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# Overcoming Food Insecurity: A CGE Analysis

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# Overcoming Food Insecurity: A CGE Analysis

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While the spectacular world economic growth over the past 30 years has significantly reduced poverty, almost 1 billion people continue to live in a state of food insecurity with less that $2 per day to spend on food and all other necessities of life. Less than 1 percent of world GDP could eliminate this insecurity if it could be translated into food in the hands of the poorest populations. Yet the problem is quite intractable. The problem is not food availability. There is plenty of food in the world to feed everyone. Providing food aid or grants does not lead to any long-term solution. If food aid is stopped, hunger returns. At the core of the problem is the lack of productivity and resourcefulness of the poorest populations. Increase their productivity and they can purchase adequate food. Link the poor to the market, and growth in the market economy will translate into reduced food insecurity. Generate rapid economic growth across a broad spectrum of low income countries and poverty and food insecurity will continue to be substantially reduced.

Food insecure populations are concentrated in a few countries and regions. Historically, Asian food insecure populations predominated. However, the rapid economic growth in India and China and the poor growth performances of the Sub-Saharan African countries has resulted in less relative food insecurity in Asia and more in Africa. The concentration of food insecurity implies an element of government failure. A characteristic of food insecure countries are governments which heavily intervene in markets, public allocative decisions are distorted by rent seeking, and public policy is not focused on overcoming market failures.

Reducing food insecurity requires a number of strategic elements: public investment priorities must focus on areas which raise the marginal product of labor in the bottom end of the

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income distribution; incentives must be developed to encourage poor people to enter the market economy; and an environment must be created to stimulate rapid overall economic growth. Investments in overcoming inadequate physical and social infrastructure and limitations in human capital are essential as is creating a legal environment with incentives to save and invest.

For developed economy policy makers, the dilemma rests in a conflict between humanitarian concerns and scarce aid resources. How to assist countries in need when the conventional remedies of food assistance and macroeconomic policy changes alone in the most severely affected countries seems unable to turn around this situation. Only a dramatic change in policy and programs in the poorest countries will yield positive results in the longer-term.

## Food Insecurity and the World Income Distribution

The world's population is highly concentrated at low income levels (fig. 1).[1] More than 4 billion people representing almost 80 percent of the world's population have incomes of less than $16 per day.[2] More than 3 billion live on less than $8 per day. Around 1 billion live on less than $2 per day and 400 million live on less than $1 per day. Although it is not clear exactly at what income a person becomes food insecure, few individuals who earn $16 per day or

[1] The following income distribution statistics start with the Deininger and Squire (1996) database. From the quintiles reported, the income distributions are converted into their Gamma Function equivalents by a parameterization described below. These individual country distributions are summed up to arrive at world totals. The numbers arrived at by our procedure differ somewhat from that arrived at by a similar process by Xavier Sala-i-Martin (2002). The underlying philosophy of summing up individual country's distribution functions to arrive at a world total is the same.

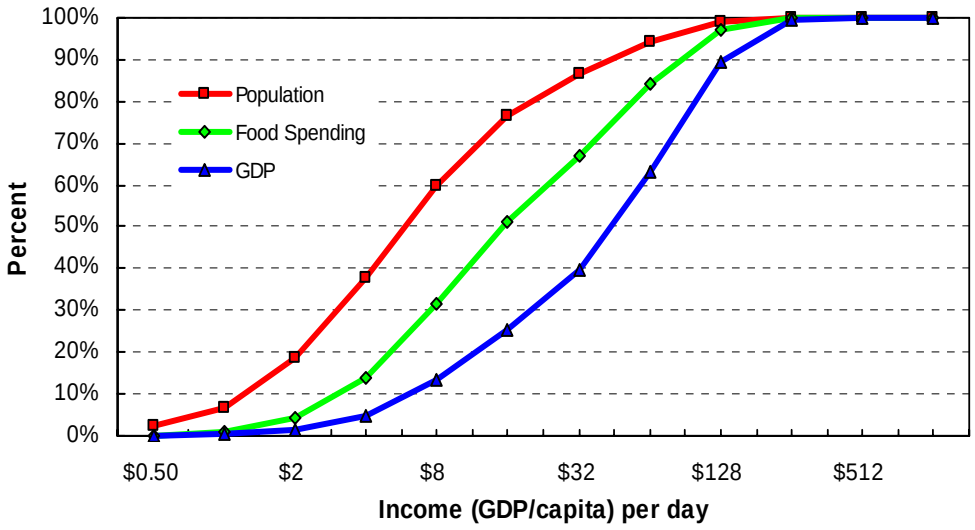
[2] In this paper, international comparisons use 1996 purchasing power parity (PPP) dollars. A purchasing power dollar is created by a rate of exchange in which the same basket of goods can be purchased in different countries for the same dollar equivalent.

