Geographical Poverty Traps in Ecuador using Pseudo Panel Data

Viviane Azevedo
Marcos Robles

Abstract

The role of geography in explaining poverty traps has been a hotly debated topic in academic and policy circles. In this paper we use a dynamic pseudo-panel data to analyze the role of geography in explaining the persistence of poverty in Ecuador. Specifically, we examine the relationship between household consumption growth and geographic variables as well as household characteristics to gauge the presence of geographic poverty traps. The latter would account for persistent differences in household consumption growth over time for households with similar socioeconomic characteristics. Based on four cross-sectional surveys for rural and urban areas in Ecuador spanning the period 1999-2006, we construct a pseudo-panel data set to track cohorts based on date of birth and years of education of the household head. In addition to the richness of our dataset, Ecuador's geographic diversity, including the unequal spatial distribution of geographic capital at the sub-national level, makes the analysis particularly suitable to testing for the existence of geographic poverty traps. The data used in the estimations also include geographic covariates such as climate conditions and altitude as well as geographic capital, such as the availability of local services and the provision of public infrastructure. We find a significant impact of geographic factors on household consumption growth, consistent with the existence of poverty traps in Ecuador.

JEL Classification: C33, H2, I32, I38, N36, O12
Key words: Spatial poverty, Geographic Poverty Traps, Pseudo-Panels, Ecuador.

V. Azevedo
University of Illinois at Urbana-Champaign and Research Department, Inter-American Development Bank, *1300 New York Avenue, N.W. Washington, DC 20577*
e-mail: viviane.azevedo3@gmail.com

M. Robles
Social Sector, Inter-American Development Bank, *1300 New York Avenue, N.W. Washington, DC 20577*
e-mail: marcos@iadb.org

1. Introduction

Poverty reduction has been a policy priority in most developing countries. The United Nation's Millennium Development Goals[1] (MDGs) have set the broad contours of the agenda for economic development in emerging and poor countries. The first goal is to reduce poverty by half by 2015. When analyzing data beyond national averages, there is widespread evidence showing persistence of poverty incidence in specific geographic areas. This holds even when the country in question has experienced a sustained periods of rapid economic growth. Several factors might account for the persistence of poverty, reinforcing the poverty "traps", including geographic conditions. To better understand the occurrence of geographic poverty traps, one needs to consider its occurrence along with households' decisions, such as the choice to live in a poor neighborhood. Assuming perfect household geographical mobility (e.g., no costs of moving between, within or across regions and no zoning laws that keep poor people out of richer neighborhoods), households living in poor areas would over time move to more productive areas where income per capita is higher.

The occurrence of geographic poverty traps implies the existence of economically significant relocation costs (as the relative costs of moving can be extremely high for poorer households) or informational asymmetries that prevent households from moving from poor areas to higher income areas. High housing costs and costs of searching for a well-paying job might have hindered relocation in many developing countries, but light of massive rural-urban migration that occurred in every major developed and developing country, such costs are unlikely to be the main cause of poverty traps. In addition, households that move to higher-income areas also face high relative prices for transportation, housing, and food. Cultural barriers such as language and regional traditions (which provide risk sharing and social protection networks within poorer communities) may also deter poor households from moving from poor areas.

Ravalion (1998) highlights two hypotheses that shed light on the reasons behind why some geographic areas remain poor even when after periods of rapid national growth. One view is that households are free (in an economic sense) to move between regions, but spatial concentrations of individuals occur because people with similar characteristics tend to concentrate. In this case, poverty traps occur because of the constant concentration of people with personal attributes that inhibit the growth in their living standards. According to this view, otherwise identical individuals will have the same growth prospects independently of where they live; thus there is no clear role to geography. Alternatively, spatial characteristics may have a causal role in determining how households' welfare changes over time depending on where they reside. Geographic poverty traps could occur because of pure geographic factors, including climate conditions and the spatial provision of public goods. According to the geographic poverty trap view, spatial mobility is relatively limited and households that live in well-endowed areas have a

[1] The Millennium Development Goals (MDGs) are eight goals to be achieved by 2015 that respond to the world's main development challenges. The MDGs are drawn from the actions and targets contained in the Millennium Declaration that was adopted by 189 nations-and signed by 147 heads of state and governments during the United Nations Millennium Summit in September 2000.

higher probability of escaping poverty when compared to similar households that live in poor areas. Poverty traps may be due in part to insufficient local supply of public goods and infrastructure as well as other geographic factors. In this case, two individuals with the same characteristics do not experience the same improvements on living standards if they live in areas with different endowments of geographic capital. This could occur in a simple growth model augmented with geographic capital (Jalan and Ravalion, 2002) which assumes that the marginal return to a given level of schooling or capital depends on geographic location.

This paper analyzes the role of geography in explaining the persistence of poverty in Ecuador. Specifically, this paper examines the relationship between household consumption growth and geographic variables by using a test for the presence of geographic poverty traps.[2] We use a rich data set that includes geographic factors such as climate conditions and geographic capital (such as local provision of infrastructure). Our findings indicate a significant impact of geographic factors on income, which in part explains the existence of geographic poverty traps in Ecuador, consistent with the evidence Jalan and Ravallion (2002) report on China. The findings are consistent with Ecuador's geographic diversity, including the unequal spatial distribution of geographic capital at the sub-national level.

The paper is organized as follows. The next section reviews the relationship and evidence between geographic variables and household measures of wellbeing in Latin America, with a focus on Ecuador.[3] Section 3 motivates and describes the empirical methodology. Section 4 summarizes the empirical results and Section 5 concludes.

2. Literature Review

This section starts by briefly discussing the macroeconomics literature on income convergence and poverty traps followed by a review of Latin America's country case studies that focus on the importance of geographic aspects on economic development.[4] Latin America has large concentrations of people in areas that are geographically challenging to inhabit. This owes to geography as much as to the lack of adequate provision of public infrastructure. In general, regions with low levels of geographic capital (e.g., inadequate provision of infrastructure) have had higher levels of poverty, worse health conditions, lower educational achievements, and limited access to basic services (Gallup et al, 2003). A specific example is the case of Peru. Escobal and Torero (2000) report that in Peru a heavy concentration of poor people lives in the most geographically-adverse zones such as the provinces in the highlands and the in the Amazon rainforest (*selva* region).

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[2] The term "Geographic variables" includes the geographic factors such as climate conditions and altitude and geographic capital which comprise infrastructure and the provision of public and private goods.
[3] We use the general term "well being" given that the papers mentioned in the next section covers a variety of topics, including health indicators and household consumption.
[4] Many of the papers discussed here are also summarized in Gallup, Gaviria, and Lora (2003); the authors did not include Ecuador in their analysis.

