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Mountains, Global Food Prices, and Food Security in the Developing World

Kamiljon T. Akramov

Bingxin Yu

Shenggen Fan

Development Strategy and Governance Division

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

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AUTHORS

Kamiljon T. Akramov, International Food Policy Research Institute
Research Fellow, Development Strategy and Governance Division
k.akramov@cgiar.org

Bingxin Yu, International Food Policy Research Institute
Postdoctoral Fellow, Development Strategy and Governance Division
b.yu@cgiar.org

Shenggen Fan, International Food Policy Research Institute
Director General
s.fan@cgiar.org

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ABSTRACT

This study explores the differences between mountain and non-mountain countries in food security and its determinants. Econometric analysis shows that mountain regions are likely to have lower food security. The findings suggest that people in mountain countries are especially affected by external shocks such as surges in global food prices. The results of regression decomposition indicate that the disparity in food availability we observed between mountain and non-mountain countries can be explained by differences in population size, income, road density, and governance factors as well as by a differential impact of external price shocks. The direct impacts of geographic and agroecological factors seem rather limited.

Keywords: mountain regions, altitude, global food prices, food security, developing countries

1. INTRODUCTION

Achieving adequate food security is arguably a necessary first step toward the alleviation of poverty and hunger and sustainable economic growth. According to the Food and Agriculture Organization of the United Nation (FAO 2009a), “food security exists when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life. Food insecurity exists when people do not have adequate physical, social, or economic access to food as defined above.” This definition identifies the four main dimensions of food security: food availability, food access, utilization, and stability.

These dimensions are especially important in mountain areas where the fragile environment negatively influences food availability and access. Other factors, such as the relative isolation of mountain regions and the inadequate access their people have to infrastructure and social services, such as all-season roads and health care, also make them more vulnerable to external shocks (FAO 2002; Huddleston 2003). The evidence suggests that countries where more than 40 percent of the population lives in mountain areas are likely to have higher levels of undernourishment than is average for developing countries (von Dach et al. 2006). Thus, it is not surprising that among 22 countries identified by FAO as highly affected by the recent food crisis, many have significant mountain populations (FAO 2008). While there has been some discussion of the importance of mountain environments on agricultural systems and food security, to our knowledge, there are no studies that rigorously explore the differences in food security between nonmountain countries and those in which at least 40 percent of the population lives in mountain areas (hereafter referred to as “mountain countries”).

This paper attempts to fill the gap in the literature by examining the differences between nonmountain and mountain countries with regard to their food security status and the factors that determine it. The paper also attempts to assess the special effects of external shocks such as surges in global food prices on food security in mountain countries. Using descriptive narratives, nonparametric tests, regression analysis, and decomposition techniques, the paper links differences in countries’ geography, agricultural potential, trade openness, infrastructure access, and governance to observe differences in food security status. The paper is organized as follows. The next section provides a brief background of the mountain context and food security. In the third section we discuss our conceptual framework and empirical methodology. The fourth section describes the data and provides the results of nonparametric tests, and the fifth section reports the econometric results. The final section provides conclusions and discusses policy implications.

2. BACKGROUND: MOUNTAIN REGIONS AND FOOD SECURITY

Economists have long recognized geography as a crucial factor in development. Recent studies of comparative growth found that differences in physical and agroecological factors have a large effect on economic development (Gallup, Sachs, and Mellinger 1999; Hall and Jones 1999; Masters and McMillan 2001; Acemoglu, Johnson, and Robinson 2001). These studies point to some important areas in which these factors can directly or indirectly affect economic development: Resource endowment and mobility of production factors, agricultural productivity, human health, and institutions. In this regard, mountain countries, with their specific biophysical and agroecological conditions, are different from nonmountain countries. The literature suggests that mountain countries are systematically different from nonmountain countries in terms of climate (the shorter length of growing periods) and soil conditions (poor quality and shallow depth of the soil). These characteristics constrain agricultural productivity and food production in various ways. Remoteness, isolation, and limited or no access to physical infrastructure (such as roads) also constrain the achievement of food security and overall economic development (Huddleston et al. 2003).

Overall, more than one fifth of the Earth's surface is covered by mountains. Mountains are defined by their altitudes, elevations, and slopes of terrain. Areas 2,500 meters above sea level or higher are always classified as mountains, irrespective of the slope of terrain. Areas between 300 and 2,500 meters high are considered mountains if they exhibit steep slopes or have a variable local morphology (that is, a wide range of elevations in a small area) or both. Climate conditions and ecosystems in mountain areas vary depending on the nature of the terrain; their latitude; and whether they are located in temperate, subtropical, or tropical regions (Huddleston et al. 2003).

More than 700 million people, or about 12 percent of the total world population, live in mountain areas. More than 600 million of these people—90 percent— live in developing and transition countries, and 75 percent of them live in rural areas and mainly survive on subsistence agriculture. About half of the world's mountain people live in the Asia and Pacific region. Three other developing regions, namely Latin America and the Caribbean, the Middle East and North Africa, and Sub-Saharan Africa, each have about 100 million mountain people. About 30 million mountain people live in transition countries. In relative terms, mountain people as a share of the total population vary across regions. For example, even though mountain people in the Asia and Pacific region make up about half of the world's mountain population, they constitute only a small share (11 percent) of the region's total population. The mountain population constitutes about 25 percent of the total population in Latin America and the Caribbean and the same percentage in the Middle East and North Africa (Kapos et al. 2000; Huddleston et al. 2003; and Price, Jansky, and Iatseni 2005).

Most rural mountain people engage in some form of agriculture as the main source of their livelihood. The land resources in mountain areas of the world comprise barren land (33 percent), forage (25 percent), forest (25 percent), cropland (7 percent), and protected areas (10 percent). Such land resources make livestock grazing and forestry natural livelihood activities in mountain areas around the world. Although production of staple cereals and vegetables for own consumption exists in virtually all of the mountain areas across the world, they depend heavily on imports of these products to meet the domestic demand. Nevertheless, in some mountain areas, crop-based farming systems are important components of local livelihoods. These include the maize-bean system in the upland areas of Central Mexico and Central America, the perennial crops-based system in the Ethiopian and Eastern African highlands, and the rice-wheat (highland mixed) system across the entire Himalaya range (FAO 2002; Huddleston et al. 2003).

About 40 percent of the mountain population in developing and transition countries, or nearly 300 million people, are estimated to be vulnerable to food insecurity. Of these, nearly 90 percent live in rural areas and almost half of those are likely to be chronically hungry (FAO 2002; Huddleston et al. 2003). The available evidence from various countries points to relatively poor food security and nutrition in mountain areas. The extreme poverty rate in Bolivia, for example, is among the highest in rural mountain areas, particularly in the regions of northern Potosi, Chuquisaca, and La Paz. Similarly, poverty rates are highest in the remote mountainous areas in the northern part of Vietnam, where the poverty headcount ratio exceeds 70 percent, compared with the national average of 35 percent (von Dach et al. 2006).

Likewise, in Peru, higher rates of acute and chronic malnutrition were observed among children under the age of five living in mountain areas, compared with the national average for the same age group (Kumar 1995). Studies have also found that there is a noticeable reduction of birth weight in infants born at high altitudes (Scrimshaw and Schürch 1998). The available evidence suggests that various micronutrient deficiencies are common in highland and mountain areas. For example, data from the Himalayas and the Andes indicate a high prevalence of vitamin A deficiency in mountain areas. This is probably due to a combination of poor diet and limited access to food that is rich in Vitamin A (Kuhnlein and Pelto 1997). Grantham-McGregor, Fernald, and Sethuraman (1999) suggest that the combination of glaciation, melting snow, and heavy rainfall in mountain areas can cause leaching, which depletes mountain soil, water, and iodine in crops. That could explain why people living in the Andean, Himalayan, and Chinese mountain ranges are likely to have iodine deficiency.

3. CONCEPTUAL FRAMEWORK AND EMPIRICAL METHODOLOGY

In this section we describe our conceptual framework and the empirical methodology used to examine how a mountain environment can influence food security.

