FOOD SECURITY IN LESS DEVELOPED COUNTRIES, 1970 TO 1990

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Despite a global food surplus, almost half of the world's less developed countries suffer significant problems concerning food. Most social science and policy discussions of food security make the "food availability" assumption that increased food supply is the key to reducing hunger. Critics argue, however, that increased food supply has little impact on hunger and that the primary culprits are entrenched inequality and militarism. A lagged panel analysis of food supply and child hunger rates (1970–1990) shows that the food supply has only modest effects on child hunger rates and that food supply is structurally rooted in development processes (domestic investment, urban bias, foreign capital penetration) while child hunger is politically based in arms imports, internal violence and political democratization. Population pressure, tapped by increased age dependency, undermines both the supply of food and the population's access to it, and cultural dualism magnifies the effects of population pressure on child hunger. The effects of economic growth "trickle down" to affect both food supply and child hunger, and economic growth is also positively correlated with political democratization, suggesting there is no short-term "trade-off" between growth, democratization, and social equity.

FOOD IS THE MOST basic of human needs and is central to the discussion of human rights and social development (Brandt 1986; Drèze, Sen, and Hussain 1995; Food and Agricultural Organization of the United Nations [FAO] 1996a; Kutzner 1991). Despite the "green revolution" and the significant growth in international food aid and assistance, between 1970 and 1990 almost half of the world's less developed countries (LDCs) suffered a decline in aggregate food supply, and more than a quarter suffered an increase in child hunger (Bongaarts 1996; FAO 1996a, 1996b). In the mid-1990s, more than 840 million, or about 20 percent of the LDC population, lacked sufficient food to meet basic nutritional needs (United Nations Population Fund 1999), and more than 200 million children, or almost one-third of those under age five, suffered from severe malnutrition (United Nations International Children's Emergency Fund [UNICEF] 1998). Malnutrition is a major barrier to economic and social development, leaving populations unable to maintain normal lives and to be economically and socially productive.

Most social science and policy discussions, including the existing major early warning models of famine, assume that increased food supply is the key to reducing hunger and that the effects of economic growth will "trickle down" to reduce hunger (FAO 1996a; Foster and Leathers 1999:67; Quinn and Kennedy 1994). Critics have questioned both assumptions. In their his-

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torical and contemporary studies of famine, Sen (1981) and Drèze and Sen (1989) show that resourceful households rarely go hungry despite aggregate food shortages and that the poor are often hungry even when food supply is plentiful. Economic growth may improve aggregate food supply, but because of unequal control of economic resources the poor and disadvantaged remain hungry. A second criticism is that economic growth does not address basic needs because of sectoral disparities created by early industrialization (Kuznets 1955), economic dependency (Bornschier and Chase-Dunn 1985; London and Williams 1990), and urban bias (Bates 1981; Lipton 1977; Weede 1996). A third critique focuses on militarism, arguing that contemporary hunger is due to internal repression, civil war and arms races (also known as the "military famine" thesis) (Action Against Hunger 2000; Cheatham 1994; de Soysa and Gleditsch 1999; Macrae and Zwi 1994). And finally, there is the neo-Malthusian argument (Cohen 1995; Ehrlich and Ehrlich 1990; Smil 1994)—that sustained high fertility is overshooting ecological limits, creating overcultivation, excessive fertilizer use, and soil degradation that leads to a fall in food production and an increase in hunger.

We address these critiques using a lagged panel cross-national analysis of food supply and child hunger. Past cross-national research has examined food supply (often misleadingly referred to as "food consumption") and has focused on the modernization/dependency debate. This past research shows that economic growth increases food supply (Firebaugh and Beck 1994) and that export dependence, foreign capital penetration, and international debt are detrimental to the food supply (Bradshaw et al. 1993; Wimberley 1991; Wimberley and Bello 1992). This neglects the more critical question of hunger and ignores other explanations, such as democratization, urban bias, population pressure, the evolutionary advantages of agrarian density, and the role of militarism. Some of this work (Bradshaw et al. 1993; Wimberley 1991; Wimberley and Bello 1992) has also misinterpreted the negative effect of foreign capital penetration, seeing it as indicating an absolute decline in food supply when in fact it merely indicates that foreign investment is *relatively* less beneficial than domestic investment, a position that is compatible with mainstream development theory (Firebaugh 1992, 1996).

WHAT IS FOOD SECURITY?

Food security has been promoted by the United Nations (FAO 1996a, 1996b; United Nations Development Programme [UNDP] 1994) and analysts of hunger and famine (Brandt 1986; Drèze et al. 1995; Foster and Leathers 1999; Sen 1981) as the most basic human need and as a central indicator of absolute poverty and physical well-being. Food security refers not only to an adequate aggregate supply of food, but also means that "all people at all times have both physical and economic access to basic food. This requires not just enough food to go around. It requires that people have ready access to food" (UNDP 1994:22). We use two indicators: (1) food supply is measured as the mean daily per capita supply of calories and protein (FAO 1996b), and (2) the child hunger rate is measured by the percentage of children under age 5 who are undernourished (UNDP 1994).[1]

Table 1 charts food security trends between 1970–1975 and 1990 in all LDCs with populations over 1 million. For food supply, we use the five-year means for 1968–1972 and 1988–1992 to eliminate annual volatility. These are derived from the food balance sheets of the FAO (1972, 1974, 1992, 1994) and include estimates of marketed and nonmarketed food from all domestic and international sources (including self-production and aid). This is the most reliable indicator of food supply available and has broader temporal and country coverage than any

[1] "Food supply" has sometimes been mislabeled "food consumption" (Wimberly 1991; Wimberly and Bello 1992), implying that aggregate supply reduces hunger. Tweeten and McClelland (1997) refer to "availability" and "access" measures and note that there is also the micro question of the metabolizing of ingested food. Both food supply and hunger rates could be seen as "access" questions in that the food supply taps the access of LDCs as aggregate units to the global food supply, while the hunger rate taps the access of households and specific groups to the country-level food supply.

Table 1. Means and Standard Deviations for Measures of Food Supply and Child Hunger: Less Developed Countries, 1970 and 1990

World Region	Daily Calories per Capita		Daily Protein Grams per Capita		Percentage of Hungry Children under Age 5[a]	
	Circa 1970	Circa 1990	Circa 1970	Circa 1990	Circa 1975	Circa 1990
All less developed countries (N = 88)	2,227.47 (299.12)	2,397.43 (416.82)	57.62 (12.97)	60.91 (14.47)	28.88 (15.34)	23.42 (13.81)
Asia and Oceania (N = 21)	2,184.0 (287.37)	2,426.32 (377.67)	54.89 (38.20)	60.51 (13.74)	46.29 (16.25)	38.24 (13.70)
Latin America (N = 21)	2,364.75 (345.77)	2,501.20 (310.96)	61.84 (14.55)	63.22 (11.84)	15.71 (7.19)	11.48 (6.74)
North Africa and the Middle East (N = 11)	2,357.65 (290.45)	3,004.76 (316.66)	64.13 (12.12)	81.18 (9.96)	18.20 (4.75)	10.70 (2.83)
Sub-Saharan Africa (N = 35)	2,130.27 (239.19)	2,126.96 (269.24)	54.70 (11.37)	53.40 (10.91)	31.52 (10.00)	27.24 (8.74)
Final caloric supply model (N = 55)	2,249.56 (302.85)	2,408.22 (383.09)	—	—	—	—
Final protein supply model (N = 55)	—	—	58.25 (12.86)	60.92 (13.10)	—	—
Final hungry children model (N = 63)	—	—	—	—	28.51 (16.35)	22.53 (14.64)

Countries with Food Security Decline

Countries that lost 100 or more mean daily calories per capita (N = 33):

Afghanistan, Angola, Argentina, Bangladesh, Burundi, Cambodia, Cameroon, Central African Republic, Chad, Cuba, Democratic Republic of Congo, Guinea, Haiti, Kenya, Laos, Liberia, Madagascar, Malawi, Mongolia, Mozambique, Nicaragua, North Korea, Paraguay, Peru, Senegal, Sierra Leone, Somalia, South Africa, Togo, Uganda, Uruguay, Zambia, Zimbabwe

Countries that lost 3 or more grams of daily protein per capita (N = 29):

Afghanistan, Angola, Argentina, Burundi, Cambodia, Cameroon, Chad, Cuba, Democratic Republic of Congo, Guinea, Haiti, Iraq, Ivory Coast, Jamaica, Kenya, Laos, Liberia, Madagascar, Malawi, Mongolia, Nicaragua, North Korea, Rwanda, Sierra Leone, Somalia, Uganda, Uruguay, Zambia, Zimbabwe

Countries in which the percentage of hungry child under age 5 increased 1 percent or more (N = 12):

Afghanistan, Angola, Burundi, Madagascar, Malawi, Mozambique, Nigeria, Senegal, Sierra Leone, Uruguay, Zaire, Zambia

Note: Numbers in parentheses are standard deviations.