Standard growth models shed light on the reasons why income differences across countries arise. However, these models are usually tested using country-level data and significant differences between growth at the national level and at the household level tend to persist over time. At the country level, the neoclassical growth theory assumes diminishing returns to capital (and other factors of production) and conjectures that poor nations will tend to catch up over time with the incomes of richer nations— the convergence hypothesis.[5] Empirical evidence in favor of convergence is mixed and two alternative arguments have emerged to justify the divergence observed in the data. First, the "club convergence" approach indicates that distinct groups of countries will converge to different equilibria depending on their initial conditions (Baumol, 1986); under this model countries converge in clubs. Note however that even if there is convergence within clubs, this does not imply convergence across clubs. From this perspective, after controlling for a set of country-specific characteristics, high- and low-income equilibria are possible. The multiple equilibria growth models argue that there is the possibility of poverty traps related to thresholds where returns are locally increasing (Azariades and Drazen, 1990).

The focus on externalities, such as geographic variables, leads to the possibility of divergent growth paths. At the individual level, there are individual characteristics and other reasons that generate multiple equilibria and inhibit initially poor households to draw near their wealthier neighbors. This might be linked to individual characteristics and intra-household decisions that affect the level of well-being. As noted by Carter and Barrett (2006), the empirical literature on poverty traps using micro data is relatively small and generally uses parametric methods to explore the dynamics of household income or consumption. Geography can also have a causal role in poverty dynamics. If geographic externalities change returns to private investment, affect borrowing constraints and hinder capital mobility, then poor areas can be "trapped" in a vicious poverty cycle. This can be true even assuming diminishing returns to investment, as poor areas experience low growth rates (Jalan and Ravallion, 2002).

The geography of poverty takes into account distinct dimensions of geographic aspects such as land productivity, climate, population settlement, infrastructure, and investment in specific areas. The famous example of the relationship between geography and economic development (Gallup, Sachs and Mellinger, 1999) analyzes the association between GDP per capita and latitude. The results indicate that countries that are close to the tropics are poorer when compared to the ones that have higher latitudes. Gallup et al. (1999) also found that countries that are in the coastal areas are richer than those that do not have access to the sea (see Map [1] in the appendix). A common criticism of this work claims that the relationship between geography and poverty is not causal and might reflect different colonization patterns and cultural differences. The more recent evidence of the micro data studies at the country level are less subject to such observations because the colonization patterns, cultural differences, and formal institutions are more homogeneous within a country than across countries and regions of the world.

[5] The empirical evidence does not fully support the convergence argument. We will not get into this discussion for a contrary view of the convergence theory see Lant Pritchett (1997).

Does geographic capital matter for economic growth?

The microeconomic studies of geography and economic development allow for a more detailed examination of the relationship between geography and development. These studies use disaggregated data either by the political subdivisions of states and provinces or by geographic regions. Ravallion (2005) uses micro data for rural China and finds evidence of spillovers and other externalities that could form geographical poverty traps. Jalan and Ravallion (2002) consider a panel of households in rural China and investigate the existence of spatial or geographic poverty traps. The main focus of their paper is to determine the impact of geographic variables on household consumption growth. The authors find that consumption growth increases with the local availability of geographic capital such as the availability of roads and the local level of literacy. Jalan and Ravallion (2002) also show empirically that geographic factors affect the returns to capital faced by households. Their results suggest that the factors captured in the geographic variables can be a constraint to household consumption growth.

A different type of micro econometric evidence can be found in Lokshin and Ravallion (2004). They estimate a non-linear dynamic model of household income in two transition economies (Hungary and Russia). The authors calibrate their dynamic model of incomes allowing current income to be a nonlinear function of past income considering attrition from the survey. The main findings are that adjustment to income shocks is nonlinear, and that there is no evidence of non-convexities that would cause temporary adverse shocks to permanently lower household income, (households eventually recover from income shocks) as would be the case in a variety of models of poverty traps. Ravallion and Wodon (1997) use household survey data for Bangladesh and find significant evidence that geography affects living standards. The authors point out that there are sizeable geographic differences in the returns of given households characteristics even after controlling for non-geographic characteristics of the household. They point out that the results are robust and consistent with the country's migration pattern.

Esquivel (2000) analyses the effects of geographic factors on the economic development of Mexico. He notes that geographic variables can explain two thirds of the inter-state variation in income per capita in Mexico. He also finds that the drier Northern states are much richer than the southern tropical ones and that economic activity is light along the coast and intense in the center of the country. Additionally, there is a strong association between vegetation and economic growth; states in which the vegetation is composed of agricultural areas and woodland tend to grow at lower rates than the other states. Esquivel (2000) analyses the geographic distribution of two indicators: life expectancy and schooling. His results indicate that geographical factors are amongst the main contributors to regional inequalities in Mexico and affect the distribution of life expectancy and schooling. Blum and Cayeros (2002), focus on how Mexico's geographical impact on growth is reinforced by political decisions and their relationship with income, growth and poverty. They argue that the main channel through which geography affects development is though the provision of public goods. For example, they describe the positive effects of public goods provision on higher rates of urbanization and literacy rates. Blum and Cayeros (2002) also point out that the fragmentation of political jurisdiction in the form of municipal governments' proxies for political barriers to mobility and that the lack of household geographical mobility also helps explain the interaction between geography and development.

The empirical evidence for Bolivia also corroborates the strong influence of geography on development. Urquiola et al. (1999) carry out the analysis considering three geographic regions: the Andean, Sub-Andean or Valley, and Lowland regions. The authors do not use the political divisions of states and municipalities as in most Latin American studies. A consistent result of their estimations indicates that tropical areas have higher income levels, in contrast with other international cross-country evidence, and reinforces the importance of considering individual country analysis. The relationship between geography and well-being (measured by GDP per capita and social development indices) indicates that the living conditions are better in low altitude cities.

Bitran et al. (2000) studies the relationship between health indicators and geographic factors such as rain and temperature in Peru. The evidence at the province level indicates that geographic factors significantly explain infant mortality and child malnutrition rates. Bitran et al. (2000) also analyzes the effect of natural geography on the effectiveness of government health investments. The authors simulate how public resources devoted to new facilities and doctors could be allocated among the provinces to reduce regional inequality in health status. Finally, Bitran et al. (2000) find that natural geographic factors exacerbate inequality in health, as do existing regional differences in the availability of public services.

Escobal and Torero (2000) also focus on Peru and find that significant differences in household consumption can be explained by spatially uneven provision of public infrastructure. According to the authors, geographic factors are important and indicate that the availability of infrastructure could be limited by the geographic factors and therefore the more adverse geographic regions are the ones with less access to public infrastructure. They point out that policy programs that use regional targeting (i.e. that prioritize intervention in one geographical area over another) are worth even if geographical factors do not significantly explain the bulk of the difference in regional growth these are justified mainly by inequalities in geographical areas. Escobal and Torero (2000) show evidence of large welfare disparities across Peru and reports that a heavy concentration of poor people lives in the most geographically-adverse areas such as the provinces in the highlands and the forest (*selva* region).