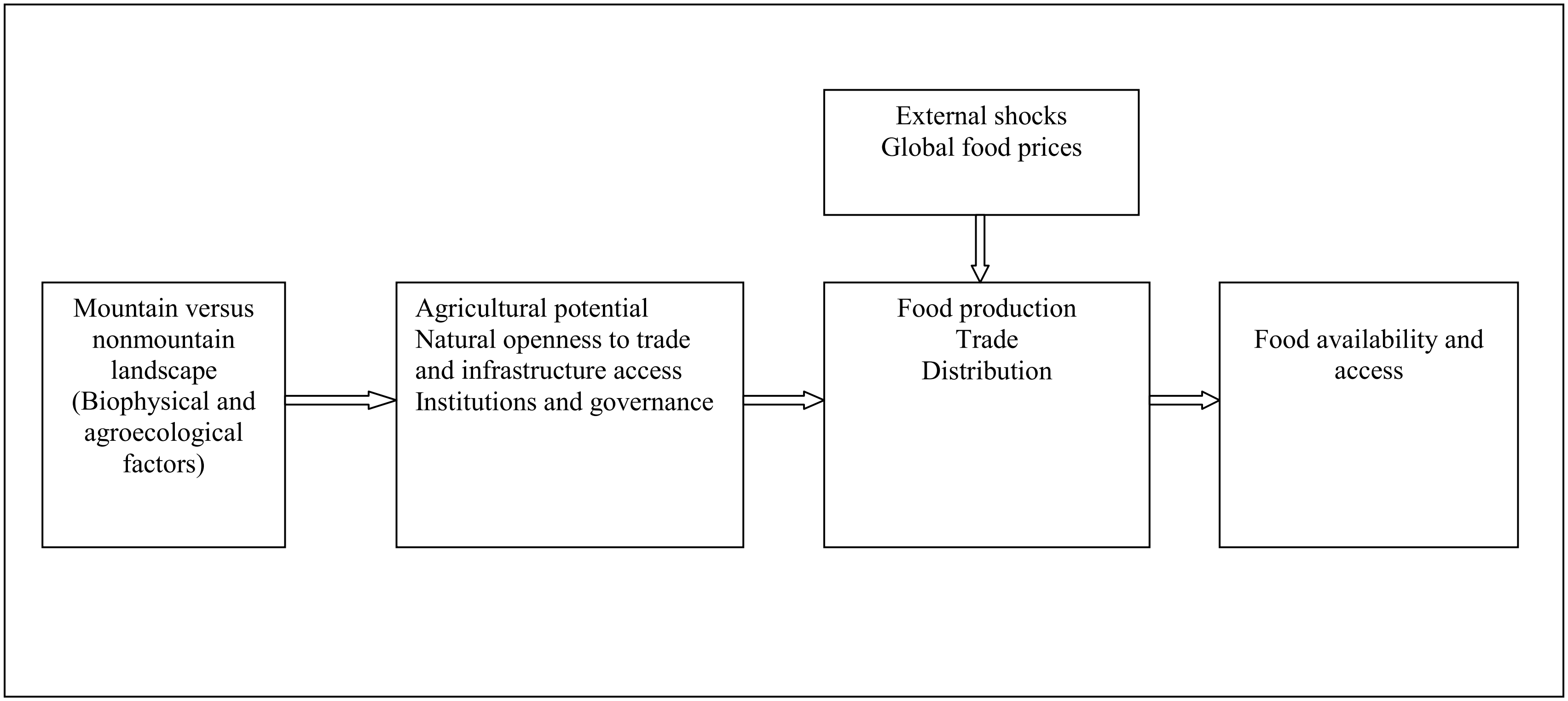
3.1. Conceptual Framework

Our conceptual framework rests on the following premises:

1. A mountain landscape might result in lower per capita arable land availability than in nonmountain regions. In addition, many unfavorable agroecological and biophysical factors could negatively affect the productivity of farmland and labor in mountain regions, and therefore influence agricultural potential and food production. In general, only two percent of mountain and 22 percent of non-mountain areas classified as good to very suitable for rainfed crops (UNEP-WCMC, 2002).
2. Since most mountain areas are remote and isolated, they might naturally be less open to trade. They are also likely to have low road density, which could negatively affect food access and distribution. The evidence suggests that the development of infrastructure in mountain regions requires substantial investment and mainly driven by the needs of lowlands (UNEP-WCMC, 2002; Huddleston et al., 2003).
3. Mountain communities are likely to develop and defend a distinctive cultural identity and institutions. The evidence shows that mountain areas have relatively higher language density because deeply dissected mountain landscape provides an important topographic foundation for the development and maintenance of language diversity (UNEP-WCMC, 2002). Because of the close association between language and culture, linguistic diversity can lead to cultural diversity. Thus, it is plausible to assume that mountain regions may develop different institutions and governance structures, and so these factors also could affect food security and economic development at some level.

Based on these assumptions, we expect a mountain environment to be an exogenous factor of food security. Our conceptual framework is schematically summarized in Figure 1. This framework conceptualizes the impact of a mountain environment on food security as a three-stage relationship in which biophysical and agroecological factors shape agricultural potential and natural openness to trade and institutions. These in turn shape food production, trade, and distribution. The latter are intermediate factors of food security. Finally, these intermediate factors influence the final status in terms of food availability and access.

Figure 1. A simple conceptual framework for linking physical endowments, external shocks, and food security



The framework also assumes that external factors such as global food prices play an important role in determining domestic food security by their impact on intermediate factors such as domestic agricultural production, relative domestic food prices, exports, and imports of food items. The nature of this impact depends on domestic agricultural supply response, on the one hand, and trade response, on the other hand. The key point here is that even if growth in domestic food production does occur, it will not necessarily translate directly into improved domestic food availability. Changes in exports (or imports) of food can offset or even negate the potential impacts of any changes in agricultural production. Further, changes in the net production position of rural households and variations in domestic food prices also might affect food security by influencing access to food.

Since mountainous and nonmountainous countries have major differences in their domestic agricultural potential and natural openness to trade, it is plausible to expect that identical external shocks, such as the recent surge in global food prices, might influence mountainous and nonmountainous countries differently. It is more likely that people in mountainous countries would be especially harmed by external shocks due to constraints on their domestic agricultural potential, remoteness, isolation, and their limited access to physical infrastructure.

3.2. Empirical Methodology

Our empirical methodology has three parts. First, we use cross-country plots, descriptive statistics, and nonparametric (Kolmogorov-Smirnov) tests to highlight the differences between mountainous and nonmountainous countries. Second, we use regression analysis to identify the impact of the mountain environment and external shocks on food security in mountainous countries. In doing so, we control for the potential impact of various policies and institutional variables. Third, we apply the regression results to decompose the food security gap between mountainous and nonmountainous countries.

Model Specifications

As mentioned above, the objective of regression analysis is to examine the impact of the mountain environment and external shocks on food security in mountain countries. Our measure of food security is national food availability proxied by daily per capita calorie intake (supply). This measure refers to the amount of food, expressed in kilocalories (kcal) per day, available for each individual in a given country. These data are compiled by the Food and Agriculture Organization of the United Nations (FAO 2009b). We are aware of the fact that these data have some methodological problems and the per capita availability of calories in some regions has been underestimated by the FAO (Smith and Haddad, 2000; Svedberg, 2002). Nevertheless, daily per capita calorie supply is highly correlated with other food security and nutrition indicators. For example, the cross-country correlation coefficient between the per capita calorie availability and Global Hunger Index is equal to -0.88. The per capita calorie availability is also highly correlated with undernourishment rate (-0.93), prevalence of underweight in children under five (-0.63), and under five mortality rate (-0.67). Thus, we consider that daily per capita calorie intake provides a plausible measure of food security across developing and transition countries.

We conduct the regression analysis in three steps. The first step is to ask whether a mountain environment is a significant determinant of food security at all. If a mountain environment does indeed have a negative impact on food production, trade, and distribution, then we would expect mountain countries to have significantly lower food availability. To assess this hypothesis we interchangeably use two measures of a mountain environment. Our first measure is a mountain country dummy variable, which equals 1 if at least 40 percent of a country's population lives in mountainous areas. The data on mountain populations is compiled by Huddleston et al. (2003). The raw data come from the Oak Ridge National Laboratory's LandScan Global Population Database. Our second measure is a country's average altitude. As mentioned above, mountain environments have various constraints on food production and distribution. Thus, the expected signs on these variables are negative.