more are food insecure.[3] On the other hand, individuals living on $1 per day or less are almost certainly food insecure. Around 7 percent of the world's population lives on $1 per day or less and almost 18 percent on $2 per day or less.

While population is concentrated at low income levels, earned income is concentrated at the highest income levels. Thus 75 percent of the world's GDP is earned by less than one fourth of all individuals--those who earn $16 per day or more. The poorest 1 billion only earn 1.3 percent of the world's income and the poorest half billion only earn 0.3 percent of the world's income.

Since the poor only spend a part of their income on food, the food expenditures of the poorest 1 billion only represents 0.8 percent of the world's GDP and the food spending of the poorest half billion represents 0.2 percent of the world's GDP.

**Figure 1. World Cumulative Distributions of Populations, Food Spending, and GDP by level of income (154 countries), 1998**




[3] In the OECD countries, only 13 percent of the populations live on $16 per day or less. This gives an indication that not only are income distributions highly concentrated at the lower end of the income distribution, but also that low income populations are concentrated outside of OECD countries in Sub-Saharan Africa, South Asia, and Latin America.

## Is Food Insecurity and Income Inequality Decreasing?

Using evidence derived from national income statistics, i.e., Deininger and Squires (1996) data set, Sala-i-Martin (2002) concludes that there is clear evidence that there has been a reduction in poverty and food insecurity based on a fixed real purchasing parity dollar.[4] This is also the approach taken in this paper and previous papers by the authors of this paper. There are problems with this approach, which tends to understate poverty and food insecurity. Using GDP per capita overstates the amount of resources available for consumption by families and individuals. Household consumption is usually between 60 to 70 percent of GDP. Government consumption and investment are not available for household consumption. Given the skewness of income, removing 30 to 40 percent of it will add a good deal to those at $1 and $2 a day in consumable income. The World Bank's measure which is dependent on survey data rather than national income data, indeed, shows exactly that, far more poverty and food insecurity and far slower reductions than does the evidence using national income statistics. However, in either case, we are talking about a lot of people with very little income to purchase food and other necessities of life.[5]

Evaluating the number and proportion of people on $1 and $2 a day still does not answer the question of whether income inequality is getting higher of lower over time. With overall income growth occurring, one would expect some decline in poverty and food insecurity. To understand what is happening to income inequality, one needs to know relative income growth at the highest and lowest sections of the income distribution. If the incomes of the highest quintile are growing more rapidly than that of the lowest quintile, then it is likely that income inequality is rising. This has certainly been the case in the United States, where almost all of the income growth since 1980 has occurred in the top 20 percent of the population. The bottom 60 percent has seen almost no income growth while the second highest 20 percent has seen some income growth. For China and India, we also know that the rural-urban income differential has been increasing over time.

Thus the fact that income inequality has been increasing in virtually every country of the

[4] See Sala-i-Martin (2002), Table 1, p.34.

world does not suggest that the global income distribution has been getting worse. If there is high income growth in several major low income countries such as China and India, then it is possible that in spite of widening income differential in almost all countries, that the global income distribution is improving. This, indeed, seems to be the case.

## A Parametric View of Income Inequality

While it is true that the world population and income are distributed unequally, much discussion emphasizes this inequality of income, more than the distribution of income. A Normal Distribution or any other distribution which is symmetric in shape cannot represent income distributions very well. An incomplete Gamma density function allows the distribution to be as skewed as desired. This Gamma density function depends on two parameters, the scale and the order.[6] [7] The scale parameter of the incomplete Gamma density function determines the location of the function and the units of measurement on the income scale, without affecting the shape of the function. Inequality and the shape of the function, independent of its income dimension, depends on the order parameter. The order parameter is a positive real number. For the income distributions across the world, the order parameter varies from 0.45 in Brazil to 5.70 in Belarus. A small order parameter implies a highly skewed income distribution while a large order parameter implies a highly equal distribution. The order parameter for the United States is 2.05.