In the case of Colombia, Sanchez and Nuñez (2000) show that geographic variables explain between one-third and one-half of household per capita income and its growth rate. The authors also find that there is substantial heterogeneity in the effect of geography on variations in household income. They note that in poor municipalities the effects of geography explain substantially more of the variation, accounting for 25-32 percent of the variation in income per capita and between 24-27 percent of the variation in income per capita growth; however, in rich municipalities geography plays a less significant role, explaining 18-25 percent of the variation in income per capita and 16-17 percent variation in income per capita growth. Amongst the geographic variables the distance to an urban center and the quality of the soil are the variables that contribute the most to changes in income per capita. Furthermore, Sanchez and Nuñez (2000) indicate that altitude, soil quality, and precipitation are the main geographical variables that contribute to population density in Colombia.

Rosenberg et al. (2000) look at the relationship between health and climate change in Brazil. The study uses a cross-section of Brazilian municipalities to estimate the impact of increases in temperature and rainfall and the indirect effects of other geographical factors such as altitude and distance from the ocean on respiratory, water-borne, and vector-transmitted diseases (such as Malaria). The diseases considered account for a sizable proportion of all hospitalizations and deaths in Brazil and are known to be sensitive to climate conditions. Azzoni et al. (1999) explores the role of geographic variables in explaining differences in per capita income between Brazilian states using micro data. They take into account geographical variables such as climate and data on infrastructure, health, and education by birth cohort level. The authors conclude that geographical variables are an important determinant of income growth and explain a great deal of the state fixed effects that reflects structural differences between the states of Brazil.

Ecuador: a geographically fragmented country

After the 2001 crisis when per capita income fell by almost eight percent as a result of unfavorable external conditions and environmental shocks, Ecuador experienced a period of economic recovery. As in previous growth spurts, the growth experienced in the last few years has not benefited all the population equally. Micro-level estimations of poverty and inequality based on the seminal work of Elbers, Lanjouw and Lanjouw (2002),[6] carried out by international development agencies as well as by the Ecuadorian national statistic offices indicate poverty fell only in a few areas. Poverty rates declined in Ecuador’s main cities of Quito and Guayaquil while other regions remained unaffected with poverty rates that were equal or higher than those observed in 1999 (Robles and Luengas, 2007). The evidence available from household surveys, disaggregated by geographic areas, indicates that rural areas were the least affected by economic growth.

This pattern of economic development is not unique of Ecuador as most countries have geographic concentrations of poverty. This paper explores the relationship between geographic characteristics or conditions such as altitude and precipitation as well as “geographic capital” such as infrastructure and the number of health clinics per number of habitants to analyze how natural and “human-planned” externalities—which result many times of government decisions to invest in specific areas—affect the well-being of households.

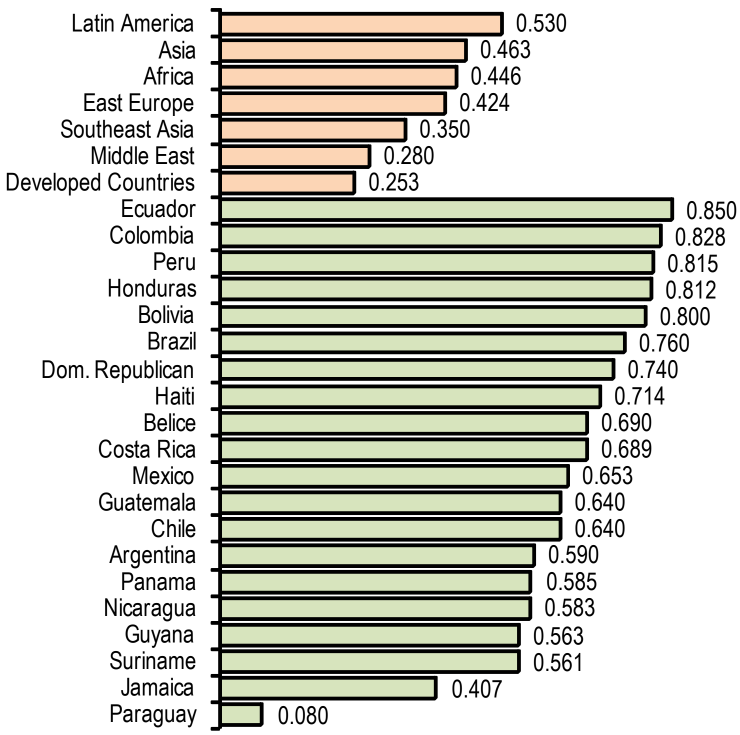
Ecuador has a diverse natural topography, which in turn is associated with a diverse set of other geographic factors. The country has three main geographic regions, plus an insular region bordering the Pacific Ocean. The coast comprises the low-lying land in the western part of the country, including the Pacific coastline; the highlands (*la Sierra*) is the high-altitude belt running north to south along the center of the country, its mountainous terrain dominated by the Andes mountain range; and the east (*El Oriente*) comprises the Amazon rainforest areas in the eastern part of the country, accounting for just under half of the country's total surface area, though

[6] Elbers, Chris, Jean O. Lanjouw and Peter Lanjouw (2002). "Micro-Level Estimation of Poverty and Inequality." *Econometrica* 71:1, pages 355-364

populated by under five percent of the population. The insular region in the Pacific Ocean comprises the Galapagos Islands, some 1,000 kilometers (620 mi) west of the mainland.

Ecuador ranks first amongst the Latin American countries in the index of Geographical Fragmentation reinforcing the need to consider its geographic diversity. The index of Geographical Fragmentation is defined as the probability that two individuals taken at random from the population live in similar eco-zones (Gallup, Gaviria and Lora, 2003). The index goes from zero, where all the population is settled to the same eco-zone to the hypothetical case where each individual comes from different eco-zones (index equals 1).

Graph 1: Index of Geographical Fragmentation*



Source: Graph 1.2 from Gallup et al (2003)
* This index is defined as the probability that two individuals taken at random from the population live in similar eco-zones. It goes from zero, where all the population is settled in the same eco-zone to one where each individual comes from a different eco-zone

While Ecuador is not a particularly large country, it has a great climate variety, mainly determined by its topography. The Pacific coastal area has a tropical climate, with a high precipitation season. The climate in the Andean highlands is temperate and relatively dry. The Amazon basin on the eastern side of the mountains shares the climate of other rain forest zones. Ecuador’s main cities are located in geographically different regions; the capital Quito is in the Highlands while the country’s largest city, Guayaquil, is on the Coast.