[a] Weight-for-age measure (Foster and Leathers 1999:62–63).

other available cross-national indicator (Foster and Leathers 1999:66–73). However, it does not tap hunger (i.e., the differential access of households and particular groups to adequate food).

To measure hunger, we use the percentage of children under 5 years of age whose body weight is more than two standard deviations below the median weight-for-age of the country's population. This "weight-for-age" method, also known as the "Gomez system" (Foster and Leathers 1999:62–63), is the most reliable gauge of preschool children who are at risk for primary (i.e., from insufficient calories) and secondary (i.e., from diarrheal infection that depletes nutrients) undernutrition.[2] It ad-

[2] Other types of unhealthy weight are not captured by this weight-for-age measure (e.g., obe-

justs for the physical characteristics of the country's population and is available beginning in 1975 from country surveys conducted by the World Health Organization (FAO 1996b; UNDP 1994). Insofar as child undernutrition is correlated with that in the population at large or among ethnic minorities, women, and peasants (Bhuiya and Karim 1989; Kelly 1992), it serves as a proxy for hunger in the general population. Because the measure is not available annually, we focus on the change from 1975 to 1990, the longest time-period currently available.

The overall trend among LDCs is toward increased food security (Table 1). Between 1970 and 1990, caloric and protein supply increased by 7.63 percent and 5.71 percent, respectively, and mean child hunger rates dropped from 28.9 to 23.4 percent. Progress, however, has been regionally uneven with the greatest improvements in North Africa and the Middle East, moderate change in Asia and Oceania and Latin America, and a decline in sub-Saharan Africa. Yet, by the weight-for-age measure, more than a third of all children are estimated to be hungry in Asia and Oceania in 1990, more than one-quarter of children in sub-Saharan Africa in 1990, and 10 percent or more in the other world regions.

Table 1 lists the LDCs with significant negative changes and the means and standard deviations for the samples used in the regression analysis below. For food supply we list all LDCs that lost 100 or more mean daily calories per capita and 3 or more grams of daily protein per capita; for child hunger rates, we list all LDCs with an increase of 1 percent or more. Over half of the countries in sub-Saharan Africa suffered declining food supply. Estimated child hunger declined everywhere except for 10 countries in sub-Saharan Africa, civil war-torn Afghanistan, and Uruguay. What drives these trends in food security?

sity, iron deficiency) but, for a study of the prevalence of child hunger, it is the best available measure. It provides the best overall measure of both linear growth and body proportion and is thus superior to measures of stunting and wasting (de Onis et al. 1993; FAO 1996b:65–66; Foster and Leathers 1999:62–63).

EXPLAINING FOOD SECURITY

We examine six explanations of food security: (1) modernization, (2) economic dependency, (3) urban bias, (4) neo-Malthusian population pressure, (5) ecological evolutionary processes, and (6) militarism. Because there are few prior cross-national studies of food security to serve as a benchmark, we draw on the findings of past studies of social welfare, especially those on the physical quality of life and other basic needs.

MODERNIZATION

Modernization theory emphasizes internal sources of economic development. It argues that domestic investment and educational growth create industrialization and cultural modernization, which in turn contribute to economic growth, societal integration, and stronger institutions for providing social welfare. In some formulations (Rostow 1960), economic savings and investment in physical capital are the key to an industrial "take-off," while for others (Inkeles and Smith 1974; Kerr 1969), including the "new" or "endogenous growth" models (Barro 1991), investment in human capital via increased education creates a labor force with modern motivation, greater skills, social mobility, and adaptability to modern technology. While some argue that there is a short-term trade-off between growth and equity (Arrow 1979; Letwin 1983), in the long run, it is assumed that economic growth "trickles down" to increase social welfare. International trade and investment are viewed as socially beneficial, stimulating economic development, the diffusion of new technology and practices, and improvements in social welfare. A significant body of research shows that economic development, industrialization, education, and urbanization improve the physical quality of life and other social welfare measures (Bullock and Firebaugh 1990; Jackman 1975; Shen and Williamson 1997; Williamson 1987), and that economic growth increases food supply, infant survival, and adult longevity (Bullock and Firebaugh 1990; Firebaugh and Beck 1994).

Modernization theorists disagree over the role of the state. Some focus solely on capi-

tal investment and industrialization (e.g., Rostow 1960), ignoring political institutions and processes, while others treat state-building and national integration as central to modernization (e.g., Huntington 1968; Kerr 1969). Among the latter, one view is that industrialization creates new groups and political demands that have to be regulated to sustain growth and political stability. Thus, there is a "growth-democracy" trade-off (Huntington 1987): Political democracies are vulnerable to political instability, and "strong" authoritarian regimes are better at regulating these new demands and introducing the economic interventions needed for industrialization (Apter 1965; Huntington 1968; Janowitz 1977). Others argue that democratization boosts economic and social development by allowing the lower classes to organize and press their interests, which inhibits corruption, encourages growth-reinforcing policies, including public investments in nutrition, education, and health, and provides greater political stability (Goldsmith 1986; Goodell and Powelson 1982; Khohli 1986; Sorensen 1991). Studies show that political democracy is positively correlated with improved physical quality of life (London and Williams 1990; Moon and Dixon 1985; Wickrama and Mulford 1996), basic needs fulfillment, more balanced urban-rural development, and lower income inequality (Crenshaw 1992; Goldsmith 1986; Sorensen 1991), which may also promote food security.

Economic Dependency

The core of economic dependency/world systems theory is the argument that international trade and investment impose negative social welfare effects. Drawing on theories of unequal exchange (Amin 1976; Emmanuel 1972), one argument points to the long-term decline in the international terms of trade for primary versus processed goods and the sectoral disarticulation (or disparity) associated with export dependence. Studies have shown that export dependence lowers economic growth and the physical quality of life (Delacroix and Ragin 1981; London and Williams 1990; Ragin and Bradshaw 1992), reduces aggregate food supply (Bradshaw et al. 1993; Firebaugh and Beck 1994; Wimberley and Bello 1992), and contributes to higher child and infant mortality (Bradshaw et al. 1993; Firebaugh and Beck 1994). Economic dependency also contributes to sectoral disarticulation, which in turn is associated with higher child mortality, higher crude death rates, and lower physical well-being (Breedlove and Armer 1997; Stokes and Anderson 1990). These effects of economic dependency should extend to child hunger.

In recent years, dependency theorists have seen foreign investment as even more detrimental to social welfare because of the global shift in core-periphery relations since the 1960s (Bornschier and Chase-Dunn 1985; Frank 1967). Several processes are responsible. First, multinational corporations (MNCs) repatriate most of their profits and discourage domestic firm formation and investment, thus reducing domestic economic growth and social welfare benefits. Second, foreign investment is more dependent on advanced technology, absorbing less labor and creating a smaller number of high-paying jobs, which contributes to income inequality and urban poverty. Third, foreign investment is largely concentrated in export industries and has weak market ties and economic multipliers with domestically oriented production. Fourth, MNCs oppose social programs that benefit the lower classes, disguise profits that would otherwise be taxed, and pressure governments to make infrastructure investments that divert funds from social programs. Thus, although flows of foreign investment may create economic growth, the long-term impact of foreign capital penetration should be negative.

Several studies of the foreign capital penetration (PEN) ratio have misinterpreted its negative effect as indicating an absolute decline in economic growth and social welfare (Bradshaw et al. 1993; London and Smith 1988; London and Williams 1990; Wimberley 1991; Wimberley and Bello 1992). As Firebaugh (1992, 1996) notes, the foreign capital penetration ratio is essentially the ratio of foreign to total capital stock.[3]

[3] This is true whether the indicator used is foreign direct investment stock over total capital stock, GDP, or adds an adjustment for population size.

Thus, a negative effect merely means that foreign investment is *relatively* less beneficial to economic growth than domestic investment (Firebaugh 1992, 1996), not that it produces an absolute decline in economic growth or social welfare. As Dixon and Boswell (1996a) argue: "often the choice [facing LDCs] is not between foreign capital and domestic capital but between foreign capital and no capital at all" (p. 547). We refer to this as the "relative benefit" thesis. Following Dixon and Boswell (1996a, 1996b), we test the interaction of the foreign capital penetration ratio with the domestic investment rate (to represent relative decapitalization) and economic growth (to represent relative distorted growth), but following Firebaugh's (1996) argument, we interpret interactions as reflecting the relative benefits of foreign versus domestic investment instead of an absolute decapitalization or distortion effect.

Urban Bias

A third approach is urban bias theory, which focuses on the political power of urban elites, arguing that elites use the state to channel resources to the cities and exploit the peasantry, who, although large in number, are geographically dispersed, disorganized, and subject to the "free-rider" problem (Bates 1981; Lipton 1977; Weede 1996:65–87). Studies show that overvalued currency, protective import tariffs, high agricultural taxes and export duties, and the creation of monopolistic crop procurement and export marketing boards discourage agricultural investment and contribute to sectoral disparity in productivity, thereby undermining agricultural development (Lofchie 1997). The most important symptom is sectoral disparity in investment, which means that the productivity of agricultural labor is about half of that in nonagriculture (Lipton 1977:189–215). This bias is not only inequitable, producing rural/urban income inequality and a significant social welfare gap, but is also inefficient, undermining agricultural development and food production.