There are a lot of countries with very unequal income distributions (fig. 2). In our collection of 134 countries, 73 have order parameters below 1.75 and 36 are under 1.0. Once we look at the population (fig. 3) or income of countries by order parameter, the skewness of the

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[5] As a means of comparison, daily commute cost runs can easily run between $6 and $10 a day in Washington, DC.

[6] For further characteristics of the gamma distribution, see either Salem and Mount (1974) or McDonald and Jensen (1979).

[7] For the incomplete Gamma function, the scale and order parameters play a similar role as the mean and standard deviation for the normal distribution. The scale determines the location of the function just like the mean, while the order determines the shape of the function just like the standard deviation.

**Figure 2. Income Distribution Parameter by Number of Countries**

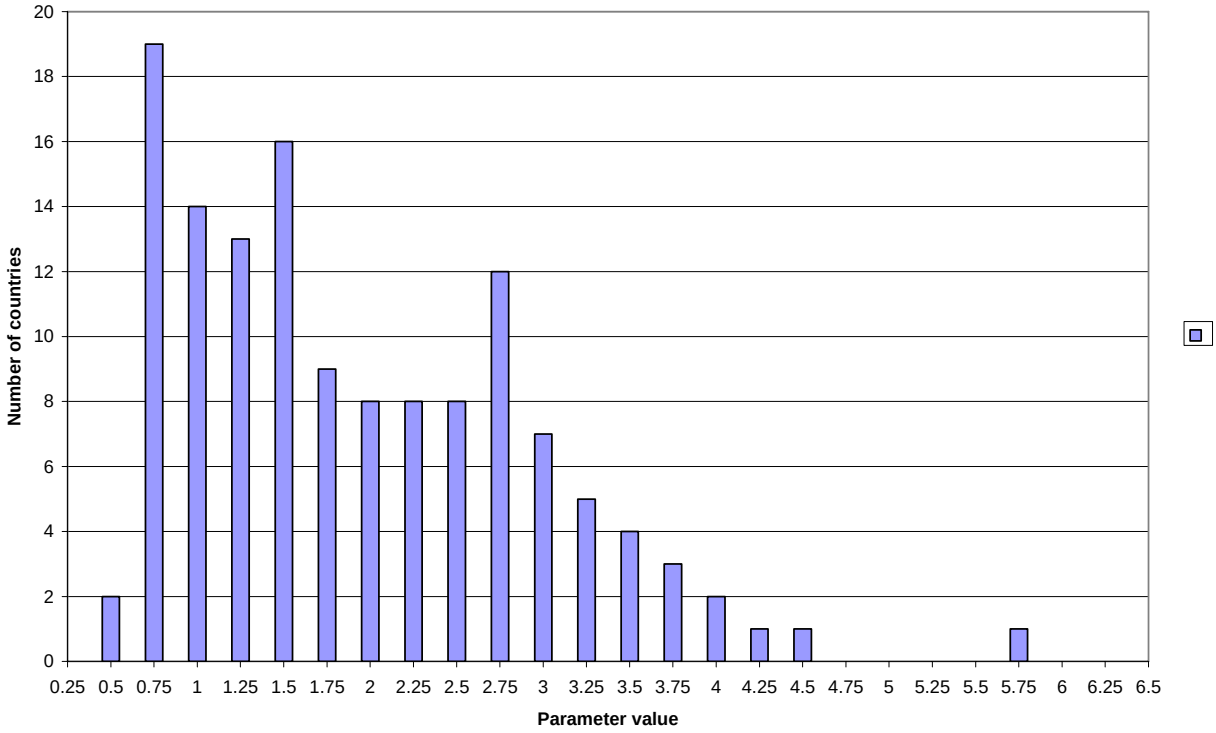
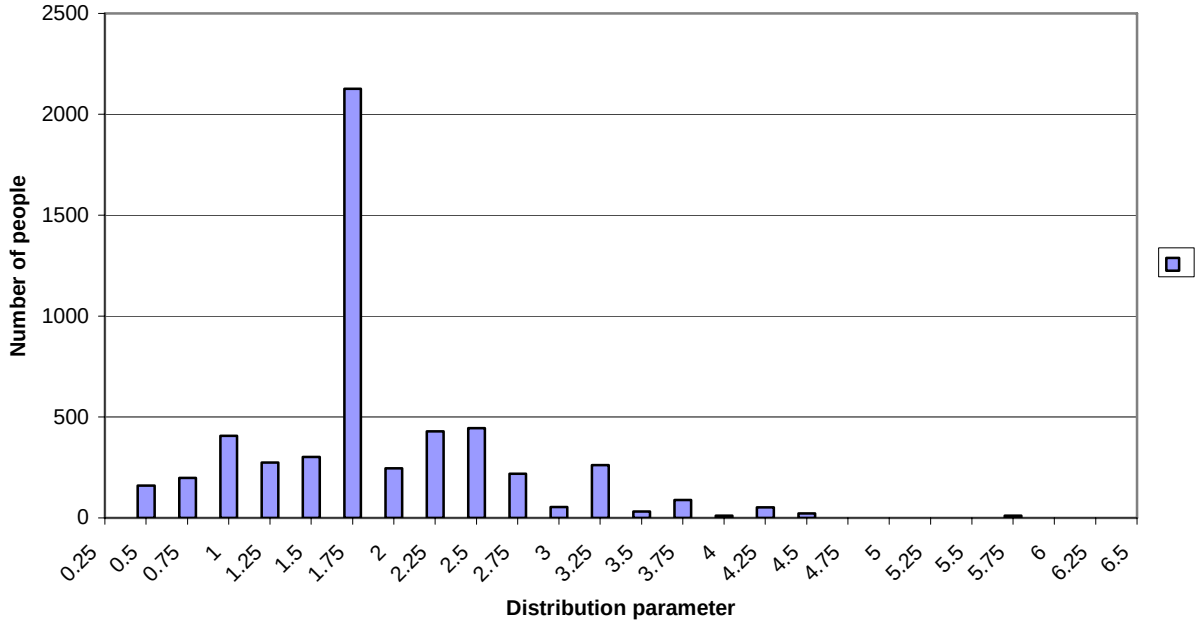