3. Methodology

Theoretical Model

The empirical model presented in this chapter is motivated by a standard growth model augmented by geographic characteristics. The main objective is to account for the geographic factors that affect the income dynamics of households. In the model, the potential income (Y) of the household h is generated by a production function that has as arguments the level of physical and human capital[7] (K) and a set of geographic factors (G) that can affect the marginal productivity of capital. The production function can be written as:

$$Y_{ht} = F(K_{ht}, G_{ht}) \tag{3.1}$$

The production function assumes constant returns to scale in both arguments and according to Euler's theorem can be written as:

$$F(K_{ht}, G_{ht}) = F_k(K_{ht}, G_{ht})K + F_G(K_{ht}, G_{ht})G \tag{3.2}$$

Furthermore, we assume that the production function assumes positive but diminishing marginal products: $F_i(K_{ht}, G_{ht}) > 0$ and $F_{ii}(K_{ht}, G_{ht}) < 0$ for $i =$K, G. The household maximizes its inter-temporal utility function subject to the budget constraint. In what follows, a lower case letter indicates individual variables (such as individual income), and upper case letters indicate aggregate quantities. For instance, y_{ht} is the potential income of the household given that it is using all its human and physical capital to produce income given the geographic characteristics in the model.

The household maximizes its inter-temporal utility

$$\underset{\{c_{h,t}\}_{t=0,\dots,+\infty}}{Max} \sum_{t=0}^{\infty} \beta^t U(c_{ht}) \quad \text{subject to } y_{ht} = F(K_{ht}, G_{ht}) \text{ for all } \quad t \geq 0 \tag{3.3}$$

where $\beta \in (0,1)$. The utility function is given by $u_{h,t}(c_{h,t}) = \ln(c_{h,t})$. This functional form belongs to the class of constant relative risk aversion (CRRA) utility function with the coefficient of relative risk aversion equal to one[8]. Furthermore, assume that there are constraints on access to credit, a reasonable assumption especially for rural areas in Ecuador, implying that capital is

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[7] K is the level of "augmented capital" as it includes physical as well as human capital, a departure from Jalan and Ravallion (2002). For the case of wage-earners households their augmented capital is reduced to its human component.

[8] The CRRA utility function is given by $u_{h,t}(c_{h,t}) = \frac{(c_{h,t})^{1-\sigma}}{1-\sigma}$. Assuming logarithmic utility, by L'Hôpital's rule, in the limit the above utility function converges to $u_c = \log c$ as $\sigma = 1$.

not perfectly mobile across households[9]. The household finances its consumption and investment in physical and human capital entirely from the production function as described below:

$$K_{h,t+1} = (1-\delta)K_{h,t} + F(K_{h,t}, G_{h,t}) - C_{h,t} \qquad \text{for all } t \geq 0 \qquad (3.4)$$

where δ is the depreciation rate of augmented capital $(0 < \delta < 1)$. Solving the household maximization problem yields the standard Euler equation:

$$u_{C_t} = \beta u_{C_{t+1}} \left[(1-\delta) + F_K(K_{t+1}, G_{t+1}) \right]$$

where F_K is the marginal productivity of capital. Increases in the marginal productivity of capital induce increases in consumption if the marginal utility of consumption is decreasing. In this otherwise standard model, geographic characteristics can influence consumption through their direct effect on the marginal productivity of the household's capital. After substituting the marginal utilities in the first order conditions, linearizing, and writing the marginal productivity of augmented capital in reduced form one obtains the following equation:

$$\Delta \ln c_{h,t} = \ln c_{h,t} - \ln c_{h,t-1} = \alpha + \beta x'_{h,t} + \gamma z'_h \qquad (3.5)$$

where x_{ht} and z_h are vectors of variables containing information on the specific household community (both time-dependent and independent) that affect the marginal productivity of capital.

We rule out perfect capital mobility and assume that in equilibrium the net marginal product of household capital is equalized across households (at a common interest rate). Under the standard assumptions of this class of growth models, this implies that differences in endowments of geographical capital do not lead to differences in consumption growth rates. This is true even if geographic differences alter the returns of household's capital; the levels of household capital adjust to restore equilibrium $F_K(K_{h,t},G_{h,t}) = F_G(K_{h,t},G_{h,t})$[10]. This assumption is necessary because we do not observe the productivity of capital. The challenge now is how to empirically estimate this model with the data available for Ecuador. Somewhat similar models have been estimated for China (Jalan and Ravallion, 2002) and for Peru (de Vreyer et al, 2002) but in both cases panel data were available.

Econometric Considerations

For many developing countries there is a dearth of panel data where specific individuals are followed over time, and Ecuador is not an exception. Cross-sectional surveys are carried out,

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[9] As in other developing countries, borrowing constraints are pervasive and financial markets are poorly developed.
[10] Within a region the level of capital adjusts (i.e. investment occurs) such that $F_K = F_G$. Nonetheless, $F_{Ki} \neq F_{Kj}$ for any pair i,j.

which leads to multidimensional data in which the samples are different every time period making it nearly impossible to track individuals or households over time.
This paper proposes the construction of a dynamic pseudo-panel data. A pseudo-panel[11] tracks cohorts of individuals over repeated cross section surveys (Deaton, 1985). As detailed in McKenzie (2004) dynamic panels are recommended if the sample size is "sufficiently large" so that the asymptotic properties of the panel hold. In order to check if asymptotic theory provides a realistic approximation of the finite sample properties of pseudo panel data estimators is an empirical question, beyond the scope of this paper[12] .

Given that a new sample of individuals is taken in each period, the use of a pseudo-panel reduces the common problems of attrition and non-response faced in typical panel data. Furthermore, pseudo-panels are very often substantially larger, both in number of individuals or households and in the time period that they span. The presentation below closely follows MacKenzie (2004) and Verbeek (2007).

The empirical model estimated is given by:

$$\Delta y_{i(t),t} = (\beta - 1) y_{i(t),t-1} + X'_{i(t),t}\gamma + \alpha_{i(t)} + \mu_{i(t),t} \qquad (3.6)$$

$$\alpha_{i(t)} = \alpha_c + \omega_{i(t)}$$

where c = 1,…, C ; i(t) = 1,…, N; t = 1,…,T, y is household consumption expenditure, X is a vector of exogenous variables including the geographical variables and $\alpha_{i(t)}$ are the non-observed individual specific fixed-effects. We assume fixed effects in the cohorts and that the parameters are homogeneous within cohorts. Note that the functional dependence of the index i = i(t) is used to highlight the fact that different individuals are observed across time. Finally, β, γ, y, and α_c are the parameters to be estimated.