Many social scientists, including Diamond (1997); Gallup et al. (1999); Masters and McMillan (2001); and Easterly and Levin (2003), have shown the link between a country's location and its economic performance. Countries that are closer to the equator tend to have a more tropical climate, which may also directly hinder agricultural production. In this regard, there is enormous variation in the nature of mountain environments despite their universal basic physical conditions of altitude and slope. Much of this variation arises from differences in temperature and precipitation regimes associated with their geographic location - whether at high or low latitudes, whether deep within a continental landmass or near coastal regions (UNEP-WCMC, 2002). That's why we control for two different measures of a country's geographic location: latitude and average distance to a coastline or navigable rivers. We expect there is a positive link between latitude and food security. Average distance to a coastline or navigable rivers reflects both transport costs and physical access to trade, and thus is expected to have a negative relationship with food security.

Given our particular interest in investigating the extent to which external shocks are detrimental to food security, we constructed a country-specific global food price index (CIFI) that captures changes to the global prices of imported food items as

$$CIFI_{i,t} = \theta_i IFI_t,$$

where IFI_t is the IMF's global food price index in year *t,* which covers cereals, vegetable oils, protein meals, meats, seafood, sugar, bananas, and oranges, and θ_i is the average (time-invariant) value of food trade in the total merchandise trade of country i. We expect that surges in the CIFI will have a negative impact on per capita calorie intake.

The variables mentioned above account for the spatial and external (global food prices) causal factors of food security. These variables can influence food security but probably cannot fully explain all the differences between mountain and nonmountain countries. Obviously, many other factors, for example, government policies that improve infrastructure and foster overall economic development can influence intermediate factors and food security. To control for such factors, we also include a number of other variables such as income per capita, population, arable land per capita, road density, trade openness, governance, and ethnolinguistic fractionalization in our empirical model. In addition, to ensure that our results are not driven by region-specific factors, we incorporate the region-specific fixed effects into the model. The geographic regions are Middle East and North Africa (MENA), Latin America and the Caribbean (LAC), Asia and the Pacific (APC), Sub-Saharan Africa (SSA), and the transition countries of Europe and Central Asia (ECA). Finally, we explicitly control for time-specific fixed effects to capture the country invariant time-specific developments.

The regression equation is in the following form:

$$FS_{i,t} = \alpha + \beta M_i + \varphi CIFI_{i,t} + \gamma X_{i,t} + \mu_r + \tau_t + \varepsilon_{i,t} \ , \qquad (1)$$

where *FS* represents food security (that is, per capita daily calorie intake in logarithmic scale) and M_i is the matrix of spatial variables, including controls for mountain environment, country-centered latitude, and distance to a coastline or a navigable river. $CIFI_{i,t}$ is a vector of the country-specific global food price index measured by IMF's global food index (specifics of this index are given below). *X* is the covariate matrix including all control regressors. *M*GFP* is the interaction between the mountain dummy and global food prices; $\alpha, \beta, \varphi,$ and γ are parameters to be estimated; μ_r and τ_t represent the region and time-specific unobserved fixed effects, respectively; and $\varepsilon_{i,t}$ is the common error term, following a normal distribution with zero mean. For each variable, i represents the country and t the time period. Note that implicit in specification (1) is the assumption that the relationship between independent variables and food security is the same for mountain and nonmountain countries. In this specification, the food security gap between these two groups, if any, will be captured by a variable that controls for mountain environment.

Before moving to the next model specifications, we would like to address some econometric estimation issues associated with the model specification. The first concern is the issue of included the region-fixed effects instead of the country-fixed effects in the model. This is a valid concern because countries within a given geographic region may have varying characteristics. The country-fixed effects model is more appropriate if the unobserved individual country characteristics are assumed to be correlated with the error term. However, coefficients on important time-constant exogenous variables including the mountain country dummy variable, altitude, latitude, and distance to coastline are unidentified in the country-fixed effects model due to perfect multicollinearity. We could estimate random effects models, which use the generalized least squares (GLS) estimator and allow us to estimate coefficients on time-constant exogenous variables while controlling for country-fixed effects. However, the random effects models, while more efficient, may result in biased and inconsistent parameter estimates if country fixed effects are correlated with the common error term. It is reasonable to expect that country-fixed effects are correlated with the error term, and that is the reason that we opt for the region-fixed effects model.

The second step in our regression analysis, given mountain countries' constraints in domestic agricultural potential and the limitations in natural openness to trade, is to examine whether mountain countries are especially affected by external shocks. To test this hypothesis, we add an interaction term between the mountain country dummy variable and the country-specific global food price index in equation (1):

$$FS_{i,t} = \alpha + \beta M_i + \varphi CIFI_{i,t} + \delta D * CIFI_{i,t} + \gamma X_{i,t} + \mu_r + \tau_t + \varepsilon_{i,t} \quad , \tag{2}$$

where D is a mountain country dummy variable. A negative and statistically significant δ would confirm that mountain countries are more affected by variations in global food prices.

Having obtained plausible evidence for the negative impact of a mountain environment on food security, in the third step, we use the mountain country dummy variable to subdivide the sample into mountain and nonmountain country subsamples and test for parameter heterogeneity between the two subsamples. In doing so, we introduce new explanatory variables defined by interacting the mountain country dummy variable with all explanatory variables entered in equation 1:

$$FS_{i,t} = \alpha + \beta Z_{i,t} + \beta^m D * Z_{i,t} + \mu_r + \tau_t + \varepsilon_{i,t} \ , \tag{3}$$

where *D* is a mountain country dummy variable and *Z* is a matrix that includes all explanatory variables, excluding altitude, entered in equation 1. Equation 3 provides a direct test of the heterogeneity of parameters between mountain and nonmountain country subsamples. To test for parameter heterogeneity, we use the Chow test[1] of null hypothesis, which says that each pair of individual parameter estimates and also the set of all parameter estimates together are the same across the mountain and nonmountain countries.

3.2.2 Regression decomposition framework

The regression results obtained from parameter heterogeneity tests allow us to decompose the food security gap between mountain and nonmountain countries. We express the food availability gap between the mean per capita daily calorie intake for mountain and nonmountain countries, FS^{m} and $\mathrm{FS}^{\mathrm{nm}}$, as follows:

$$FS^{nm} - FS^{m} = (\alpha^{nm} - \alpha^{m}) + \Delta\beta(\frac{Z^{nm}+Z^{m}}{2}) + \Delta\bar{Z}(\frac{\beta^{nm}+\beta^{m}}{2}) \ , \tag{4}$$

where $\Delta\bar{Z} = \bar{Z}^{nm} - \bar{X}^{m}$ and $\Delta\beta = \beta^{nm} - \beta^{m}$, $\bar{Z}^{nm}$and $\bar{X}^{m}$ are mean values of explanatory variables, and $\beta^{nm} and\ \beta^{m}$ are estimated regression coefficients; subscripts nm and m represent nonmountain and mountain subsamples, respectively.

[1] The Chow test becomes similar to the Wald test when the models are estimated with the robust standard errors.

In equation 4, the differences in the endowments (Zs) are weighted by the means of the respective regression coefficients and the differences in the regression coefficients are weighted by the means of the respective endowments. The components of equation 3 refer to two sources of food security gap between the nonmountain and mountain countries: (1) the difference in parameters, that is, the difference in intercepts and slopes, which are the first two terms of equation 4; and (2) the difference in the mean values of the independent variables, the third component in equation 4. Thus, we have a way of partitioning the gap in food security between the nonmountain and mountain countries into a part attributable to the fact that the nonmountain group has better endowments than the mountain group and a part attributable to the fact that the groups have differing parameter estimates.

4. DATA AND NONPARAMETRIC TEST RESULTS

In this section we describe our data, report the descriptive findings, and provide the results of two-sample nonparametric tests.

4.1. Data and Descriptive Findings

To conduct the regression analysis, we compiled an unbalanced panel dataset consisting of 133 developing and transition countries over the period 1995–2005 (see the Appendix, Table A1 for a list and typology of countries). However, missing data effectively reduced the sample to 116—127 countries in most regressions. The dataset is mainly compiled from the databases of the World Bank (World Bank 2009), the Food and Agriculture Organization of the United Nations (FAO 2009b), the International Monetary Fund (IMF 2009). Data for democracy are from the Freedom House political rights and civil liberties database (Freedom House 2009). Ethnic fractionalization data are from Desmet, Ortuño-Ortin, and Wacziarg (2009). Data on spatial location of each country are from Gallup, Sachs, and Mellinger (1999).

Table 1 provides a list of the variables and their expected relationships with food security. Figure 2 compares the trends of these variables across the two groups.