**Figure 3. Distribution Parameter by Number of People**



histogram declines. What this tells us is that the most-unequal income distributions occur in small countries. The group with an order parameter between 1.75 and 2 is the largest group based on population. This group would include China, and India. When we evaluate the income of countries with different order parameters, the histogram moves slightly more toward the right. No OECD country has an order parameter below 1.38.

**Parametrizing the Gamma Distribution**

Any measure of inequality such as the Gini coefficient has a one-to-one relationship with the order parameter. Any such function between a measure of inequality and the order parameter of the Gamma density can be inverted to solve for the order. The function that relates the Gini coefficient to the order parameter has an explicit formula, while the inverse function does not. Thus solving for the inverse relationship is an inherently numerical process. The order parameter can be thought of as the number of income opportunities available to a household.

The order parameter for the income distribution in the 154 countries examined was based on the income share of the bottom 80 percent of the population, rather than the Gini coefficient. A table of the numerical relationship between this share and the order parameter of a gamma distribution was constructed and used to infer the order from the reported income share. The estimated order parameters were reported with two significant digits of precision.

The scale parameter for each country was obtained by dividing per capita GDP by the estimated order parameter. Per capita GDP is reported in PPP$ in the annual *World Development Report*. The distributions examined in this paper use only the PPP estimate of the scale parameter.[8] The scale parameters (in $PPP) range from $27,176 in Kuwait and the United Arab Emirates to $121 in Rwanda. The scale parameter for the United States is $12,383. One can think of the scale parameter as the average, of an exponential distribution, which an income earner entering the workforce can expect to draw.

[8] Alternatively, we could have used GDP measured in Atlas dollars. However, that would not have keep purchasing power constant.

## The Problem of Significantly Reducing World Food Insecurity

In 1998, the 1 billion food insecure people (FIP) represented 18 percent of the world population. Given Census Bureau[9] projected population growth rates, world population will reach approximately 7.2 billion by the year 2015, a 21 percent increase over the 17 years and the population of food insecure countries will go from 3.4 billion to 4.3 billion implying an increase of more than 25 percent without remediating circumstances.[10] To continue to achieve substantial reductions in FIP over the projections period requires income in low income countries and for the FIP to grow faster than population. High income growth alone if it is not translated into gains for the lowest income groups will not translate into fewer FIP. Fortunately, recent developments in low income countries suggest that there have been substantial increasing in income growth and also substantial decreases in population growth. If this pattern should continue, and current forecasts imply that they will, we can expect substantial reducing in poverty and food insecurity measured as a fixed real income available per day.