In the case of a genuine panel data, Equation (3.6) could be consistently estimated (for fixed T and N →∞) by the Anderson and Hsiao (1981) instrumental variables estimators; or more efficiently by the Generalized Method of Moments (GMM) estimator of Arelano and Bond (1991). These estimators are based on the first difference of equation 3.6 and then using lagged values of the dependent variable as instruments. In pseudo-panel data the variable $y_{i(t),t-1}$ is not observed (as the individuals at t-1 are not the same as the ones at t) limiting the use of these methods. Estimation restrictions are carried out even when we consider cohort averages as in the following equation:

$$\Delta \bar{y}_{c(t),t} = (\beta - 1)\, \bar{y}_{c(t),t-1} + \bar{X}'_{c(t),t}\gamma + \alpha_c + \bar{\omega}_{c(t)} + \bar{\mu}_{c(t),t} \qquad (3.7)$$

[11] Also called "time-series of repeated cross sections" and "synthetic panels"
[12] McKenzie (2004) and Verbeek and Vella (2005) apply Monte Carlo simulations to shed light on this issue.

where c(t) stands for the mean values of all individuals in cohort c observed at time t; for example $\bar{y}_{c(t),t} = (1/n_c)\sum_{i=1}^{n_c} y_{i(t),t}$. Even though $\bar{y}_{c(t),t-1}$ is not observed, the lagged dependent variable $\bar{y}_{c(t-1),t-1}$ is an unbiased estimate when the cohort sizes are sufficiently large (Verbeek, 2007).

An empirical model that considers c = 1,…, C and t = 1,…,T is:

$$\Delta \bar{y}_{c(t),t} = \alpha_c + (\beta-1)\bar{y}_{c(t-1),t-1} + \bar{X}'_{c(t),t}\gamma + \varepsilon_{c(t),t} \tag{3.8}$$

$$\varepsilon_{c(t),t} = (\beta-1)(\bar{y}_{c(t),t-1} - \bar{y}_{c(t-1),t-1}) + \bar{\omega}_{c(t)} + \bar{\mu}_{c(t),t}$$

It can be shown that in (3.8) the regression error $\varepsilon_{c(t),t}$ is correlated with the lagged dependent variable $\bar{y}_{c(t-1),t-1}$ biasing the results of the OLS estimation of β and γ. Note, however, that this is a direct consequence of measurement error from considering different individuals at time t and t – 1, but not the typical genuine panel data reason that there is a correlation of the lagged dependent variable and the individual effect. Asymptotic theory indicates that the bias is significantly reduced when the cohort sample sizes tend to infinity since both $\bar{y}_{c(t),t-1}$ and $\bar{y}_{c(t-1),t-1}$ are unbiased estimates of the cohort mean[13]. The error term, $\varepsilon_{c(t),t}$ is then randomly distributed and OLS can be used to estimate (3.8).

The asymptotic behavior of pseudo-panel data estimators are derived using alternative asymptotic theory since there are two additional dimensions – the number of cohorts (C) and the number of observations per cohort (n_c) - to the standard panel data dimensions N and T. As shown in MacKenzie (2004), Verbeek and Vella (2005), and Verbeek (2007) one can consider the asymptotic properties of the pseudo-panel and estimate equation (3.8) consistently by OLS which corresponds to the standard within estimator. Verbeek and Vella (2005) refer to a specification like 3.8 as the augmented IV estimator and highlights that it is equivalent to use instrumental variables (IV) with the cohort dummies as instruments in a pseudo-panel or OLS to the model where all variables are replaced by their cohort sample averages; concluding that equation (3.8) can then be consistently estimated by OLS. The asymptotic properties have been used in several important empirical papers. The sample sizes differ considerably, for example Browing, Deaton and Irish (1995) use T=7, C=16 and on average 190 observations per cohort while Propper, Rees and Green (2001) use T=19, C=70 and an average of 80 observations per cohort. Another example is Blundell, Duncan and Meghir (1998) that have T=25, C=8 and an average of 142 observations per cohort.

[13] As in Antman and McKenzie (2007) our identifying assumption is that a law of large numbers applies within a cohort, so that as the number of individuals within a cohort $n_c \to \infty$, $(\frac{1}{n_c})\sum_{i=1}^{n_c} \varepsilon_{i,t} \xrightarrow{p} 0$

4. Data and Results

Data Used

We use the National Ecuadorian Household Survey (ECV, *Encuesta de Condiciones de Vida* - Survey of Living Conditions) [14], which are carried out by the National Institute of Statistic and Census (*Instituto Nacional de Estadística y Censos*, INEC) using similar questionnaires for the last four waves of the survey[15]. The survey consists of information on different aspects of household welfare, including household income and consumption, household production, health, education, employment, access to public goods and services.[16] The variable that measures consumption is calculated and cross-checked by four different Ecuadorian institutions in the context of a national effort to estimate consumption-based poverty and inequality indicators.[17] The consumption variable takes into account home production, imputed rents, as well as the consumption of durable goods and is expressed in 2006 American dollars.[18]

The information on the geographic characteristics including climate, altitude, precipitation and the availability of infrastructure comes from the official information of the SIISE 4.5 and is maintained by a government agency[19]. In the analysis, we will follow the political division of the country. Ecuador is divided into 22 provinces, which are divided into 205 cantons, which are subdivided into parishes.[20] Finally, the database contains information about the geographical variables according to the canton and parishes of residency. The appendix contains information on the sources and the variables used. As a group, these variables describe the natural characteristics as well as the geographical capital since they include measures of public and private infrastructure, soil, and altitude. It also contains information on ethnicity and socio-economic status of the individuals.

Pseudo Panels

Since the geographic factors are different for urban and rural areas, we construct two pseudo-panels to take into account such differences. The cohorts are constructed using the last four waves of the ECV survey following Deaton and Paxson (1994) and Deaton (1997). The construction of the cohorts follows the recommendations of Verbeek (2007) regarding the size of the cohorts and the variables chosen to construct the cohorts. The cohorts were constructed based on date of birth and years of education of the household head; both variables are time independent (if household heads have completed all their schooling) and allow each individual to

[14] The household survey data is publicly available. However, details pertaining to the measurement issues considered in the official calculations of poverty and inequality indicators as well as the precise geographic locations have not been released to the public domain.
[15] In Ecuador the ECV was carried out in 1995, 1998, 1999, and 2006.
[16] Detailed information can be found at www.inec.gov.ec/ECV/bases/ecv.html.
[17] INEC, SENPLADES, CISMIL y la Secretaría Técnica del MCDS
[18] The household survey ECV is available for 1995, 1998, 1999, and 2006.
[19] Produced and maintained by Secretaría Técnica del MCDS (2007).
[20] http://www.ecuador.org/esp/clima.htm

be classified in only one cohort. According to Verbeek (2007), choosing these variables are important to maintain the asymptotic properties of the pseudo-panel. Considering each birth year of the household head to create the cohorts would have led to small sample sizes, especially in rural areas. This is due to the sample design of the household survey and reflects the fact that national household surveys consider a smaller sample of rural areas[21].