As mentioned above, our dependent variable is daily per capita calorie intake. Although average daily per capita calorie consumption in the mountain countries has increased from nearly 2,170 kcal in 1995 to more than 2,360 kcal in 2005, it is still significantly lower (about 12 percent or 290 kcal) than that in the nonmountain countries. Over the period 1995–2005, average daily per capita calorie intake in the nonmountain countries increased from approximately 2,520 to 2,650 kcal (Figure 1). Based on our mountain-country criteria, 24 countries in our sample are identified as mountain countries and 109 are identified as nonmountain countries. Average altitudes are equal to 1,312 meters in the mountain countries and 467 meters in the nonmountain countries. The mountain countries appear to be more dependent on volatility in global food prices than the nonmountain countries.

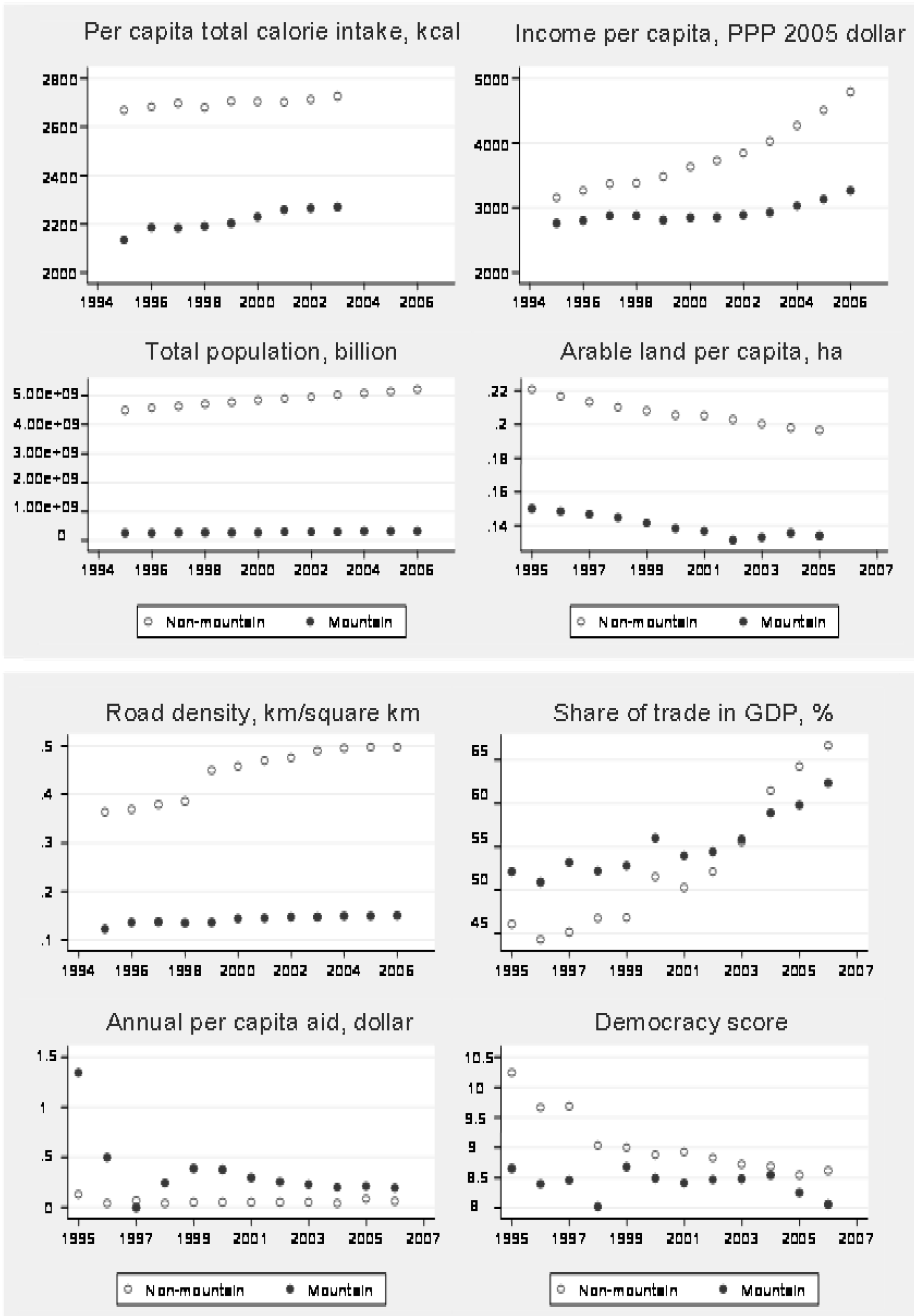
On average, the nonmountain countries are more populous than the mountain countries, but the population growth rates are relatively higher in the mountain countries. The relationship between population size and food security can be twofold. On the one hand, higher population size and density might improve food access and availability if there are economies of scale. On the other hand, if there is a competition between farming, housing, and other uses of land, higher population sizes and density may be detrimental to domestic food production. As a result, a relationship between population and food security could be positive, negative, or insignificant. Our next control variable is average per capita income, measured in 2005 constant international dollars (based on Purchasing Power Parity). Average per capita income in the nonmountain countries is significantly higher than in the mountain countries. Moreover, the average income gap between the nonmountain and mountain countries has an increasing trend. Obviously, per capita income and food security are highly correlated and likely to be jointly determined by exogenous factors such as mountain environment. This could lead to a classical simultaneity bias in our regressions. However, our goal in this study is not to establish a causal link between per capita income and per capita calorie intake. We use income per capita income as a mere control variable.

Table 1. Variable definitions and descriptive statistics

Variable	Definition	Observations	Mean	SD	Min	Max
Calories (log)	Daily per capita calorie intake (kcal)	1,463	7.813	0.186	7.303	8.158
Mountainous country	1 if at least 40% of country's population live in mountain areas, 0 otherwise	1,463	0.18	0.38	0	1
Altitude (log)	Average altitude in meters	1452	5.974	1.125	0.742	8.066
Latitude	Country centered latitude in decimal degrees	133	15.9	22.7	-35.8	61.7
Distance	Mean distance to coast or navigable river (kilometers)	127	478.3	542.1	1.043	3,418.5
Population (log)	Log of total population	1,463	15.941	1.654	11.493	20.989
Income per capita (log)	Log of GDP per capita in constant US$2000	1,414	6.972	1.251	4.034	10.142
Arable land per capita (log)	Arable land per person (ha)	1,452	-1.709	0.946	-6.690	0.697
Road density (log)	Road density	1,433	-1.722	1.243	-5.314	1.345
Trade	Trade as % of GDP	1,421	81.4	38.7	1.5	228.9
Food export	Food export as % of merchandise export	1,198	6.4	12.4	0.00	93.8
Food import	Food import as % of merchandise export	1,198	6.4	12.4	0.00	93.8
Food aid per capita	Net multilateral food aid per capita, WFP (constant US$)	1,448	0.38	1.48	0	28.5
Global food prices	IMF food price index	1,463	93.4	10.7	80.2	112.3
Democracy	Sum of political rights and civil liberties scores (Freedom House)	1,463	7.9	3.6	2	14
Ethnic fractionalization	Probability of randomly selected two people being from different ethnic group	1,463	0.48	0.31	0	0.97

Source: Authors' computations.

Figure 2. Trends of food security indicators and related variables



Source: Authors' calculations based on FAO (2009b) and World Bank (2009).
Note: Based on a sample of 133 developing and transition countries.

Domestic agricultural potential is measured by total per capita arable land. The higher values of per capita arable land are expected to boost food production and security. A simple analysis shows that the nonmountain countries are likely to have higher per capita arable land than the mountain countries. Moreover, the availability of per capita arable land is declining in the mountain countries relatively aster than in the nonmountain countries. Access to infrastructure is measured by road density, and a positive relationship between this variable and food security is expected. Average road density has been steadily increasing (from 0.37 kilometers per square kilometer in 1995 to 0.66 in 2005) in the nonmountain countries. However, this trend is not observed in the mountain countries, where average road density (approximately 0.2 kilometers per square kilometer) has not changed much. This trend indicates that the gap in road density between the mountain and the nonmountain countries is increasing.

The impact of trade openness is measured by the share of total trade flows in gross domestic product. Overall, the nonmountain countries seem more open to trade than the mountain countries. We expect that trade openness is likely to benefit food security. Another important control variable is food aid. On average, the mountain countries receive more per capita food aid than the nonmountain countries. The impact of food aid on food security indicators is not clear. It can be positive if food aid replaces food imports and has no effect on domestic production in recipient countries (Barrett 2002). However, this impact can be negative if food aid acts as a disincentive to domestic production (Tweeten 1999).