Studies show that rural/urban disparity is associated with lower economic growth (Bradshaw 1987; Bradshaw and Noonan 1997), greater income inequality (Chenery, Robinson, and Syrquin 1986), and lower physical quality of life (Breedlove and Armer 1997; Stokes and Anderson 1990). However, these inequities may simply be a result of the economic backwardness and cultural dualism of traditional rural social systems (Alderson and Nielsen 1995; Nielsen 1994). Because we lack direct measures of the political power of urban elites, we control simultaneously for the *change* in rural/urban disparity net of simultaneous controls for the initial level of sectoral disparity, agricultural labor force, and the development level. We treat the change in disparity as indicating urban bias (i.e., underinvestment in and exploitation of the rural sector) when it is significant net of these other controls. The initial level of rural/urban disparity is treated as indicating a heritage of cultural dualism. Some argue that dependency is responsible for urban bias (Gugler 1997; London and Smith 1988; Stokes and Anderson 1990), which we test by examining the effect of economic dependency on the change in sectoral disparity.

Neo-Malthusian Pressure

Neo-Malthusians argue that high fertility and population growth lead to an ecological "overshoot" in terms of overcultivation, excess fertilizer use, deforestation, desert formation, and soil degradation, all of which should undermine food security (Cohen 1995; Ehrlich and Ehrlich 1990; Ehrlich, Ehrlich, and Daily 1993; Smil 1994). These variables are sometimes gauged by the density of rural labor force normed against measures of arable land, termed "agrarian adversity" (Firebaugh 1979). Increased age dependency (essentially expanded household size owing to high fertility) is especially detrimental in rural areas because this pressures rural households to put marginal land into production and intensifies land use, thus degrading the soil and reducing agricultural output, thereby undermining food security.

There is considerable debate about such claims. As noted above, the "green revolution" and the expansion of cultivated lands have kept agricultural production ahead of population growth in the LDCs (Bongaarts 1996). Elsewhere (Scanlan 2001), we show that rural and total population growth do not

affect food security, but slow downward change in fertility and increased age dependency reduce food supply and contribute to hunger. We extend this observation here by examining the interaction between age dependency and sectoral disparity, testing the argument that cultural dualism magnifies population pressure. Peasants have an economic incentive to maintain high fertility, which leads to overcultivation, use of marginal land, and agricultural decline.

Ecological Evolutionary Theory

A rival interpretation to agrarian density is advanced by ecological evolutionary theory. This theory contends that traditional "plow" agriculture and resulting high levels of agrarian density facilitate rapid industrialization and thus improved social welfare (Lenski, Lenski, and Nolan 1995). Studies have found that agrarian density accelerates fertility decline, promotes rapid industrialization, and lowers income inequality (Crenshaw 1993; Crenshaw and Ameen 1993). Thus, agrarian density may also improve food security.

Militarism

A final thesis is the "military famine" argument that militarism is responsible for hunger and that violent conflict, political repression, and structural inequality, not the aggregate food supply, is the major cause of hunger (Action Against Hunger 2001; Cheatham 1994; de Soysa and Gleditsch 1999; Macrae and Zwi 1994; Poleman 1997). Militarism, refers to the use of military force to regulate political conflicts (Ross 1987), including both civil and international relations. Militarism includes international arms races, which result in reduced public investment in basic needs such as nutrition, health, and education programs (Brzoska and Ohlson 1987), and civil and interstate wars, state repression, and military coups. Such internal violence disrupts food production and distribution, including international food assistance, because rival forces use food as a political weapon to control populations and territory (de Soysa and Gleditsch 1999), often targeting ethnic minorities and the rural poor. In earlier work, we found that arms imports, military instability, repression, and civil wars reduce the food supply and contribute to child hunger (Scanlan and Jenkins 2001). Here we examine a broader range of violence measures and investigate how these interact with development processes.

Possible Interactions and Mediating Processes

The factors identified by the theories discussed above may also mediate and interact with each other. For example, modernization should produce a demographic transition, whereas economic dependency should slow fertility decline (London 1987), thus alternately countering and aggravating population pressures. If the "democratic instability" thesis (Huntington 1968) is correct, democratization should give rise to militarism and internal violence, thereby disrupting food security. Or alternatively, dependent development may lead to bureaucratic-authoritarian rule, military coups and internal repression (Cardoso and Faletto 1979), which should also undermine food security. Thus militarism should stem from underlying structural development processes associated with either modernization or economic dependency. If, however, military instability is not rooted in these development processes, then it may fit a distinct "military famine" thesis according to which hunger is largely a political problem. There is also the long-standing debate about rural/urban disparity, which some attribute to foreign investment and export dependency (Gugler 1997), urban bias (Bradshaw 1987; Lipton 1977), and long-standing cultural dualism (Alderson and Nielsen 1995; Nielsen 1995). Finally, there is the "food availability" question about whether food supply reduces hunger. If we find little impact of food supply on child hunger and different causal factors emerge for food supply and child hunger rates, then hunger must be assumed to have distinct origins. Given these arguments, we examine the data with an eye to multiple explanations, possible overlaps, and interactions.

METHOD AND MEASUREMENT

We use a lagged panel or conditional change model. We predict the value of the depen-

dent variable for food supply and child hunger, (Y_{t2}), net of its earlier value, Y_{t1}, and independent variables measured at an earlier time. This is the best method for capturing structural trends that display considerable stability over time in which values at an early point have a strong effect on later values (Allison 1990; Finkel 1995:7–11). In effect, this model estimates the impact of independent variables on *change* in a dependent variable, which thus provides an assessment of the longitudinal trend (Hannan 1979).

This model also has several advantages over a cross-sectional and an unconditional change-score design. First, relative to a cross-sectional design, it helps rule out reciprocal effects and possible spuriousness. Second, it is more appropriate for testing arguments about structural trends that involve a significant time lag. For example, the foreign capital penetration and cultural dualism (rural/urban disparity) arguments are about structural effects that take several decades to become fully manifest. Third, because it controls for the typically strong correlation between the dependent variable at two points in time, including the possibility of serial correlation of measurement errors, it provides a conservative estimate of the effects of independent variables (Hannan 1979). Fourth, it improves on unconditional change-score models, which assume that the lagged endogenous variable has no effect on later values. This assumption is unrealistic with a phenomenon like food security that tends to remain stable over time with small incremental changes. A lagged panel model is also superior to fixed-effects models or the "method of first difference" (Allison 1990) insofar as it allows us to examine independent variables that are long-standing structural conditions as well as trends (Finkel 1995:7–8). Although it is more vulnerable to specification bias than fixed-effects models, we test a broad set of theories, including dummy controls for region that test for unmeasured regional factors. We also checked all of our equations for heteroskedasticity by inspecting plots of residuals and using the Breusch-Pagan test in LIMDEP 6.0 (Breusch and Pagan 1979; Judge et al. 1985) and found no evidence of problems.

To provide a substantial time lag, we predict food supply and child hunger for 1990 net of lagged controls for 1970–1975. Some of our arguments are about long-standing structural conditions (e.g., foreign capital penetration), while others involve change (e.g., increased investment in human capital). We therefore measure structural variables circa 1970 and changes in variables between 1965–1970 and 1985–1990. To check the possibility that structural conditions might generate persisting patterns masked by our lagged panel, we also examine cross-sectional models and report the small differences from the lagged panel analysis. To maintain consistent signs in the models (i.e., positive signs indicate favorable change in food security), we use the percentage of healthy weight children to index improvements in child hunger rates.

We draw on theory and past research to define how change in independent variables is represented. First, where the question is a simple structural trend, we use a first-difference score ($X_{t2}-X_{t1}$). Second, where the time period of exposure is critical (e.g., growth in age dependency) we use the average annual percentage change ($100\times\{[(X_{t2}-X_{t1})/number\ of\ years]/X_{t1}\}$). Third, where the issue is the amount of change relative to a base value, regardless of time exposure (e.g., increased export dependency), we use the percentage change ($100\times[(X_{t2}-X_{t1})/X_{t1}]$). Finally, where compounding should affect the process (e.g., the rate of investment or economic growth) we use one of several compounding formulas. Recent studies of the compounding of the rate of foreign investment (de Soysa and Oneal 1999; Dixon and Boswell 1996a, 1996b; Firebaugh 1992) have used the following formula:

$$Annual\ I_r = 100\times n\left(\frac{1973K}{1967K}-1\right),$$

where n is the number of years for the change, and 1973 and 1967 are the ending and starting points for the time period for K. This is the mathematical equivalent to annual compounding. To capture annual compounded economic growth, we use the natural log of the ratio of GNP per capita in 1990 to the natural log of GNP per capita in 1970 or $\ln(Y_{t2}/Y_{t1})$ (Jackman 1980:606).