The cohorts were constructed considering date of birth of the household head grouped into 5 year intervals from 1930 to 1974 (1930-1934, ..., 1970-1974), including only those between 21-65 years old in 1995 and between 32-76 years old in 2006. Years of education were grouped differently for urban and rural areas. For rural areas we select the following 4 groups: 0-2 years, 3-5 years, 6 years, and 7 years or more. For the urban area the groups are 0-5 years, 6 years, 7-11 years, and 12 or more years. The cohorts have on average 370 and 430 individuals for the urban and rural areas, respectively.[22]

After defining cohorts, a set other variables are combined into the data set including consumption, variables related to socioeconomic characteristics of households, and geographic variables according to the cantons and parishes of household residency. Using this information, the panels are generated by averaging all variables at the cohort level. It is worth noting that because the geographical capital can affect household welfare through land productivity, health conditions, frequency and intensity of natural disasters, and access to markets (Gallup et al., 2003), the variables selected not only describe the geographical (natural) patterns but also account for differences in infrastructure, availability of public goods and services, and agricultural conditions.

Table 1 summarizes the descriptive statistics for urban and rural areas. The average and standard deviation are calculated using the urban and rural pseudo-panels separately[23]. The differences in geographic capital in urban versus rural areas are noticeable. The generally higher levels of consumption in urban areas (double than in rural areas) are evident and the relationship between consumption growth and geography will be considered in the empirical analysis. In urban areas there is more evidence of agglomeration economies (approximated with population density), access to credit and electricity, and number of doctors per person. The geographic capital in rural areas is noticeable higher in variables related to agriculture such as abundance of farmed lands and transitory crops, as well as to the availability of fertilizers and pesticides. A notable fact is that geographical capital in these areas is generally more dispersed than in urban areas, which is likely to affect consumption at the household level. Finally, it is worth noting the difference in human capital of urban and rural households. Urban households are on average more educated and have better jobs. Variables such as years of education of the household head, employment

[21] Rural areas require smaller samples because they represent a smaller share of the total population, and the variance among the socioeconomic variables is also smaller. Household characteristics in rural areas are more homogeneous than in urban areas.

[22] A reduced number of the 288 cohorts have less than 100 individuals which were maintained to take advantage of having a balanced panel.

[23] Finally, in order to calculate averages and generate descriptive statistics prior to estimation, we considered cohorts' averages as indicated in equation (4.3) taking into account the weights so that the panel would be representative at the national level.

status of family members, presence of young children and elderly people [24] are examples of the human capital disparities between urban and rural areas.

Table 1 : Descriptive Statistics

Variables	Urban		Rural	
	Average	St. dev	Average	St. dev
Consumption- per capita (2006$ x month)	122.66	61.11	57.15	24.36
Geographical (canton or parish level)				
Residence in Mountain Provinces	0.548	0.116	0.464	0.095
Distance (minutes)	97.381	8.749	93.009	10.315
Population density (persons x km2)	1436.5	271.0	231.6	155.6
Range of altitude (meters over sea level)	1041.5	138.6	1071.9	190.4
Index of natural disasters (0-12)	7.935	0.258	6.773	0.444
Average temperature (°C)	20.061	1.087	18.464	1.440
Roads 1st order (km per capita)	0.297	0.059	0.582	0.092
Roads 2nd order (km per capita)	0.153	0.054	0.647	0.273
Number of doctors x 10 thousand habitants	19.62	1.84	11.59	1.34
Surface with transitory crops (%)	10.82	1.91	15.87	2.92
UPAs access to credit (%)	9.552	1.277	8.008	1.414
Farmed land per capita (acres)	1.555	12.203	2.412	5.886
Fertilizers and pesticides expenditure per acre	25.52	108.16	88.71	84.47
Per capita surface of UPAs (acres)	0.478	0.110	2.099	0.601
UPAs access to electricity (%)	67.89	2.64	64.73	3.68
Afro descendent population (%)	0.058	0.010	0.048	0.027
Controls (household level)				
Years of education of household head	8.906	4.639	4.694	3.315
Proportion of adults without education	0.024	0.034	0.075	0.084
Children aged 6-11	0.688	0.280	0.986	0.402
Children aged 12-14	0.362	0.182	0.507	0.247
Members aged 15 to 59	2.967	0.701	3.023	0.770
Adults older than 60	0.245	0.449	0.323	0.530
Proportion of children in primary or secondary	0.352	0.121	0.342	0.109
Proportion of self-employed	0.099	0.050	0.112	0.057
Proportion of employed	0.217	0.051	0.079	0.043

Source: INEC “Agro National Census 2000”, “Population and House Census 2000” and “ECV” four waves between 1995 and 2006; Secretaría Técnica del MCDS “SIISE 4.5”; and Official data from the Ministries and other public institutions.

Jalan and Ravallion (2002) propose an empirical test that can shed light on the presence of geographical poverty traps by analyzing the external effects of geographical factors on the growth rate of consumption. Their test consists of regressing the growth rate of consumption at the household level on geographic variables, allowing for heterogeneity at the micro growth process. Following this alternative, we estimate the consumption model specified in the equation 3.8, taking into account the heterogeneity in the growth process at cohort level (fixed effects at this level). As previously discussed, without the fixed-effects, significant coefficients on

[24] The availability of roads and health clinics may seem to be higher in rural areas at first glance. Note that in per capita terms this is not true (the population density of urban areas is about 6 times the one in rural areas).

geographic variables are likely to include the effects of unobserved spatially autocorrelated household characteristics. We follow the pseudo linear dynamic model literature and use OLS estimation to check for the presence of geographic poverty traps (McKenzie, 2004; Verbeek and Vella, 2005;Antman and McKenzie, 2007; Verbeek, 2007). Furthermore, an alternative GMM estimation at the cohort average level as in the equation 3.7 is carried out. In both cases, the consumption model is estimated considering household socioeconomic characteristics— control variables. With these controls, the significance of geographical variables will indicate the existence of geographic poverty traps. That is, households with the same socioeconomic characteristics may have different consumption growth rates because they live in places with different geographic capital. The OLS results are summarized in table 2 for rural and urban areas; table 3 contains the GMM alternative specification.

The presence of significant geographic variables indicate that the geographic capital matter for consumption growth at the individual (or household) level. Households with the same profile have a different expected consumption growth due to the geographical capital of the place where they live. All the signs of the regression coefficient for these variables are as expected, although some of them differ for rural and urban areas, reflecting the complexity of the interactions between geography and consumption growth. For example, while residence in mountain provinces, dispersion of altitude and size of farmed land per capita negatively affect consumption in urban areas, these variables positively affect consumption in rural areas. In particular, for urban areas the residence in mountain provinces means to be away from an exit to sea and export ports, and for rural areas it means proximity to economically important cities as Quito and Cuenca.