The literature suggests that countries with democratic regimes are more likely to succeed in improving food security than authoritarian regimes (Sen 1982). Thus, countries with better democracy (political rights and civil liberties) scores are expected to be more food secure. Overall, mountain countries appear to be less democratic than nonmountain countries. We also control for ethnolinguistic fractionalization using an index that measures the probability that two randomly selected individuals from a given country are not from the same ethnic group as an additional proxy for institutions and governance. In fact, a growing body of research shows that ethnic fractionalization negatively influences the quality of institutions and governance in a given country (Alesina, Baqir, and Easterly 1999; Easterly and Levine 1997; Kimenyi 2006). Collier and Hoeffler (2004) argue that ethnic fractionalization is a major factor in instability and conflict. Thus, a negative relationship between ethnic fractionalization and food security is expected. On average, the mountain countries have a lower ethnic fractionalization index (0.39) than the nonmountain countries (0.50)

4.2. Nonparametric Tests of Differences

The descriptive results above suggest that there are important differences between the mountain and nonmountain countries. In this subsection, we conduct the Kolmogorov–Smirnov tests to check whether two underlying probability distributions between the mountain and the nonmountain countries differ. In this case, the directional hypothesis of equality of distribution functions are evaluated with the statistics

$$D+ = \max_x \{ F(x) - G(x) \} \text{ and}$$
$$D- = \min_x \{ F(x) - G(x) \},$$

where $F(x)$ and $G(x)$ are the empirical distribution functions for the mountain and the nonmountain countries, respectively. The combined statistic is

$$D=\max(|D+|, |D-|).$$

Let m be the sample size for the mountain country sample, and n be the sample size for the nonmountain country sample. The asymptotic limiting distribution of the D statistic is

$$\lim_{m,n\to\infty} Pr\left\{\sqrt{mn/(m+n)}\, D_{m,n} \leq z\right\} = 1 - 2\sum_{i=1}^{n}(-1)^{i-1}\exp\left(-2i^2z^2\right),$$

and the asymptotic p-value can be obtained by evaluating the distribution through a counting algorithm (Gibbons 1971).

The results of the Kolmogorov–Smirnov tests are provided in Table 2. The p-values indicate that the mountain countries may have a different distribution function than the nonmountain countries. These results align with our descriptive findings.

Table 2. Equality of distribution test for food security indicators and related variables

Indicator	Mountain	Nonmountain	Difference	p-value
Total daily calorie intake per capita, kcal	2213.8	2698.0	-484.2	0.00
Altitude	1,312.0	466.8	845.2	0.00
Latitude	7.0	5.7	1.3	0.00
Distance	524.6	467.5	57.1	0.00
Population	11.7	44.5	-32.8	0.00
GDP per capita, constant $2000	975.5	1430.9	-455.4	0.00
Arable land per capita, hectares	0.1	0.2	-0.1	0.00
Road density, km per square meter	0.1	0.4	-0.3	0.00
Share of trade in GDP, %	55.4	52.9	2.5	0.00
Food aid per capita, kg grain equivalent	0.3	0.1	0.3	0.00
Democracy	8.4	9.0	-0.6	0.00
Ethnic fractionalization	0.6	0.4	0.2	0.00

Source: Authors' calculations based on World Bank (2009).
Note: All variables are based on 133 developing countries, except for a 70 country sample for food supply, grain production, nutrition gap, distribution gap, and food aid per capita. The group mean is weighted by population.

5. EMPIRICAL RESULTS

This section provides econometric results. First, we explain whether a mountain environment is a significant determinant of food security at all. Second, we examine whether mountain countries are especially affected by fluctuations in global food prices. Then, we test parameter heterogeneity between mountain and nonmountain countries. Finally, we use these regression results to decompose the food security gap between the two groups of countries.

5.1. Is Mountain Environment an Important Determinant of Food Security?

Table 3 provides regression results, with robust standard errors, obtained within the framework of equation 1. Our dependent variable is the log of daily per capita calorie intake. The estimated coefficients on the log-transformed independent variables—altitude, distance, population, income per capita, arable land per capita, and road density—represent elasticities. The coefficients on the mountain country dummy variable, global food price index, democracy, and ethnic fractionalization need to be transformed as $100[\exp(\hat{\beta}) - 1]$ to represent the percentage change in the dependent variable due to a one unit change in these variables (Wooldridge 2003).

Column 1 (specification C1) presents the results of a very simple regression of the log-transformed daily per capita calorie intake on spatial variables. In column 2 (C2), we include region fixed effects in the specification. The results clearly indicate that spatial variables explain variations in food availability across countries. The results without region fixed effects show that the mountain country dummy, latitude, and distance to a coastline or a navigable river explain about one-quarter of the variations in per capita calorie intake. The explanatory power of the regression model significantly increases (48 percent) if we control for region fixed effects. The coefficient on the mountain country dummy variable suggests that the gap in daily per capita calorie intake between mountain and nonmountain countries is about 10.9 percent (model C1). Note that this gap increases to 13.5 percent if we control for region fixed effects in the estimation (model C2).

Table 3. Determinants of per capita daily total calorie intake (log)

Variable	C1	C2	C3	C4	C5	C6	C7
Mountainous country	-0.115***	-0.146***	-0.067***		-0.065***	-0.066***	
Altitude (log)				-0.026***			-0.024**
Latitude	0.003***	0.0006*	0.001***	0.001***	0.001***	0.001***	0.001**
Distance (log)	-0.01**	0.003	0.008**	0.01***	0.01***	0.012***	0.013***
Population (log)			0.017***	0.021***	0.016***	0.015***	0.019***
Income per capita (log)			0.082***	0.087***	0.082***	0.082***	0.087***
Arable. land per capita (log)			0.016***	0.023***	0.022***	0.022***	0.028***
Road density (log)					0.013***	0.013***	0.010***
Trade (%)			0.0003***	0.0002***	0.0004***	0.0003***	0.0002**
Food aid per capita			-0.006**	-0.006**	-0.007***	-0.007**	-0.006**
Global food prices (index)			-0.001	-0.001**	-0.0002	-0.0002	-0.001*
Democracy			-0.003***	-0.003**	-0.002*	-0.002	-0.002

Table 3. Continued

Variable	C1	C2	C3	C4	C5	C6	C7
Ethnic fractionalization			-0.032***	-0.015	-0.017	-0.018*	-0.005
Intercept	7.84***	7.81***	7.08***	7.15***	7.09***	7.12***	7.19***
Region fixed effects	No	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	No	No	No	No	No	Yes	Yes
No. of countries	127	127	121	121	116	116	116
No. of observations	1397	1397	1238	1238	1238	1238	1238
F stat.	133.3	68.3	227.5	223.2	227.8	225.5	222.6
Adjusted R^2	0.25	0.48	0.73	0.73	0.73	0.73	0.73

Source: Authors' calculations.
Note: Cross-country (region) fixed effects models estimated by the within estimator; *p<0.1, **p<0.05, ***p<0.01.

Of course, the coefficient on the mountain country variable reflects differences in distributions of agricultural potential, natural openness to trade, institutions, and other covariates. Thus, this gap significantly declines when we estimate the full model controlling for these covariates and year fixed effects (models C3 to C7). However, the results clearly indicate that the gap in daily per capita calorie intake between mountain and nonmountain countries is still significant. This finding is consistent across various specifications of the model. What's more, the size of the coefficient, which varies from –0.064 to –0.067, suggests that a mountain ecosystem exerts a substantial impact on food availability.

The estimated coefficients on the population, income per capita, arable land per capita, road density, and trade openness variables are statistically significant and have the expected sign. For example, a 1.00 percent change in income per capita is associated with about 0.1 percent change in daily calorie supply. Further, a 1.00 percent change in per capita arable land availability is associated with about a 0.02–0.03 percent change in per capita daily calorie intake. Similarly, the results suggest that the higher the road density the higher the per capita daily calorie intake. A 1.00 percent change in road density is associated with 0.01 percent change in per capita daily calorie intake. This means that a change in road density one standard deviation is associated with a 12–13 percent change in daily calorie supply. It is also worth noting that the coefficients on democracy and ethnic fractionalization have the expected sign and are consistent across various estimated models. However, the statistical significance of these coefficients differs across various estimated models. One explanation for these results is that these variables are sluggish over time; correlate with the individual country fixed effects, and their estimated coefficients and standard errors may not be precise.

