty or lack of income opportunities in rural areas by engaging in activities generating income not related to agricultural production. Unfortunately, due to data constraints, the role of remittances sent by migrants to their households to compensate for market failures in their regions of origin cannot be tested.

Overall, environmental degradation in Pakistan seems to generate migration. Self-selection occurs among non-migrants, who fail to perceive better opportunities elsewhere. Migration occurs among the poorest, possibly induced by a sense of relative-deprivation.

Policies aimed to combat poverty, and achieve a more equal distribution of wealth, should be integrated and supported by appropriate environmental policies towards a more effective management of scarce natural resources. Many developing countries experienced the "tragedy of the commons", where the failure of rural communities to co-operate on a sustainable management of natural resources lead to overuse and uncontrolled exploitation of those precious resources. Well defined property rights and entitlements on natural resources, as well as their enforcement, are necessary for a better management of scarce resources. The concentration of property rights on land in Pakistan, which is typical of many rural economies, suggests the need for institutional reforms and a redistribution of land assets.

By alleviating poverty such policies may create conditions for less mobility within the country, as well as prevent potential migration across countries.

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**Summary**

This paper investigates the linkages between the environment, income and migration, exploring the role that environmental factors play in inducing migration *within* a rural developing economy. The environment has a deep economic value, representing a source of living for most developing countries: exogenous shocks on the environment, determined for instance by extreme climatic events, and the gradual degradation of natural resources, associated with population pressure and human activities might induce human displacement and migration. Because of the deterioration of the environment people could be forced to seek for new opportunities or might choose to look for better opportunities, migrating either temporarily or permanently. The paper introduces a theoretical framework of analysis drawing upon the traditional economics literature on migration. Based on the theoretical framework proposed, this paper describes the specification and the estimation of the econometric model, which falls into the class of switching regression models with endogenous switching. The econometric model allows for the estimation of a migration decision function in two stages, relating migration to income and the environment, and accounting for the self-selection of migrants. The model in fact consists of two income equations, which explain respectively income for migrants and for non-migrants, as well as one criterion function, which describes the dichotomous decision to migrate. The econometric model is applied to a data set on Pakistan, containing micro cross-country data on migrants within Pakistan, as well as detailed climate and environmental variables. Some descriptive statistics and policy analysis on migration and income variables is provided, and results from the econometric estimation of the empirical model are illustrated. Non-income variables seem to play the most relevant influence on the decision to migrate, and environmental factors seem to be the key factors in influencing mobility. The policy implications of the main findings of this research are illustrated.

**Key words:** Migration, Income, Environment, Inequalities, Self- Selection

**JEL:** C35, C51, C52, O13, O15, O53

## Non Technical Summary

This paper addresses the role of environmental factors as determinants of migration flows within a rural economy. The environment has a deep economic value, representing a source of living for most developing countries: exogenous shocks on the environment, determined for instance by extreme climatic events, such as flooding or drought, and the gradual degradation of natural resources, associated with population pressure and human activities, such as deforestation and desertification, might induce human displacement and migration. Because of the deterioration of the environment people could be forced to seek for new opportunities or might choose to look for better opportunities, either temporarily or permanently. The paper proposes a methodological framework to analyse the relationship between environmental factors and the individuals' choice to migrate, based on the traditional theory on the determinants of migration. The econometric model is illustrated, followed by the empirical analysis focused on migration flows within Pakistan. The empirical work exploits a micro data set which contains cross-section socio-economic and demographic information on individuals and their households across Pakistan, as well as data on forests and climate. The paper estimates the role of income, environmental factors and individuals' economic and demographic characteristics in determining their choice to migrate, and provide descriptive statistics on the relevant variables.