Table 2: Consumption Model with cohort fixed effects (*) - Pseudo panel 1985-2006 (**)
(Dependent Variable: Differential of logarithm of household consumption per capita)

Variables	OLS estimation					
	Urban Areas			Rural Areas		
	Coef.	SE		Coef.	SE	
Lagged differential of consumption	-0.844	0.121	***	-0.916	0.083	***
Geographical (canton or parish level)						
Residence in Mountain Provinces (dummy)	-0.332	0.149	**	0.644	0.160	***
Distance (minutes)	0.012	0.004	***	0.005	0.002	**
Population density (persons x km2)	0.000	0.000		0.000	0.000	
Range of altitude (meters over sea level)	-0.001	0.000	***	0.000	0.000	
Index of natural disasters (0-12)	0.075	0.092				
Average temperature (°C)				-0.016	0.023	
Roads 1st order (km per capita)	1.441	1.073				
Roads 2nd order (km per capita)	0.041	0.674		-0.175	0.112	
Number of doctors x 10 thousand habitants				0.079	0.019	***
Surface with transitory crops (%)				0.043	0.021	**
UPAs access to credit (%)	-0.028	0.020		-0.018	0.026	
Farmed land per capita (acres)	-0.074	0.022	***	0.009	0.002	***
Fertilizers and pesticides Expenditure per acre	0.001	0.000	***	0.000	0.000	**
Per capita surface of UPAs (acres)	0.305	0.275				
UPAs access to electricity (%)	0.057	0.008	***	-0.015	0.005	***
Afro descendent population (%)				-2.315	0.769	***
Controls (household level)						
Years of education of household head				0.064	0.044	
Proportion of adults without education	-6.446	1.485	***			

Household size (logarithm)	-1.382	0.518**	-0.363	0.476
Children aged 6-11	0.307	0.272	0.037	0.138
Children aged 12-14	0.622	0.292**	-0.520	0.217 **
Children aged 15-17	0.403	0.396	0.192	0.141
Members aged 18 to 59	0.209	0.137	-0.040	0.149
Adults older than 60	0.115	0.165	-0.168	0.214
Proportion of children in primary or secondary	-0.691	1.034	1.374	0.582 **
Proportion of self-employed	2.885	0.472***	3.488	0.514 ***
Proportion of employed			1.161	0.763
Constant	-3.777	1.121	-0.907	0.814
Adjusted R-squared	0.905		0.964	
corr(α_c, Xb)	-0.578		-0.687	
Rho (fraction of variance due to α_c)	0.841		0.968	
Hausman test (Ho: fixed effect are random)				
Chi2	59.32		68.47	
Prob>Chi2	0.000		0.000	

Notes: (*) With robust estimator of variance of parameters. (**) Not all information available about the geographic capital was incorporated in each urban-rural regression. Some of them had to be removed because they generated high correlations with others.
*, **, *** indicate that the variables are significant at 10%, 5% and 1%, respectively.

Two significant geographical variables, one related to local infrastructure and another to social exclusion conditions, explain part of the differences in consumption growth in rural areas: access to medical doctors (positively) and presence of afro descendent population (negatively). In urban areas, the presence of infrastructure in the form of paved roads has a positive impact on individual consumption growth. The same is true for variables that are directed related to agricultural activity: the access to electricity and to fertilizers and pesticides (using as proxy the expenditure on fertilizers and pesticides) by the production unit, indicating that consumption growth is higher in places that have access to these services.

Results on Table 2 corroborate the importance of estimating the consumption growth model accounting for fixed effects. First, high values of the correlation between the fixed effects and other independent variables (the term corr(α_c,Xb) in Table 2) indicate that fixed effects should be used. Second, the value of *rho* is another statistic that indicates how much of all residual variance is due to the fixed effects. These values for both areas suggest that almost all the variation is related to cohort differences indicating that an important part of consumption heterogeneity due to unobservable factors corresponds to the variation at the cohort level. Despite these evidences, we use the Hausman test for fixed effects. Hausman test's null hypothesis –that the random effects estimator is consistent– is rejected for urban and rural areas. Therefore, because the regressors are correlated with α_c, the fixed effect estimator is consistent.

Although the pseudo panel can be consistently estimated by OLS, table 3 displays an alternative GMM estimation. GMM uses as instruments first-differenced (equation 3.7) lagged levels of endogenous variable, lagged variations of this variable and also lagged variations of predetermined variables (Blundell and Bond, 1998; Arellano and Bover, 1995). [25] This estimation method assumes that there is no autocorrelation in the idiosyncratic errors and

[25] In the statistical package Stata, xtdpdsys implements this estimator.

requires the initial condition that panel-level effects be uncorrelated with the first difference of the first observation of the dependent variable. Table 3 shows that results are consistent with the OLS alternative, confirming the existence of geographical poverty traps.

Table 3: Consumption Model with cohort fixed effects (*) - Pseudo panel 1985-2006 (**)
(Dependent Variable: Differential of logarithm of household consumption per capita)
GMM Estimation

Variables	GMM estimation					
	Urban Areas			Rural Areas		
	Coef.	SE		Coef.	SE	
Lagged differential of consumption	-0.596	0.086	***	-0.575	0.100	***
Geographical (canton or parish level)						
Residence in Mountain Provinces (dummy)	-0.465	0.226	**	0.383	0.322	
Distance (minutes)	0.009	0.004	**	0.005	0.005	
Population density (persons x km2)	0.000	0.000		0.001	0.001	***
Range of altitude (meters over sea level)	-0.001	0.000	***	0.000	0.000	
Index of natural disasters (0-12)	0.039	0.091				
Average temperature (°C)				-0.014	0.039	
Roads 1st order (km per capita)	1.342	0.573	**			
Roads 2nd order (km per capita)	0.589	0.464		-0.249	0.252	
Number of doctors x 10 thousand habitants				0.049	0.020	**
Surface with transitory crops (%)				0.044	0.020	**
UPAs access to credit (%)	-0.009	0.020		-0.029	0.024	
Farmed land per capita (acres)	-0.116	0.038	***	0.006	0.003	**
Fertilizers and pesticides Expenditure per acre	0.000	0.000		0.001	0.000	**
Per capita surface of UPAs (acres)	0.445	0.238	*			
UPAs access to electricity (%)	0.054	0.008	***	-0.026	0.014	*
Afro descendent population (%)				-1.510	1.220	
Controls (household level)						
Years of education of household head				-0.030	0.015	*
Proportion of adults without education	-0.821	0.711				
Household size (logarithm)	-1.858	0.477	***	0.169	0.747	
Children aged 6-11	0.237	0.220		0.099	0.167	
Children aged 12-14	0.416	0.203	**	-0.273	0.405	
Children aged 15-17	0.476	0.337		0.509	0.363	
Members aged 18 to 59	0.189	0.092	**	-0.181	0.192	
Adults older than 60	0.163	0.079	**	-0.273	0.159	*
Proportion of children in primary or secondary	-0.292	0.623		0.126	0.573	
Proportion of self-employed	2.064	0.482	***	4.899	0.697	***
Proportion of employed				1.731	0.663	***
Constant	-2.778	1.027	***	-0.126	1.588	

Notes: (*) Not all information available about the geographic capital was incorporated in each urban-rural regression. Some of them had to be removed because they generated high correlations with others.
*, **, *** indicate that the variables are significant at 10%, 5% and 1%, respectively.