The estimated coefficients of the country-specific global food price index have a negative sign in all estimated models, but statistical significance varies across specifications. Nevertheless, the coefficients suggest that the average marginal effect that global food prices have on per capita daily calorie intake is negative in a full sample. However, our hypothesis is that the mountain countries are especially affected by global food prices. We provide the results of formal tests of this hypothesis in the following subsection.

5.2. Are Mountain Countries Especially Affected by Global Food Prices?

In general, the impact of global food prices on domestic food security is not certain. On the one hand, higher global food prices can enhance food access and security if they help to increase the incomes of smallholders and the rural poor. On the other hand, there are trade-offs between domestic food consumption and food exports due to the possibility of a reallocation of food items between domestic and international markets. High global food prices can make exports of food crops more profitable, and thus can negatively influence domestic food availability. Further, it is more likely that global price shocks are especially detrimental for countries with limited domestic food production potential and lower natural openness to trade. Thus, it is logical to ask whether mountain countries are especially affected by fluctuations in global food prices.

Table 4 provides regression results based on equation 2. The estimated coefficients on the country-specific global food price index are largely negative but not robust to changes in model specifications. At the same time, the coefficients on the interaction of this variable with the mountain country dummy variable are robust, statistically significant, and have expected negative signs across all estimated models. To formally test whether the estimated coefficients on the country-specific global food price index in the mountain subsample are significantly different from the estimated coefficients in the nonmountain sample, we apply a generalized form of the Chow test. The test results confirm that the estimated coefficients on this variable are significantly different for two subsamples. This suggests that mountain countries are especially affected by changes in global food prices.

Table 4. Regression results for interaction of global food prices with mountain country dummy

Variable	CI1	CI2	CI3	CI4	CI5	CI6
Altitude (log)	-0.01***	-0.012***	-0.013***	-0.011**	-0.013***	-0.014***
Latitude	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***
Distance (log)	0.012***	0.010**		0.011***	0.007**	
Population (log)	0.019***	0.020***	0.021***	0.018***	0.019***	0.019***
Income per capita (log)	0.083***	0.083***	0.084***	0.082***	0.082***	0.084***
Arable land per capita (log)	0.023***	0.018***	0.029***	0.023***	0.019***	0.030***
Road density (log)	0.012***		0.007**	0.011***		0.006**
Trade (%)	0.0004**	0.0003***	0.0004**	0.0003**	0.0003***	0.0003***
Food aid per capita	-0.006**	-0.005**	-0.002	-0.005***	-0.005*	-0.001**
Global food prices (index)	0.0004	-0.0001	-0.0004	0.0002	-0.0002	-0.0006
Global food prices * mountain dummy	-0.004***	-0.004***	-0.003***	-0.004**	-0.004***	-0.003***
Democracy	-0.002*	-0.003**	-0.002**	-0.001	-0.002**	-0.002*
Ethnic fractionalization	-0.018*	-0.031***	-0.017*	-0.020*	-0.031***	-0.018*
Intercept	7.095***	7.10***	7.174***	7.128***	7.136***	7.210***
Region fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	No	No	No	Yes	Yes	Yes
No. of countries	116	116	120	116	116	116
No. of observations	1238	1238	1282	1238	1238	1282
F stat.	229.5	225.0	239.1	228.8	225.2	238.0
Adjusted. R^2	0.74	0.74	0.74	0.74	0.73	0.73

Source: Authors' calculations.
Note: Cross-country (region) fixed effects models estimated by the within estimator; *p<0.1, **p<0.05, ***p<0.01.

The impact is economically substantial. A one unit (1.0 percentage point) increase in the country-specific global food price index translates to a 0.4 percent decline in per capita daily calorie intake. In other words, a standard deviation increase of 1 in the global food price index translates to a 3–4 percent decline in per capita daily calorie supply. If we consider more recent dramatic surges in global food prices, the magnitude of this impact on mountain countries becomes even more substantial. That is why it is not surprising that among 22 countries identified by FAO as highly affected by the recent food crisis, mountain countries are highly represented.

5.3. Are Parameters Heterogeneous between Mountain and Nonmountain Countries?

The results in the previous subsection indicate that controlling for the heterogeneous impact of global food prices significantly reduces the size (from -0.024 down to -0.01) of the coefficient on mountain environment (average altitude). This leads us to ask whether all other parameters are heterogeneous between mountain and nonmountain countries. Thus, we use that criterion (mountain country) to subdivide the sample and test for parameter heterogeneity between mountainous and nonmountainous countries. In doing so, we interact the mountain country dummy variable with all explanatory variables entered in equation 1. This allows us to directly test the heterogeneity of parameters between mountain and nonmountain countries.

We use a generalized Chow test[2] of a null hypothesis so that the set of all parameter estimates together are the same across the mountain and nonmountain country samples. We pool the data and estimate the fully interacted model and then apply the Chow test. The Chow test rejects the hypothesis that the set of estimated coefficients in the mountain country subsample are the same as the set of estimated coefficients in the nonmountain country subsample. Hence, this formal test confirms in a statistical sense that the parameters are heterogeneous across the two subsamples. The Chow tests for individual parameters reject the null hypothesis for all variables except the arable land per capita and latitude. The impact of these variables on per capita daily calorie supply appears to be analogous in both subsamples.

The regression results are provided in Table 5. Overall, the core results obtained in previous subsections remain robust after dividing the sample. However, the results here indicate that there are considerable differences in estimated coefficients between mountain and nonmountain countries. For example, the association between per capita income and daily calorie supply is considerably stronger in mountain countries (0.078 + 0.029 = 0.107) than in nonmountain countries (0.078). As mentioned above, per capita income and food security are highly correlated and likely to be jointly determined by mountain environment. Therefore, these results have to be interpreted with caution. Similarly, the link between road density and per capita calorie supply is more pronounced in mountain countries (0.01 + 0.021 = 0.31) than in nonmountain countries (0.01). The coefficients on the size of the population and its interaction with the mountain dummy variable suggest that scale effects are significant for nonmountain countries but practically nonexistent for mountain countries. Further, democracy and ethnic fractionalization variables also have significant parameter heterogeneity between the two samples. The negative effects of these variables on per capita food availability are significantly higher in the mountain country sample. For instance, a change in the ethnic fractionalization index in nonmountain countries by 1.0 standard deviation translates to about a 1.5 percent change in per capita daily calorie supply. This effect is about two times higher in mountain countries.

[2] This test is statistically identical to the Wald test when the regression models are estimated with the robust standard errors.

Table 5. Determinants of per capita daily calorie intake for mountain and nonmountain countries

Variable	F1	F2	F3	F4
Latitude	0.001***	0.001***	0.001***	0.001***
Latitude * MD	-0.0006	-0.0006	-0.0006	
Distance (log)	0.007*	0.007*	0.008**	0.008**
Distance (log) * MD	0.027**	0.026**	0.022**	0.018*
Population (log)	0.020***	0.018***	0.018***	0.019***
Population (log) * MD	-0.022**	-0.022**	-0.017**	-0.017**
Income per capita (log)	0.079***	0.078***	0.078***	0.078***
Income per capita (log) * MD	0.030***	0.030***	0.028***	0.029***
Arable land per capita (log)	0.020***	0.021***	0.020***	0.020***
Arable land per capita (log) * MD	-0.017	-0.017		
Road density (log)	0.011***	0.010***	0.010***	0.012***
Road density (log) * MD	0.020*	0.018*	0.021**	0.013*
Trade (%)	0.0003***	0.0003***	0.0003***	0.0003**
Trade (%) * MD	0.0005**	0.0005**	0.0005**	0.0005**
Food aid per capita	-0.014***	-0.015***	-0.015***	-0.015***
Food aid per capita * MD	0.012**	0.013**	0.013**	0.015**
Global food prices (index)	0.0007	0.0006	0.0006	0.0007
Global food prices * MD	-0.004***	-0.004***	-0.004***	-0.005***
Democracy	-0.001	-0.001	-0.001	-0.001
Democracy * MD	-0.01***	-0.01***	-0.01**	-0.01***
Ethnic fractionalization	-0.031**	-0.031***	-0.031**	-0.034**
Ethnic fractionalization * MD	-0.091**	-0.087**	-0.080**	-0.060**
Intercept	7.065***	7.098***	7.092***	7.086***
Region fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	No	Yes	Yes	Yes
No. of countries	116	116	116	116
No. of observations	1238	1238	1238	1238
F stat.	225.7	230.3	234.2	237.6
Adjusted R^2	0.75	0.75	0.75	0.75

Source: Author's calculations.
Notes: Cross-country (region) fixed effects models estimated by the within estimator; MD is mountain dummy.
Significance levels: *p<0.1, **p<0.05, ***p<0.01.