The basic equation for our models is:

$$Y_{t2} = \hat{a}_0 + \hat{a}_1(Y_{t1}) + \hat{a}_2(X_{t1}) + \hat{a}_3(Z_{t2} - Z_{t1}) + ... + \mathring{a}, \quad (1)$$

where Y is food supply or child hunger, X is a structural condition, and Z is a process represented by a first-difference score.

An additional substantive question mandates that food supply be examined in terms of change. Famine is not a sudden event but a long-term development. Thus, it is important to capture structural trends in hunger. Anthropometric research (FAO 1996b:128–42; Foster and Leathers 1999:66–73) also shows that there is no simple caloric or protein threshold for undernutrition. Healthy food intake is always somewhat relative to the climate, culture, age and sex composition, and average body sizes of the population in question. Thus, North Korea, which had 2,867 mean daily calories per capita in 1990, experienced widespread famine five years later with an 18 percent drop to 2,360 mean daily calories per capita, despite the fact that this was considerably higher than the daily caloric supply in almost all of sub-Saharan Africa. Thus, as a gauge of food security, the change in food supply is often more relevant than the absolute level.

We present results using the maximum number of cases available for each model, which reduces the vulnerability to subsample differences. In Table 1, the means and standard deviations for the countries included in the final models are close to those for the full sample of LDCs for which there is available data on caloric and protein supplies and child hunger rates; this suggests that the regression results are representative of the broader set of LDCs. We also tested these equations using a constant N, which produced similar results. We also conducted exhaustive tests for influential cases using standard methods (Bollen and Jackman 1985) and found none. On the caloric analyses, Nigeria and Madagascar were negative outliers, and on protein supply, Nicaragua and Mauritania were negative outliers. In the child hunger analysis, India and Zambia had more child hunger than predicted. These were not influential cases, however, as removing them did not affect our results. Thus, we include them in the results shown. To test for multicollinearity, we used variance inflation factors and bivariate correlations as well as testing all variables sequentially. We discuss below the few instances of multicollinearity that we found.

MEASUREMENT

Table 2 shows the measurement and data sources for our variables. Most of our measures have been used before so we discuss fully only those that are distinctive. As noted, the measure of food supply is based on the mean of the five years surrounding 1990 (i.e., 1988–1992) and 1970 (i.e., 1968–1972), while child hunger is measured by the percentage of children who are of *healthy* weight. These are the most recent food security measures currently available and allow us to test the food availability thesis.

Five measures tap *modernization*. First, GDP per capita taps the level of economic development and serves as a control variable throughout.[4] It is highly skewed so we use the natural log. Second and third, investments in physical and human capital are gauged by the first-difference changes in domestic investment and in secondary schooling rates. A fourth measure is political democratization, gauged by the first-difference change in political democracy (1965–1985). Finally, to tap political instability, we use military instability based on the morale, loyalty, and level of coup activity by the military during the 1970s and 1980s. We also include a set of internal violence and political repression measures to evaluate the "democratic instability" thesis (see militarism discussion below).

Economic dependency is measured by: export dependency based on the percentage change in primary products exports as a percent of total exports;[5] foreign capital pen-

[4] Variables measuring energy consumption per capita and industrial labor produce identical results, but they slightly reduce the available sample size. Thus, we use the GDP per capita measure.

[5] We also tested the 1970 level and percentage change 1970 to 1985 in commodity concentration based on the top three commodities as a percentage of total exports. And we tested export intensity as measured by the 1970 level and percentage change 1970–1985 in exports/GDP ratio. None of these were significant. The primary

Table 2. Measurement of Variables Used in the Analysis

Variable	Description and Data Source
DEPENDENT VARAIBLES:	
Food supply	The five-year mean calories per capita and grams of protein per capita, 1988–1992 (FAO 1994, 1992) and lagged control, 1968–1972 (FAO 1972).
Percentage of healthy weight children	The percentage of children under 5 who are of healthy weight in 1990 and the lagged control, 1975. In the regression models, positive signs indicate fewer children of unhealthy weight (UNDP 1994).
INDEPENDENT VARIABLES:	
Modernization Theory	
Level of economic development (ln)	Real gross domestic product per capita (1980 U.S. dollars), 1970 and 1975 (Summers and Heston, 1991).
Domestic investment	Average annual percentage change in real domestic investment (1980 U.S. dollars) over GDP, 1970–1980 (World Bank 1994).
Human capital investment	First-difference change in secondary schooling rate constructed as the ratio of total secondary school enrollment to the population of the age group that officially corresponds to that level of education, 1970–1985 (World Bank 1997).
Political democratization	First-difference change in index of political democracy, 1965–1985 (Gurr 1989).
Military instability	Measure based on military morale and loyalty, coded for the 1980s as utterly unstable = 4, unstable = 3, barely unstable = 2, not wholly stable = 1, stable = 0 (Kidron and Smith 1983 and supplemented by Morrison et al. 1989).
Dependency Theory	
Export dependency	Percentage change in primary products as a percentage of total exports between 1970 and 1985 (World Bank 1997).
Foreign capital penetration ratio (PEN ratio)	Total foreign stock of direct investment in a country divided by total capital stock, 1967 (Ballmer-Cao and Sheiddegger 1979).
Foreign debt service load	Percentage change in the debt service ratio (debt payments divided by total exports) between 1970 and 1985 (United Nations Conference on Trade and Development 1975–1988; World Bank 1997).
Economic growth	The logged ratio of the startpoint / endpoint of real gross domestic product per capita (1980 U.S. dollars), 1970 to 1985 (Summers and Heston 1991). Also used as a test for the "food availability" thesis.
Urban Bias Theory	
Rural/urban disparity ratio 1965 (cultural dualism)	The ratio of percent nonagricultural GDP to percent agricultural GDP divided by the ratio of the percent of nonagricultural labor force to percent agricultural labor force, 1965 (World Bank 1997).
Change in rural/urban disparity ratio, 1965 to 1985 (urban bias)	The first difference change in the rural/urban disparity ratio,1965–1985 (World Bank 1997).
Neo-Malthusian and Ecological-Evolutionary Theories	
Age dependency	Average annual percentage change in the ratio of the proportion of the population under age 15 to those over age 15, 1970–1985 (World Bank 1994).
Agricultural density	The agricultural labor force divided by the surface area of arable land in square kilometers, 1970 (World Bank 1997).

(Continued on next page)

(Table 2 continued)

Variable	Description and Data Source
Militarism Theory	
Arms imports	Average annual percentage change in the value of arms imports over real GDP between 1970 and 1985 (Brzoska and Ohlson 1987).
Ethnic political discrimination	The summed percentage of the country population that is a minority experiencing severe political discrimination in the form of neglect, social ostracism, and political exclusion and repression 1970 to 1985 (Gurr 1993).
Internal violence	Dummy variable for the presence of civil war or genocide/politicide, coded yes = 1, 1970–1990 (Fein 1993; Harff and Gurr 1989; Kidron and Smith 1983, 1991; Singer and Small 1993).
Presence of civil war	Dummy variable for the presence of civil war, coded yes = 1, 1970–1990 (Kidron and Smith 1983, 1991; Singer and Small 1993).
Presence of genocide/politicide	Dummy variable for the presence of genocide/politicide, coded yes = 1, 1970 (Fein 1993; Harff and Gurr 1989).

etration (foreign direct capital stock in 1967 divided by total direct capital stock in 1967);[6] and foreign debt service load defined as the percentage change in debt payments over total exports between 1975 and 1985).[7] Foreign investment stock is a structural factor so we use the initial stock ratio. The key issue for exports and debt is the extent of economic squeeze, making the percentage change the most relevant measure. We use the interaction of the foreign capital penetration (PEN) ratio with economic growth and domestic investment (see Table 2 for definition) proposed by Dixon and Boswell (1996a) and, following Firebaugh (1992, 1996), we interpret these as reflecting the *relative benefits* of foreign versus domestic investment rather than an absolute distortion of growth or decapitalization. We also include a set of measures for military instability, internal violence, and repression to evaluate the "authoritarian repression" argument (see dependency/world system discussion on p. 722).

Urban bias is measured by the first-difference change in Bradshaw's (1987) rural/urban disparity index (1965–1985) net of simultaneous controls for the initial level (1965) of disparity (which captures cultural dualism), the development level, and the percentage of the labor force in agriculture. Because this is an indirect proxy for urban bias, which is a political process, it is important to control for the last three terms to make sure that we are tapping urban bias. This ensures that any effects are not simply due to development level or a large agricultural labor force, which could be construed as merely a low level of development.

Population pressure is measured by the average annual rate of change in the age dependency ratio between 1970 and 1985. We use the ratio of the population under age 15 to that over age 15 because less than 5 percent of the average LDC population is over 65. The effects of the more conventional age dependency ratio (population under age 15 plus over age 65 as a percentage of the total population) were slightly weaker, suggesting the "youth bulge" is critical. (We also used the average annual change in the fertility rate, which produced similar but slightly weaker results.) Agricultural density is interpreted as representing rural adversity (Firebaugh 1979) or, following *ecological evolutionary theory*, the organizational ad-

products variable is more central to the unequal exchange thesis and was the only measure that was ever significant.