After finding that geographic variables influence consumption growth, following Jalan and Ravallion (2002), we estimate the critical values of each geographic variable. The critical value is determined at a point in which consumption growth is zero, keeping the other geographical variables and the controls constant. The calculation is simple and the results are intuitive as this indicates if the critical values for a geography poverty trap occur within the boundaries of the data. As previously discussed, one might find that higher endowments of geographic capital increase the marginal product of household capital, it may still be the case that no area in our sample has so little geographic capital to entail falling consumption. The critical values are calculated using the coefficients of the consumption growth model that takes into account the control variables and the fixed effects at the cohort level. All the other variables are kept at their sample mean values.

Table 4 reports such values for the significant geographic capital variables. We consider only the variables related to infrastructure and the provision of services and estimate the boundaries for urban and rural areas separately. Furthermore, the estimation was carried out using the mean values of the independent variables for two periods: 1995-1999 and 1999-2006, periods of economic recession and growth, respectively. During the recessionary period (1995-1999) real consumption (in constant values) decreased 33 percent in urban areas and 11 percent in rural areas, and on the growth periods consumption increased 48 percent and 23 percent for urban and rural areas respectively.

Table 4: Critical Values to Avoid Geographic Poverty Traps

	Level	Urban				Rural			
		Critical	Average	Min	Max	Critical	Average	Min	Max
1995 - 1999									
Distance (minutes)	Canton	97	98	70	130	88	92	59	123
Number of doctors x 10 thousand habitants	Canton					11	12	7	27
Surface with transitory crops (%)	Canton					15	15	7	23
Farmed land per capita (acres)	Canton	1.6	1.4	0	116	0	2.4	0	47 In
Fertilizers and pesticides expenditure per acre	Canton	7	31	0	1788	44	84	0	931
UPAs access to electricity (%)	Canton	68	68	60	76	66	65	53	85
1999 - 2006									
Distance (minutes)	Canton	90	95	70	128	73	91	59	117
Number of doctors x 10 thousand habitants	Canton					11	12	7	27
Surface with transitory crops (%)	Canton					15	17	6	22
Farmed land per capita (acres)	Canton	1.2	0.2	0	4	0	2.3	0	47
Fertilizers and pesticides expenditure per acre	Canton	0	28	0	503	0	82	0	504
UPAs access to electricity (%)	Canton	66	67	61	74	71	66	55	85

Note:
Consumption growth 1995-1999: Urban -33%, Rural -11%
Consumption growth 1999-2006: Urban 48%, Rural 23%
Source: Author's calculation's. Includes only significant variables related to public infrastructure and services

We find that in general, geographic capital can be considered the most limiting factor for growth in consumption in periods of recession. The critical values are higher in this period than in periods of expansion (or economic growth). The results in Table 4 also indicate that for rural areas the factors directly related to access to services related to agriculture (i.e. UPAs access to electricity) are more limiting than in urban areas. For both periods, we find that in order to obtain a positive consumption growth in the rural areas, the number of doctors should be greater than 10 for ten thousand habitants, keeping all other determinants at the mean level. In the latter case, for example we observe that some cantons have a value of 7 while others have a value of 27. The results also indicate that the critical values might change significantly for some variables; for example the use of fertilizers and pesticides in rural areas.

5- Final Remarks

The geography-poverty nexus has been hotly debated by academic and policy makers. In this paper we construct and use pseudo dynamic panel data of household and geographic variables to gauge the effects of geographic variables on household consumption growth. The results indicate that geographic factors play a significant role in explaining differences in household consumption growth in Ecuador. The estimations are consistent with the hypothesis that geographical capital affects consumption, even after accounting for household characteristics. The literature on poverty traps suggests that geographic factors such as altitude and temperature as well as infrastructure and the provision of public capital are important in explaining why some localities remain persistently poor. The significance and impact of geographical variables differ across urban and rural areas, indicating the heterogeneous determinants of household consumption growth. In addition, given Ecuador's geographical diversity, the results are consistent with the fact that household socioeconomic factors alone cannot fully explain differences in consumption growth.

Since the evidence shows that geographic factors have played a significant role in explaining the dynamics of household consumption, poverty reduction programs should take into account such factors. Social programs aimed at reducing the incidence of poverty in specific localities could be enhanced by concomitantly improving the provision of local infrastructure and market access (logistics, relocation costs) in addition to directly targeting household welfare.

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Appendix 1: Data sources and definitions

This table contains the other sources of the data. After we worked out the panel this information was cross checked with the Ecuadorian authorities, before the estimations were carried out.

From Administrative registries in ministries and other governmental institutions:	
At the cantons level:	• Index of natural disasters values between 0-12 (includes risk and current activities of seismic activities; volcanoes; tsunami; land slide , floods and droughts); • Direct or potential distance between a populated area, main street, street or river to a not so populated area. (expressed in minutes); • Houses with sewage system connected to public network (percentage of total homes with access); • Roads 1st order (with asphalt) and roads 2nd order (without asphalt) in kilometers per habitants • Number of doctors and number of health related staff non doctors (per 10 thousand habitants).
At the parishes level:	• Population density (habitants per kilometer squared) • Average temperature (in centigrade) • Average precipitation (millimeters cubical per year); • Median Altitude (meters above the sea level) and altitude range (difference between the maximum and the minimum altitude) • Health clinics without rooms or over-night stay (number of clinics per 10 thousand habitants); • Number of students per teacher in public and private schools for primary and secondary grades
From the Censo Nacional Agropecuario, 2000 (Census on Agriculture and Livestock – year 2000)	
At the cantons level:	• Area used for Agriculture and Livestock (UPAs) per person (hectares) • Area of farming of the UPAs with access to irrigation (% of the total area available for farming) • Uses of the soil (land): (1) area of the UPAs with permanent cultures (% of the total area); (2) area of the UPAs used on transitory cultures (% of the total area) • UPAs with access to electricity (% of total UPAs); • UPAs with access to credit (% of total de UPAs). **UPAs in spanish stands for "Unidades de Producción Agropecuaria"**
From the Censo de Población y Vivienda, 2000 (Census on population and Houses- year 2000)	
At the parishes level:	• Functional illiteracy (% pop older 15) (percentage of the population older than 15 years old with 3 or less years of schooling) • Indigenous population (proportion with respect to total population); • Afro descendent population (proportion with respect to total population); • Infant mortality per one thousand (Number of kids that die before reaching 1 year old and that were born alive)

Source: Gallup, Sachs and Mellinger, 1999