5.4. Decomposition Results

In general, the results above suggest that the food security gap between the mountain and nonmountain countries is due not only to differences in the means of the explanatory variables but also to differences in the nature of the relationship between these variables and food security. In this subsection, we use a regression decomposition technique to further explore the contributions of these factors to the observed total food security gap between mountain and nonmountain countries. This is done by using equation 3, which refers to two sources of the food security gap between the nonmountain and mountain countries: (1) the difference in parameters, that is, the difference in intercepts and slopes; and (2) the difference in the mean values of the independent variables.

In order to decompose the food security gap between the mountain and nonmountain countries, we use the regression results from Table 5 (column F3). Table 6 provides the regression coefficients and the means of the explanatory variables for mountain and nonmountain countries. For each subsample there are two columns containing the parameter estimates, denoted as β^{m} and β^{nm}, respectively, and means of the explanatory variables, $\overline{X}^{m}$ and $\overline{X}^{nm}$, respectively. The results show that the mean log of daily per capita calorie intake is higher in the nonmountain countries than in the mountain countries, 7.835 and 7.707, respectively. This suggests that the observed gap in per capita calorie intake between the two groups is 12.8 percent.

Table 7 presents the results of the decomposition analysis. Overall, the results for decomposition show that the mountain countries have fewer favorable endowments (that is, such countries are less endowed by nature with favorable conditions for agriculture), which makes up for more than 53 percent of the gap in per capita daily calorie intake. The overwhelming share (nearly 80 percent) of the differences due to dissimilarities in explanatory variable results from the income variable. The total contribution of the differences in parameters makes up nearly 47 percent of the gap. Overall, income per capita, population size, trade openness, global food prices, governance, and road density appear to be important explanatory variables that contribute to the gap in per capita daily calorie supply.

Table 6. Regression coefficients and mean values of variables for decomposition

Variable	**Nonmountainous countries**		**Mountainous countries**	
Per capita calorie intake (log)	**7.835**		**7.707**	
	β^{nm}	$\bar{X}^{nm}$	β^{m}	$\bar{X}^{m}$
Latitude	0.001	16.154	0.0006	14.600
Distance (log)	0.008	5.484	0.0296	
Population (log)	0.018	15.973	0.001	15.708
Income per capita (log)	0.078	7.064	0.107	6.439
Arable land per capita (log)	0.020	-1.665	0.020	-1.853
Road density (log)	0.010	-1.722	0.032	-1.847
Trade (%)	0.0003	80.266	0.001	78.056
Food aid per capita	-0.015	0.353	-0.002	0.600
Global food prices	0.001	13.862	-0.004	15.340
Democracy	-0.001	7.997	-0.010	8.384
Ethnolinguistic fractionalization	-0.031	0.497	0.049	0.394
Intercept and region fixed effects	6.975		6.973	
No. of countries	93		23	
No. of observations	987		251	
F stat.		234.2		
Adjusted R^2		0.75		

Source: Author's calculations.

Notes: The average gap in daily per capita calorie intake between nonmountain and mountain countries from 1995 to 2005 period was 12.8%. Regression coefficients are from model F3 in Table 5. Mean values of variables are estimated separately for two samples.

Table 7. Decomposition of the differential in daily per capita calorie intake between non-mountain and mountain countries

Factor	Gap due to coefficients	Gap due to variables	Total	%
Latitude	0.010	0.001	0.011	5.9
Distance (log)	-0.123	-0.004	-0.128	-66.8
Population (log)	0.271	0.002	0.273	142.9
Income per capita	-0.191	0.054	-0.137	-71.7
Arable land per capita (log)	0.000	0.004	0.004	2.1
Road density (log)	0.038	0.002	0.040	21.0
Trade (%)	-0.043	0.001	-0.042	-22.3
Food aid per capita	-0.006	0.001	-0.005	-2.2
Global food prices	0.066	0.004	0.070	36.8
Democracy	0.072	0.001	0.074	36.5
Ethnolinguistic fractionalization	0.036	-0.007	0.028	14.9
Constant and region fixed effects	0.002		0.002	0.9
Total contribution	0.060	0.068	0.128	100
In %	46.8	53.2	100	

Source: Author's calculations.
Notes: Some totals may not add to 100, due to rounding. The average gap in daily per capita calorie intake between non-mountain and mountain countries from 1995 to 2005 was 12.8%. Factor contributions due to coefficients and variables are computed using equation 4.

6. CONCLUSIONS

The study seeks to explore the notion that there is a food security gap between nonmountain and mountain countries. We use descriptive narratives, regression analysis, and decomposition techniques to examine the gap in daily per capita calorie intake and per capita food availability in grain equivalents between the two groups of countries. Descriptive findings show that the mountain countries have important differences in food security as well as in factors that determine these outcomes. In our regression specifications, we control for these important determinants of food security that account for differences in income, agricultural potential, infrastructure access, trade openness, institutions, and governance. The regression decomposition technique helps to decompose the total differential in food security indicators between the nonmountain and mountain countries into two parts.

Our results show that there is a significant gap in daily per capita calorie intake as well as per capita food availability in grain equivalents between the two groups of countries. Our findings confirm the importance of income, population, agricultural potential, infrastructure access, and trade openness for food security. In addition, the results suggest that mountainous countries are especially vulnerable to external shocks such as surges in global food prices. Further, regression decomposition analysis shows that the food security gap between nonmountain and mountain countries is due not only to the mean differences in the determinants of food security but also the differences in the relationship between the determinants and food security of the two groups. From a policy perspective, the results indicate that measures that enhance income-generating capacity and infrastructure access in mountainous regions may help to improve the overall food security. Higher levels of trade openness and agricultural exports can also increase food security in mountain regions. Further, given the natural constraints and limited availability of arable land in mountain areas, using intensive agricultural practices may have a positive effect on food security. Obviously, more research needs to be done to further explore the sources of the food security differential between nonmountain and mountain countries. Moreover, future research should investigate how effective various policy options are at improving food security in mountain countries.

APPENDIX

The countries are grouped based on their calorie intake and natural endowment status in Table A1 below. Daily per capita calorie intake falls below the sample mean in 17 of the 24 mountain countries. Among the nonmountain countries, calorie consumption is more evenly distributed: low calorie intake is observed in 47 countries and high calorie intake in 62 countries. In more than half of the high calorie consumption countries (33 of them), high calorie consumption is associated with better land conditions where arable land accounts for more than one-fourth of total area. Similarly, low calorie consumption is associated with poor land quality (less than a quarter of total area is arable) in more than two-thirds of low calorie consuming countries in the nonmountain group.

In terms of regional distribution, low food security countries, captured by low calorie intake, are disproportionally concentrated in Sub-Saharan Africa. Sub-Saharan African countries make up one-third of the sample but account for more than half of low food security countries. About 80 percent of countries in this region are identified as low food security. South Asia is another region that calls for immediate action: calorie intake is below the sample average in all six countries in the region. The food consumption situation is relatively better in East Asia and Latin America, where half of the countries report low nutrient consumption. The East Europe and Central Asia region demonstrates the best food security situation. For example, only 3 out of 29 countries need to increase calorie supply to achieve food security: Armenia, Tajikistan, and Uzbekistan. Food insecurity is also noticeable in two countries in Middle East and North Africa: Yemen and Djibouti.