[6] We prefer this more straightforward ratio, but alternative versions (e.g., foreign direct stock divided by GDP with and without the control for population size [Bornschier and Chase-Dunn 1985:71–72]) produced identical results.

[7] We also tested the 1970 level and change 1970 to 1985 in international debt load GDP and debt load per capita, but these were never significant.

vantages of traditional "plow" agriculture (Lenski et al. 1995).[8] These theories predict opposite signs on agrarian density.

We tap *militarism* by: the average annual rate of change in arms imports over GNP (1970–1985); the intensity of ethnic political discrimination;[9] and internal violence as measured as the presence of a civil war or a genocide/politicide between 1970 and 1990.[10] The military instability measure (discussed above as a modernization and a dependency variable) can also be viewed as an indicator of militarism insofar as it taps military coups and political interventions. The arms import question is best indexed by a rate of change, tapping the social burden created by arms races, including budget squeezes on governmental basic needs programs. We also separately test the two components of the internal violence measure. Because militarism might be a result of underlying modernization, economic dependency, urban bias, or age dependency, we also regressed all the militarism measures on these relevant structural development factors. None was significant, indicating that militarism is independent of these factors.

RESULTS

Food Supply

Do the effects of economic growth "trickle down" to yield increased food security? This question is critical to the modernization-economic dependency discussion, in which some modernization theorists contend that there is an equity versus growth trade-off—that growth produces greater inequality, and increased inequality (including democratization) undermines growth incentives (cf. Huntington 1987 and Kenworthy 2000). Advancing a different argument with a similar outcome, economic dependency theories contend that foreign investment creates growth without social welfare (or "distorted growth"), which likewise "trades off" against equity.

Table 3 shows the results predicting for change in mean daily calories per capita. Because caloric deficiency is central to food security (Foster and Leathers 1999:28), we show the results for caloric supply and then discuss the small differences when predicting supply of protein. Economic growth boosts food supply, improving the adjusted R^2—from .28 to .39 for the model including the lagged term alone (Model 1). All modernization theory variables improve food supply (Model 2). This supports arguments about the benefits of domestic investment and political democratization as well the thesis about military instability. It also suggests that growth and equity are compatible in terms of boosting food supply and, in view of the positive correlation between economic growth and political democratization (r = .34), that there is no "democracy versus growth" trade-off that undermines food supply. Political democratization is also weakly or negatively correlated with the various political instability measures (r = .10 for military instability, –.24 for internal violence, –.27 for civil war, and –.11 for ethnic political repression), undermining the "political instability" thesis.

The "relative benefits" version of the dependency/world system argument about foreign investment is also supported in that the PEN ratio interactions with economic growth and domestic investment are both significant (Model 3), thus indicating that foreign investment is less beneficial to caloric supply than is domestic investment. Note that this result fits the "relative benefits" argument that foreign investment is simply less beneficial to food supply compared with domestic investment. In a simple equation (not shown) containing only the lagged calorie term, development level and export dependence, export dependence is

[8] To see if population pressure has magnified effects in dense agrarian systems, we also tested the interaction between agricultural density (1970) and the annual rate of change in fertility rate (1965 to 1985) but these tests were not significant.

[9] We also tested the argument that ethnic heterogeneity blocks development and social integration, producing food insecurity. Ethnic heterogeneity (Sullivan 1991:252–59) reduces food supply slightly but has no impact on hunger. The number of ethnic groups did not have a significant effect on either food supply or child hunger.

[10] We also tested measures for the presence of interstate war derived from the Correlates of War project (Singer and Small 1993), but the variable was not significant in predicting either caloric/protein supply or child hunger rates.

Table 3. Unstandardized OLS Regression Coefficients Predicting Daily Calories per Capita from Single Theories, 1970 to 1990

Independent Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Controls						
Daily calories per capita, 1970	.66*** (.12)	.32** (.11)	.22* (.13)	.40** (.14)	.43** (.14)	.45*** (.13)
Economic growth, 1970–1985	262.73*** (75.28)	—	404.62** (159.93)	—	—	—
Modernization Theory						
Level of economic development, 1970 (ln)	—	112.67** (44.89)	182.39*** (46.78)	85.67* (50.69)	95.01* (53.68)	153.30*** (43.93)
Average annual percentage change in domestic investment, 1970–1980	—	11.28** (4.42)	15.36** (5.30)	—	—	—
Change in human capital investment, 1970–1985	—	7.71** (3.23)	—	—	—	—
Change in political democratization, 1965–1985	—	20.55* (9.47)	—	—	—	—
Military instability	—	−73.42** (26.41)	—	—	—	—
Dependency/World Systems Theory						
Percentage change in export dependency, 1970–1985	—	—	−216.97 (132.30)	—	—	—
Foreign capital penetration ratio (PEN), 1967	—	—	−231.55** (86.72)	—	—	—
Average annual percentage change in domestic investment, 1970–1980 × foreign capital penetration ratio, 1967	—	—	−8.01* (3.96)	—	—	—
Economic growth, 1970–1985 × foreign capital penetration ratio, 1967	—	—	−178.49* (94.44)	—	—	—
Foreign debt service load, 1970–1985	—	—	−.001 (.10)	—	—	—

(Continued on next page)

also significant and negative, but once the PEN measure is included, it loses significance. This indicates that its effects are tied up with foreign investment. The debt service load is not significant here or in other possible alternative specifications.

Increased rural/urban disparity reduces the food supply net of the initial development level and our cultural dualism measure, the 1965 level of rural/urban disparity ratio (Model 4). To ensure that this measure taps urban bias, we substituted the percentage of the labor force in agriculture for the development level and obtained similar results (not shown). None of the dependency measures was significantly correlated with either the 1965 level or the 1965–1985 first difference change in the rural/urban disparity ratio, indicating that urban bias is a distinctive force in its own right.

Increased age dependency reduces food supply, while agricultural density has no significant effect (Model 5). The effect of the change in fertility rate was similar but slightly weaker (not shown). We also tested the interactions of age dependency with agricultural density, the 1965 level of the rural/urban disparity ratio and the 1965–1985 change in the rural/urban disparity ratio to see if population pressure is magnified by these contexts, but none of these tests was significant (not shown).

(Table 3 continued)

Independent Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Urban Bias Theory						
Rural/urban disparity ratio, 1965	—	—	—	-38.69* (21.26)	—	—
Change in rural/urban disparity, 1965–1985	—	—	—	-16.78** (7.02)	—	—
Neo-Malthusian and Ecological-Evolutionary Theories						
Average annual percentage change in age dependency, 1970–1985	—	—	—	—	-142.91** (46.31)	—
Agricultural density, 1970	—	—	—	—	.83 (.75)	—
Militarism Theory						
Change in arms imports/GDP, 1970–1985	—	—	—	—	—	-1.38*** (.40)
Ethnic political discrimination	—	—	—	—	—	-58.26 (178.71)
Internal violence	—	—	—	—	—	35.38 (70.76)
Constant	1,047.44	1,085.26	1,207.15	1,188.93	668.93	539.46
Number of cases	78	53	48	66	72	77
F-value (F-probability)	25.33 (.0001)	17.52 (.0001)	8.42 (.0001)	10.53 (.0001)	18.04 (.0001)	13.79 (.0001)
Adjusted R^2	.39	.66	.59	.37	.49	.46

Note: Numbers in parentheses are standard errors.

*$p < .05$ **$p < .01$ ***$p < .001$ (one-tailed tests)

Of the militarism variables, only the arms imports variable has significant effects in reducing food supply (Model 6). Although internal repression and violence create hunger (see below), they do not disrupt the aggregate supply of food. Thus, in addition to military instability, arms imports may limit food supply, presumably reflecting reduced expenditures on food and health programs.

Using the increment to adjusted R^2 over a simple equation that includes only the lagged endogenous term for 1970 calorie supply (R^2 = .28), the modernization variables are the most important (increasing R^2 to .66 in Model 2), followed by dependency/world system variables in Model 3 (R^2 = .59), neo-Malthusian population pressure in Model 5 (R^2 = .49), and urban bias in Model 4 (R^2 = .37).