Table A.1. Typology of the mountain and nonmountain countries by calorie intake and arable land availability

Calorie intake	Mountain	Arable land	Sub-Saharan Africa	East Asia and Pacific	South Asia	Middle East and North Africa	Latin America and the Caribbean	East Europe and Central Asia
Low	Mountain	Low	Burundi, Eritrea, Ethiopia, Rwanda, Swaziland	Laos	Nepal	Yemen	Colombia, El Salvador, Guatemala, Honduras, Peru	Armenia, Tajikistan
		High		Mongolia			Bolivia	
	Non-mountain	Low	Angola, Botswana, Comoros, Congo Republic, DRC, Gambia, Guinea, Guinea-Bissau, Kenya, Liberia, Madagascar, Malawi, Mozambique, Senegal, Sierra Leone, Uganda	North Korea, Philippines, Solomon Islands, Thailand	Bangla-desh,India, Maldives, Pakistan, Sri Lanka	Djibouti	Dominican Republic, Haiti, Panama, Venezuela	Uzbekistan
		High	Benin, Burkina Faso, Cameroon, Central African Republic, Chad, Mali, Namibia, Niger, Sudan, Tanzania, Togo, Zambia, Zimbabwe	Cambodia			Nicaragua, Paraguay	

Table A.1. Continued

Calorie Intake	Mountain	Arable land	Sub-Saharan Africa	East Asia and Pacific	South Asia	Middle East and North Africa	Latin America and the Caribbean	East Europe and Central Asia
High	Mountain	Low	Lesotho				Costa Rica, Ecuador	Georgia
		High						Bosnia-Herzegovina, Kyrgyzstan, Macedonia
	Non-mountain	Low	Cape Verde, Cote d'Ivoire, Ghana, Mauritania, Mauritius, Nigeria	Brunei, China, Indonesia, Malaysia, Myanmar, South Korea, Vietnam		Algeria, Egypt, Jordan, Lebanon, Saudi Arabia, United Arab Emirates	Barbados, Chile, Grenada, Jamaica, Suriname, Trinidad and Tobago	Albania, Azerbaijan, Cyprus, Slovenia
		High	Gabon, South Africa	Fiji		Iran, Libya, Morocco, Syria, Tunisia	Argentina, Belize, Brazil, Cuba, Guyana, Mexico, Uruguay	Belarus, Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Kazakhstan, Latvia, Lithuania, Moldova, Poland, Romania, Russia, Serbia and Montenegro, Slovakia, Turkey, Turkmenistan, Ukraine

Source: Authors' compilation.
Notes: Based on 133 developing and transition countries. Calorie intake is high if daily per capita calorie intake is above sample mean (2,600 kcal) and low otherwise. Arable land availability is high if share of arable land in total area is above same mean (24 percent) and low otherwise. Region classification is based on World Bank country groups (World Bank 2009).

REFERENCES

Acemoglu, D., S. Johnson, and J. Robinson. 2001. The colonial origins of comparative development: An empirical investigation. *The American Economic Review* 91(5), 1369–1401.

Alesina, A., R. Baqir, and W. Easterly. 1999. Public goods and ethnic divisions. *Quarterly Journal of Economics*. 114 (4): 1243–1284.

Barrett, C. B. 2002. *Food aid and commercial international food trade*. Trade and Markets Division Background Paper. Paris: Organization for Economic Cooperation and Development.

Collier, P., and A. Hoeffler. 2004. Greed and grievance in civil war. *Oxford Economic Papers* 56 (4): 563–595.

Desmet, K., I. Ortuño-Ortin,. and R. Wacziarg. 2009. The political economy of ethnolinguistic cleavages. Working Paper 15360. Cambridge, Mass.: The National Bureau of Economic Research.

Easterly, W., and R. Levine. 1997. Africa's growth tragedy: Policies and ethnic divisions. *The Quarterly Journal of Economics* 112 (4): 1203–1250.

Easterly, W. and R. Levine. 2003. Tropics, germs, and crops: the role of endowments in economic development. *Journal of Monetary Economics*, 50 (1): 3-39.

FAO (Food and Agriculture Organization of the United Nations). 2002. *The state of food security in the world 2002*. Rome.

________. 2008. *The state of food security in the world 2008: High food prices and food security:—Threats and opportunities*. Rome.

________. 2009a. *The state of food security in the world 2009: Economic crises—Impacts and lessons learned*. Rome.

________. 2009b. Food security statistics. http://www.fao.org/economic/ess/food-security-statistics/en/. Accessed November 15, 2009.

Freedom House. 2009. Freedom in the World: Comparative and historical data. <http://www.freedomhouse.org/template.cfm?page=439 >. Accessed November 15, 2009.

Gallup, J. L., J. D. Sachs, and A. D, Mellinger. 1999, Geography and development. *International Regional Science Review* 22(2): 179–232.

Gibbons, J. D. 1971. *Nonparametric statistical inference*. New York: McGraw-Hill.

Grantham-McGregor, S. M., L. C. Fernald, and K. Sethuraman. 1999. Effects of health and nutrition on cognitive and behavioral development in children in the first three years of life. Part 2: Infections and micronutrient deficiencies: Iodine, iron, and zinc. *Food and Nutrition Bulletin* 20 (1): 76–99.

Hall, R. E., and C. I. Jones, 1999. Why do some countries produce so much more output per worker than others? *The Quarterly Journal of Economics* 114(1): 83–116.

Huddleston, B., E. Ataman, P. de Salvo, M. Zanetti, M. Bloise, J. Bel, G. Francheschini, and L. Fe` d'Ostiani. 2003. *Towards a GIS-based analysis of mountain environments and populations*. Environment and Natural Resources Working Paper 10. Rome: FAO.

IMF (International Monetary Fund). Primary commodity prices database, available online at http://www.imf.org/external/np/res/commod/index.asp.

Kapos, V., J. Rhind, M. Edwards, M. F. Price, and C. Ravilious. 2000. Developing a map of the world's mountain forests. In *Forests in sustainable mountain development: A state-of-knowledge report for 2000*, ed. M. F. Price and N. Butt. Wallingford, U.K.: CAB International.

Kimenyi, M. S. 2006. Ethnicity, governance and the provision of public goods. *Journal of African Economies,* vol. 15, African Economic Research Consortium Supplement 1: 62–99

Kuhnlein, H. V., and G. Pelto, eds. 1997. Culture, environment, and food to prevent vitamin A deficiency. Ste. Anne de Bellevue, Quebec: Centre for Nutrition and the Environment of Indigenous Peoples (CINE).

Kumar, K. 1995. Mountain and people: A people's perspective from the Indian Himalayas. Paper presented at the NGO Consultations on Sustainable Mountain Development. February 1995. Lima, Peru.

Masters, W. A., and M. S. McMillan. 2001. Climate and scale in economic growth. *Journal of Economic Growth* 6 (3): 167–186.

Millennium Ecosystem Assessment. 2005. Ecosystems and human well-being: Current state and trends. In *Findings of the Condition and Trends Working Group* (ch. 24 Mountain Systems). Washington, D.C.: Island Press.

Price, M. F., L. Jansky, and A. A. Iatsenia, eds. 2005. *Key issues for mountain areas*. New York: United Nations University Press.

Sen, A. 1982. *Poverty and famines : An essay on entitlements and deprivation.* Oxford: Clarendon Press

Smith, L. C. and L. Haddad. (2000). *Explaining child malnutrition in developing countries: A cross-country analysis*. Washington DC: International Food Policy Research Institute.

Svedberg, P. 2002. Undernutrition Overestimated, *Economic Development and Cultural Change* 51(1): 5-36.

Scrimshaw, N. S., and. B. Schürch, eds. 1998. Causes and consequences of intrauterine growth retardation. *European Journal of Clinical Nutrition* 52, Supplement 1.

Tweeten, L. 1999. The economics of global food security. *Review of Agricultural Economics* 21 (2): 472–488.

UNEP—WCMC (United Nations Environmental Program—World Conservation Monitoring Centre). 2002. *Mountain Watch: Environmental change and sustainable development in mountains*. Cambridge, UK.

von Dach, S. W., C. Ott, A. Klaey, and B. Stillhardt. 2006. Will international pursuit of the Millenium Development Goals alleviate poverty in mountains? *Mountain Research and Development* 26 (1): 4–8.

Wooldridge, J. 2002. *Introductory econometrics: A modern approach*. Cincinnati, OH: South-Western College Publishing.

World Bank. 2009. *World development indicators 2009.* Washington, D.C.: World Bank

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2033 K Street, NW
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Tel.: +1-202-862-5600
Fax: +1-202-467-4439
Email: ifpri@cgiar.org

IFPRI ADDIS ABABA

P. O. Box 5689
Addis Ababa, Ethiopia
Tel.: +251 11 6463215
Fax: +251 11 6462927
Email: ifpri-addisababa@cgiar.org

IFPRI NEW DELHI

CG Block, NASC Complex, PUSA
New Delhi 110-012 India
Tel.: 91 11 2584-6565
Fax: 91 11 2584-8008 / 2584-6572
Email: ifpri-newdelhi@cgiar.org