Because of the theoretical centrality of modernization and its consistent results (in Table 4) we build combined models by treating the significant modernization variables as the base and then adding significant variables from the other theories. Neither of the interaction terms for decapitalization or distorted growth are significant net of controls for modernization (Models 1 and 2). In a separate equation (not shown) with the simple foreign capital penetration (PEN) ratio, the modernization terms plus the lagged caloric control, foreign capital penetration was not significant, indicating that its drawbacks are weaker than the modernization factors. In Model 2, economic growth reduces all of the modernization terms below significance, suggesting that the benefits of modernization are largely tied up with economic growth. Next we add the rural/urban disparity ratio and change in rural/urban disparity, and we find that both are weaker than the modernization variables (Model 3). Age dependency

Table 4. Unstandardized OLS Regression Coefficients Predicting Daily Calories per Capita from Combined Models, 1970 to 1990

Independent Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Controls						
Daily calories per capita, 1970	.27*	.17	.30**	.34**	.32	.24*
	(.12)	(.12)	(.12)	(.13)	(.11)	(.11)
Economic growth, 1970–1985	—	344.48*	—	—	—	210.80**
		(155.17)				(86.75)
Modernization Theory						
Level of economic development, 1970 (ln)	126.08**	164.59**	83.85*	101.19*	109.08**	159.27**
	(47.76)	(50.96)	(49.91)	(49.60)	(43.98)	(46.71)
Average annual percentage change in domestic investment, 1970–1980	14.35**	6.40	11.32**	10.85*	10.55**	9.73*
	(6.00)	(4.92)	(4.60)	(4.62)	(4.36)	(4.14)
Change in human capital investment, 1970–1985	6.83*	4.53	7.16*	7.18*	7.97**	5.01
	(3.42)	(3.48)	(3.43)	(3.66)	(3.16)	(3.23)
Change in political democratization, 1965–1985	19.50*	7.80	22.51**	19.12*	19.40*	7.53
	(9.95)	(10.83)	(9.96)	(9.76)	(9.28)	(10.04)
Military instability	−58.49*	−50.17	−62.25*	−75.34*	−68.67**	−38.67
	(24.25)	(30.59)	(29.26)	(33.94)	(26.01)	(27.62)
Dependency/World Systems Theory						
Foreign capital penetration ratio (PEN), 1967	−93.31*	−111.33*	—	—	—	—
	(49.90)	(55.39)				
Average annual percentage change in domestic investment 1965–1980 × foreign capital penetration 1967	−4.19	—	—	—	—	—
	(3.52)					
Economic growth 1970–1985 × foreign capital penetration	—	−124.92	—	—	—	—
		(86.15)				
Urban Bias Theory						
Rural/urban disparity, 1965	—	—	−9.08	—	—	—
			(13.16)			
Change in rural/urban disparity, 1965–1985	—	—	−10.58	—	—	—
			(1.46)			
Neo-Malthusian and Ecological-Evolutionary Theories						
Average annual percentage change in age dependency, 1970–1985	—	—	—	−38.35	—	—
				(51.82)		
Militarism Theory						
Change in arms imports/GDP, 1970–1985	—	—	—	—	−1.58*	−2.10**
					(.90)	(.88)
Constant	1,198.29	1,311.11	1,339.77	1,060.32	1,123.97	1,125.05
Number of cases	50	50	50	48	53	53
F-value	10.96	10.81	10.52	14.12	16.13	16.38
(F-probability)	(.0001)	(.0001)	(.0001)	(.0001)	(.0001)	(.0001)
Adjusted R^2	.62	.64	.61	.66	.67	.70

Note: Numbers in parentheses are standard errors.

*$p < .05$ **$p < .01$ ***$p < .001$ (one-tailed tests)

added to the modernization variables is not significant, suggesting that it is counteracted by modernization processes (Model 4), and in Model 5, arms imports remains significant alongside modernization.

Finally, in Model 6 we add the control for economic growth, which causes all the modernization factors to loose significance, while arms imports remain significant. This result reinforces our conclusion that modernization improves caloric supply through its effects on economic growth and that arms imports constitute an economic burden on food supply. The standardized coefficients for Model 5 (with growth removed) show that modernization variables are the most important, with human capital investment (.25), military instability (–.24), and domestic investment (.23) being the strongest, followed by political democratization (.17) and arms imports (–.14). Thus, modernization and militarism arguments are supported, and the idea that economic dependency, urban bias, and a rapid increase in age dependency indirectly reduce food supply is supported as well.

We conducted four additional sensitivity tests. Taking mean daily protein grams per capita as the dependent variable produces similar results except that human capital investment, political democratization, the PEN ratio × economic growth interaction, and the urban bias variables are not significant. Thus, protein supply appears to be less influenced by structural development processes but the other significant factors remain the same. Second, to test for underspecification, we added dummy variables for all world regions to Model 6 in Table 4, but none was significant, suggesting that there are no major omitted variables. Third, we ran these equations with a constant 48 countries with complete measures for all variables, which produced the same pattern of significant factors. Fourth, a simple cross-sectional model predicting the 1990 caloric/protein supply also found the same factors significant with slightly stronger *t*-statistics, indicating that the trend and 1990 outcome values have the same origins.

CHILD HUNGER

We turn now to our second measure of food security, the change in the percentage of children who are of healthy weight. First we test the "food availability" thesis (Model 1, Table 5). Because our dependent variable is the percentage of healthy weight children, positive regression coefficients indicate progress in reducing child hunger rates. Although increased food supply (change in daily calories per capita) reduces child hunger, the increment to adjusted R^2 is modest, from .78 for an equation including only the lagged term (not shown) to .79 in Model 1. Model 2 adds economic growth, showing that growth is positive and significant, reducing the significance of improved food supply, indicating that it is more central. Model 3 removes the economic growth variable and controls for the modernization variables, of which political democratization is the only significant factor. The change in caloric supply is not significant, and removing it does not alter this result. Rather than undermining political stability and creating hunger, political democratization appears to be a strong positive force reducing child hunger and part of its benefits are associated with increased caloric supply.

Neither the economic dependency variables nor the urban bias variables affect the percentage of healthy weight children (Models 4 and 5). We also examined these and alternative measures of export and debt dependence (see notes 5 and 6), with simpler equations controlling only for the lagged term and change in caloric supply. None of these was significant (not shown). And we tested an interaction between the development level and foreign capital penetration to see if foreign investment was stronger among the more developed LDCs, but this interaction was not significant either (not shown). Removing the caloric supply variable does not alter any of these results. Export dependence and foreign capital penetration do not appear to affect the prevalence of child hunger.

Increased age dependency boosts child hunger rates but agricultural density is not significant (Model 6). The change in total fertility rate has similar effects (not shown) but lower significance, so we show the age dependency effect. Arms imports and internal violence increase rates of child hunger, but ethnic political discrimination has no significant impact (Model 7). We also tested separate dummy variables for genocide/

Table 5. Unstandardized OLS Regression Coefficients Predicting the Percentage of Healthy Weight Children from Single Theory Models, 1975 to 1990

Independent Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Controls							
Percentage of children of healthy weight, 1970	.80*** (.06)	.80*** (.05)	.71*** (.08)	.67*** (.08)	.77*** (.06)	.74*** (.06)	.75*** (.05)
Change in daily calories per capita, 1970–1990	.005* (.003)	.003 (.003)	.003 (.003)	.003 (.003)	.004* (.002)	.004* (.002)	.005** (.002)
Economic growth, 1970–1985	—	6.17** (1.78)	—	7.44 (4.65)	—	—	—
Modernization Theory							
Level of economic development, 1970 (ln)	—	—	.42 (1.31)	3.15** (1.22)	.95 (1.07)	−.10 (1.11)	.96 (.90)
Average annual percentage change in domestic investment, 1970–1980	—	—	−.07 (.13)	−.09 (.15)	—	—	—
Change in human capital investment, 1970–1985	—	—	.11 (.09)	—	—	—	—
Change in political democratization, 1965–1985	—	—	.60** (.25)	—	—	—	—
Military instability	—	—	−.63 (.69)	—	—	—	—
Dependency/World Systems Theory							
Percentage change in export dependency, 1970–1985	—	—	—	1.24 (3.35)	—	—	—
Foreign capital penetration ratio (PEN), 1967	—	—	—	.54 (2.45)	—	—	—
Average annual percentage change in domestic investment, 1970–1980 × foreign capital penetration ratio, 1967	—	—	—	.04 (.10)	—	—	—
Economic growth, 1970–1985 × foreign capital penetration ratio, 1967	—	—	—	.31 (2.82)	—	—	—
Change in foreign debt service load, 1970–1985	—	—	—	.001 (.003)	—	—	—

(Continued on next page)

politicide and civil war, but owing to multicollinearity between these two terms, we show only the "internal violence" measure that combines these two measures. In simpler equations controlling only for the lagged term and arms imports, we found that ethnic political discrimination and genocide/politicide had significant effects (not shown). Genocide/politicide is stronger than ethnic political discrimination, reducing discrimination to nonsignificance when they are included together. This suggests that ethnic political discrimination is an underlying problem that leads to genocide/politicide and thereby increases in child hunger rates. Civil wars are statistically significant only when all terms other than the lagged term and change in caloric supply are included, suggesting that civil war is not a central source of child hunger rates. Gauging relative importance by increments to adjusted R^2 over Model 1, the neo-Malthusian age dependency variable and the militarism variables have the strongest effects on child hunger, adding 6 to 8 percent to the explained variance (.85 and .86 respectively); including political democratization increases the adjusted R^2 by only 1 percent (.80).

(Table 5 continued)

Independent Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Urban Bias Theory							
Rural/urban disparity, 1965	—	—	—	—	.39 (.31)	—	—
Change in rural/urban disparity, 1965–1985	—	—	—	—	.07 (.02)	—	—
Neo-Malthusian and Ecological Evolutionary Theories							
Annual average percentage change in age dependency, 1970–1985	—	—	—	—	—	−2.81** (.92)	—
Agricultural density, 1970	—	—	—	—	—	−.02 (.02)	—
Militarism Theory							
Change in arms imports/GDP, 1970–1985	—	—	—	—	—	—	−.01* (.01)
Ethnic political discrimination	—	—	—	—	—	—	−4.89 (3.68)
Internal violence	—	—	—	—	—	—	−3.59** (1.27)
Constant	19.47	22.99	23.09	14.01	17.38	21.43	20.09
Number of cases	49	49	49	47	63	69	73
F-value (F-probability)	92.70 (.0001)	80.59 (.0001)	29.26 (.0001)	22.42 (.0001)	52.00 (.0001)	75.71 (.0001)	72.40 (.0001)
Adjusted R^2	.79	.83	.80	.82	.80	.85	.86

Note: Numbers in parentheses are standard errors.

*$p < .05$ **$p < .01$ ***$p < .001$ (one-tailed tests)

The combined models in Table 6 include all significant terms from Table 5 and treat change in caloric supply and development level as controls in addition to the endogenous lagged term. As in the analysis of caloric supply, we treat the significant modernization variables as the base model and then introduce the other variables, beginning first with age dependency. We also control for the interaction between age dependency and the 1965 level of rural/urban disparity ratio to see if age dependency is magnified by cultural dualism. Political democratization is positive and significant and rural/urban disparity does magnify the influence of increased age dependency (Model 1), suggesting that the influence of rapid increase in age dependency is greater in dualistic societies. We also tested for the interaction of rural/urban disparity with agricultural density, but it was never significant (not shown). In Model 2, political democratization and the presence of genocide/politicide are significant, but the arms import variable is not. We reintroduced the genocide/politicide measure here (not shown) because it proved stronger than the combination internal violence measure. Genocide/politicide seems to be more central than civil wars as a source of child hunger, although both are contributing factors. Model 3 combines variables from all three theories and shows that all earlier results work additively. Finally, we add economic growth (Model 4), which reduces child hunger and appears to account for the benefits of political democratization. Standardized coefficients for the variables in Model 3 with the age dependency × rural/urban disparity interaction removed showed that the genocide/politicide (−.15) and age dependency (−.14) variables are the strongest, closely followed by political democratization (−.11) and change in caloric supply

Table 6. Unstandardized OLS Regression Coefficients Predicting the Percentage of Healthy Weight Children from Combined Models, 1975 to 1990

Independent Variable	Model 1	Model 2	Model 3	Model 4
Controls				
Percentage of healthy weight children, 1970	.73*** (.06)	.73*** (.06)	.72*** (.06)	.71*** (.05)
Change in daily calories per capita, 1970–1990	.001 (.003)	.004* (.002)	.001 (.002)	.0005 (.025)
Economic growth, 1970–1985	—	—	—	5.33** (1.97)
Modernization Theory				
Level of economic development, 1970 (ln)	.18 (1.06)	.67 (1.02)	−.14 (1.00)	1.33 (1.08)
Change in political democratization, 1965–1985	.53** (.20)	.43* (.20)	.39* (.19)	.21 (.19)
Urban Bias Theory				
Rural/urban disparity, 1965	−.57 (.40)	—	−.66* (.37)	−.64* (.35)
Neo-Malthusian Theory				
Average annual percentage change in age dependency, 1970–1985	−.43 (1.43)	—	.28 (1.33)	1.55 (1.34)
Rural/urban disparity, 1965 × average annual percentage change in age dependency, 1970–1985	−.83* (.44)	—	−1.00** (.42)	−1.01** (.39)
Militarism Theory				
Change in arms imports/GDP, 1970–1985	—	−.01 (.01)	−.01 (.01)	−.01 (.01)
Presence of genocide/politicide	—	−4.98** (1.67)	−4.97** (1.57)	−4.08** (1.51)
Constant	23.21	22.91	28.41	24.74
Number of cases	58	58	58	58
F-value (F-probability)	47.19 (.0001)	54.49 (.0001)	43.71 (.0001)	45.28 (.0001)
Adjusted R^2	.85	.85	.87	.89

Note: Numbers in parentheses are standard errors.

*$p < .05$ **$p < .01$ ***$p < .001$ (one-tailed tests)

(−.08).[11] When economic growth is added to the model, this rank order remains intact, but economic growth has the strongest standardized coefficient. This suggests that the keys to reducing child hunger are economic growth, the prevention of violence, the expansion of political and civil rights associated with political democratization, and the reduction of rapid population growth in traditional dualistic societies.

We also conducted four sensitivity tests to check these results. Substituting change in daily protein grams per capita for caloric supply produces results similar to those for caloric supply except that protein is consistently significant throughout and washes

[11] We omitted the interaction term from this model because standardized coefficients for interaction terms are not directly interpretable.

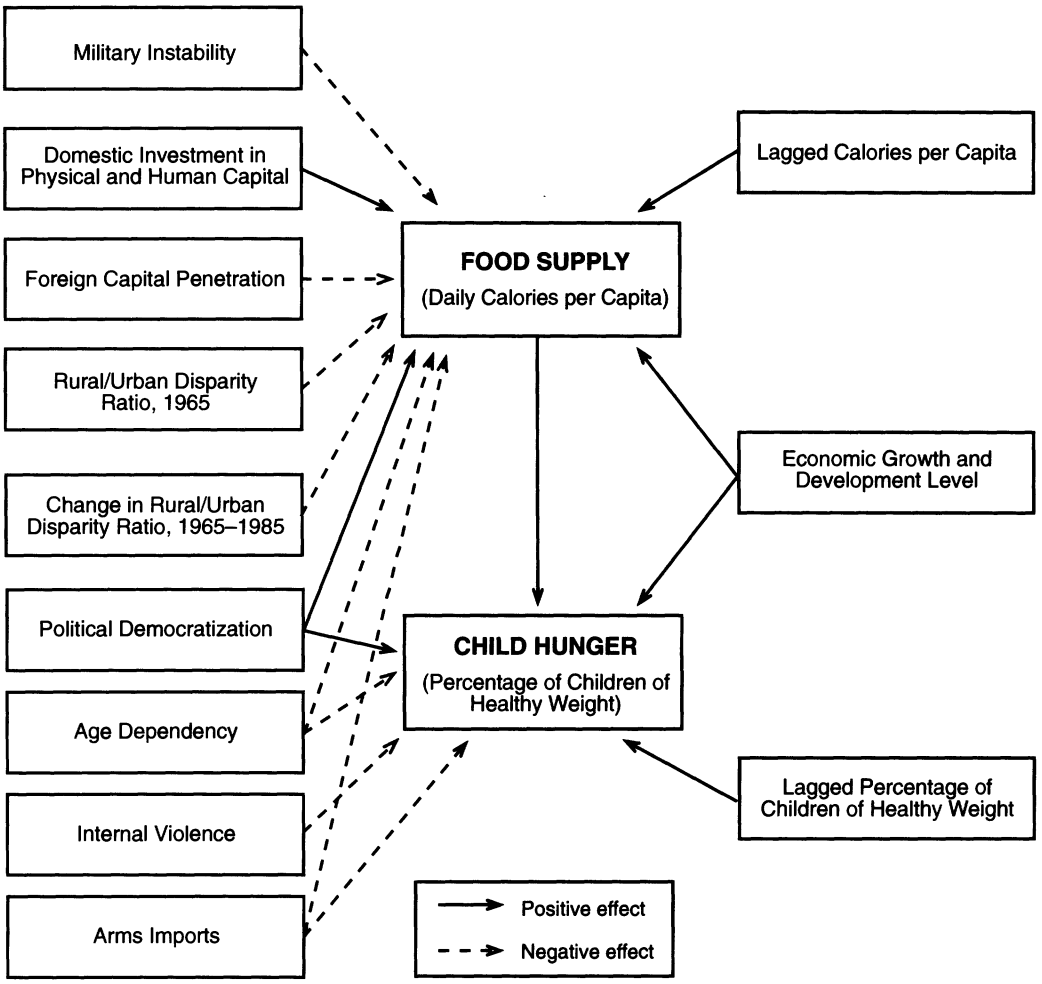

Figure 1. Findings on Variables Affecting Food Supply and Child Hunger in Less Developed Countries, 1970 to 1990

out economic growth and the age dependency × rural/urban disparity interaction. Protein supply is more central to hunger reduction and is closely tied to economic growth. None of the world region dummy variables added to Models 3 and 4 in Table 6 were significant, and models for the constant 49 LDCs with complete data produce the same pattern of significant factors (not shown). In the cross-sectional analysis predicting the percentage of 1990 healthy weight children, the only difference from the lagged panel results is that arms imports and the age dependency × rural/urban disparity interaction are not significant. This suggests that arms imports and population pressure in dualistic societies *do increase* child hunger, but that they are not important if the question is predicting the static 1990 level of child hunger.

Overall, the internal political security afforded by political democratization and freedom from internal violence plus population pressure in traditional dualistic societies are the strongest sources of increased child hunger. Food supply has a positive but small impact, suggesting that critics of the "food availability" thesis who contend that food supply is irrelevant have overstated their argument. They are, however, correct that increased food supply alone is not sufficient to reduce hunger. In poor dualistic societies, problems associated with increased rapid population growth plus more general restrictions on political freedoms are more important than increasing the food

supply. Second, economic growth does "trickle down" to increase food supply and thereby reduce child hunger rates (Model 4 in Table 6) and is associated with the benefits of political democratization. Thus food supply and child hunger have some shared as well as divergent origins.

Figure 1 summarizes our major findings, allowing us to explore these conclusions more closely. We show only simple variables in the figure and discuss the interaction terms in the text. Political democratization, age dependency, and arms imports influence both major aspects of food security—the supply of food and the access to food for children—as do the effects of economic growth, which "trickle down" to increase food supply and reduce hunger. In terms of their relative explanatory power, internal violence, age dependency-linked population pressure, and political democratization are the most important variables affecting child hunger, while modernization processes and age dependency are the most central variables affecting food supply. This points to significant differences between the two measures of food security. Food supply is more rooted in the structural development processes associated with domestic and foreign investment and urban bias, while child hunger is shaped primarily politically, especially by political democratization, internal violence, and arms imports. Increased food supply does reduce child hunger, but its impact is relatively small.

CONCLUSIONS

Food is a fundamental basic need and should be treated as a universal human right. Food also has significant implications for the potential economic and social development of both the LDCs and the developed world. People without secure access to food are unlikely to progress economically or to contribute indirectly to the welfare of other populations through economic trade, cultural exchange, or social interaction. Thus, alleviating hunger and poverty in LDCs is in the long-run interest of the developed world as well as that of the LDCs. As Sen (1981) and others (Drèze and Sen 1989, 1995) argue, world hunger is generally not a question of sudden starvation but rather of chronic undernutrition that leaves populations vulnerable to disease and their members unable to lead active and productive lives.

Our most important finding is the relatively weak impact of food supply on child hunger rates. Most researchers have assumed this "food availability" thesis (see Foster and Leathers 1999; Osmani 1995), and policy discussions have focused on ways to improve agricultural production and food aid in emergencies. Despite a global food surplus and increased international trade and food assistance, child hunger persists in LDCs and is only modestly reduced by recent increases in the supply of food. The child hunger problem is not simply a question of growing more food, but of distributing it so that disadvantaged children, minorities, women, and rural households have secure access to this supply. Our evidence suggests that entrenched inequality, especially that associated with ethnic political discrimination and internal violence against minority and other groups, is key to the persistence and increase in child hunger rates. Hunger is, in this sense, a political problem and must be addressed through political change—especially political democratization, restrictions on arms trade, and the reduction of generalized violence.

Our results suggest several policies that might contribute to improved food security. First is the reduction of internal violence, the promotion of political democratization and restrictions on international arms trade. Supporting "military famine" arguments (Cheatham 1994; de Soysa and Gleditsch 1999; Macrae and Zwi 1994; Poleman 1997) about the hazards of militarism and internal violence, we found that genocide/politicide, civil war, arms imports, and underlying political discrimination against targeted ethnic groups are central to child hunger. We also found that political democratization is a key source of improving child hunger rates. This points to the importance of monitoring international human rights, early warning and prevention efforts targeted on internal violence, and restraints on international arms trade. Some have argued that democratization in LDCs is politically destabilizing and undermines incentives to invest and engage in productive effort (Apter 1965; Huntington 1968). Our evidence contradicts this

view. We do not find support for either the "political instability" thesis or either version of the "growth-equity" trade-off idea. Instead, political democratization reduces child hunger rates and improves food supply. It is also positively correlated with economic growth, suggesting that political democratization encourages economic growth and improvements in basic needs. This fits the results of other recent studies (Kenworthy 2000; King 1998), suggesting that the political problem in LDCs is *not enough* democracy, not its premature or destabilizing introduction.

Our second policy suggestion focuses on the population pressures created by persistent high fertility and the rapid growth in age dependency. Scanlan (2000) showed that persistent high fertility and the resulting rapid growth in age dependency create an ecological "overshoot" that undermines both aspects of food security. We have shown that this is magnified in traditional dualistic societies in which households have an economic incentive for maintaining high fertility, which leads to the use of marginal lands, overcultivation, and soil degradation. Scanlan (2000) also found that increased age dependency lowered food security and was associated with lower women's status and higher fertility. This suggest that improving women's status through education and employment opportunities should be central to improving both food supply and child hunger rates.

A third policy issue is balanced growth. Development experts have long debated the wisdom of balanced versus unbalanced growth. Studies show that urban bias in terms of protective tariffs, overvalued currency, state monopolies on agricultural exporting, heavier rural taxation and "price-twisting," and subsidies for urban industries may contribute to urban-centered (or "unbalanced") growth, but that this urban bias also creates sectoral disparities in productivity and investment, social welfare differences, and lowers overall economic growth (Chenery et al. 1986; Krueger, Schiff, and Vales 1991; Lofchie 1997). We found that increased rural/urban disparity reduces food supply but does not affect child hunger rates. This suggests that urban bias has more impact on agricultural production than on social welfare. It is also possible that our indirect measurement of urban bias, which relies on change in sectoral disparity in labor productivity net of initial dualism and development level, underestimates urban bias. Further work on "biased" policies and political institutions is needed to further evaluate this.

Building on recent discussions of foreign capital penetration (Dixon and Boswell 1996a, 1996b; Firebaugh 1992, 1996), we found that foreign investment is *relatively less* beneficial for food supply than is domestic investment but does not affect child hunger. In contrast to previous dependency researchers who interpreted the negative effects for the foreign capital penetration ratio as indicating an absolute decline in social welfare (Bradshaw et al. 1993; Wimberley and Bello 1991), the ratio merely indicates the "relative benefits" of foreign versus domestic investment. Our negative effects, including the foreign capital penetration ratio interactions with economic growth and domestic investment, show merely that foreign investment is less beneficial than domestic investment. As Dixon and Boswell (1996a) argue, "often the choice (in LDCs) is not between foreign capital and domestic capital but between foreign capital and no capital at all" (p. 547).

In supplemental analyses (not shown, but available on request from the authors), we explored this further by examining other factors often linked with dependency, namely land tenure inequality, income inequality, and the intensity of ethnic economic discrimination. None of these was significant in predicting food supply or child hunger, and at least in cross-sectional analyses, were not associated with economic dependency. We also examined the growth of international food imports, including international food aid, which some have argued is part of the "new international food order" that is disrupting food security in LDCs (Friedman 1982, 1993; McMichael 1996). We found no support for this idea. In fact, international food imports boost the food supply while having no impact on child hunger. Thus, while foreign trade and investment, including increased food imports, may not reduce hunger, these factors also do not appear to be responsible for child hunger and may ac-

tually boost the food supply. We also found that the "relative disadvantage" of foreign capital penetration was not significant, net of modernization controls, suggesting that at most it is a secondary factor for food supply. In sum, this suggests that the traditional dependency/world system advice to internationally "delink" is, at best, irrelevant, and that delinking may even be counterproductive if we take into consideration the question of food imports. At the same time, the failure of food imports to reduce child hunger suggests that international food imports must be better targeted to address underlying hunger problems.

Our overall results support a structural modernization view that focuses on investment in human and physical capital and is expanded to include political democratization. This view is limited, however, by the fact that these investments are more central to improving food supply. The economic and population aspects of structural modernization seem to be critical to economic growth but do not appear to "trickle down" to reduce hunger. Hunger is largely a political question, and insofar as political democratization boosts economic growth, and thereby reduces child hunger, economic growth is a critical concern. Overall, our evidence suggests that it is domestic politics, especially political democratization and freedom from severe political repression coupled with population pressure in traditional dualistic societies, that is central to this growth process. Further research using a time-series analysis with simultaneous equations could assess the interaction of political democratization, internal violence, and economic growth in their impact on food security.

This points to the need to expand discussions of food security beyond traditional concerns—agricultural development, domestic investment, and basic needs investments—by addressing basic political security. Food supply alone is not the central issue in reducing hunger. Hunger is also a distributional problem, and the obstacles to improved distribution are primarily political. Conflict regulation, violence prevention, the reduction of international arms trade, and the protection of civil and political rights should be central to policies that address hunger. A second focus should be reducing fertility and improving women's status in LDCs. Insofar as these factors are influenced by structural modernization, they point to the need for an enlarged and revised modernization theory frameworku. Such a framework will need to recognize the independent importance of political democracy and conflict regulation as well as the importance of incorporating useful insights from ecological and urban bias theories and the "relative benefits" of domestic versus foreign investment.

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