### Nature of the Analytic Problem

On top of continuation of current trends, are there policies and program options that can taken to further reduce poverty and food insecurity by 2015? [11] Analytically, what has to be accomplished is that income growth at the lowest end of the income distribution has to more than compensate for the natural population increase by a sufficient amount to lower the FIP.

Population growth alone increases FIP by more than 25 percent. Income must increase sufficiently to shift the distribution function far enough to the right to reduce the FIP. To achieve

[9] For current population data go to: http://www.census.gov/ipc/www/idbnew.html.

[10] This estimate does not take into account the higher fertility and birth rates among the poorest members of any country. See Lam (1997).

[11] The analytic framework we use is to combine a long-term projections application of GTAP with a Gamma Function representation of national income distributions. Our modeling framework provides a structural basis on which to interpret the regression result of Timmer (1998) and others attempting to explain the linkage between growth and the reduction of poverty

a reduction in FIP of say 50 percent requires that real per capita income of the lowest income groups grow more than 4.4 percent a year over 1998-2015. Current baseline projections have both China's and India's per capita income growing by that amount or more. The rest of the South Asia is projected to have per capita income growth by around 2 percent and Sub-Saharan African countries projections are in excess of 2 percent. This is a significant change from what was being projected only 5 or more years ago. At that time, per capita income growth in Africa had been near zero. While it is always possible that some of the current patterns will not persist, we can be reasonably confident that significant improvement in poverty and FIP will happen if things do continue as projected.

**GTAP and Income Distribution Analysis**

Using the GTAP framework to derive results for income distribution analysis has its own problems. The GTAP framework is not set up to give income distribution results. Thus one needs to develop a method to link the results of GTAP scenario runs with factors that will impact on income distribution. Using Kuznets (1955) as a guide, the following variables significantly impact on the order and scale parameters.[12]

$$\text{(1)} \quad \text{Order} = g(\underset{+}{\text{AgGDP/GDP}}, \underset{-}{\text{fertility}}, \underset{-}{\text{AgLabor/Labor}}, \underset{-}{\text{d(GDP/Pop)/dt}}, \underset{+}{\text{Scientists/pop}})^{13}$$

$$\text{(2)} \quad \text{Scale} = (\text{GDP/Pop})/\text{Order}$$

The equation reported in Table 1 was used to adjust order parameters between the 1998 base and the 2015 scenarios. Only the effects of the agricultural share of GDP and the labor force composition were used to transform order parameter into 2015 equivalent. Effects of fertility, scientists per capita, and income growth rates were not taken into account. Thus, if the agricultural share of GDP falls 2 percentage points from the 1998 base and the agricultural labor

[12] The data for the estimates are drawn from ILO, and UN(1996).

[13] The estimates of the coefficients for this function appear in table 1.

Table 1. Tying the Order Parameter to Socieconomic Variables

| Variable | Coefficient | t-ratio |
|---|---|---|
| Intercept | 2.7778 | 7.18 |
| Fertility | 0.2142 | 1.04 |
| Ln(fertility) | -1.8292 | -2.18 |
| Agricultural Share of GDP | 0.0346 | 4.42 |
| Agricultural Share of Labor Force | -0.0071 | -1.4 |
| Growth of Per Capita Income | -0.0221 | -1.72 |
| Scientist per 1000 Population | 0.2718 | 4.08 |

Adjusted $R^2$ = 0.5174
F(7, 127) = 24.77
Number of observations = 134
Mean order parameter = 1.876
Standard Error of Regression = 0.775

share falls 1 point, the change in the order parameter would be (.0346)(-2)-.0071(-1) = -.0621. Consequently, if the initial order parameter in that country was 0.80, the order parameter for that country in 2015 would be 0.7379, and the income distribution would show somewhat more inequality (more like Honduras than like Mexico). The corresponding Gini coefficient would rise from 0.544 up to 0.56.

In our analysis, shocks to unskilled labor and total factor productivity (TFP) are the primary means to increase income and productivity of the FIP in low income countries. Four scenarios were examined:

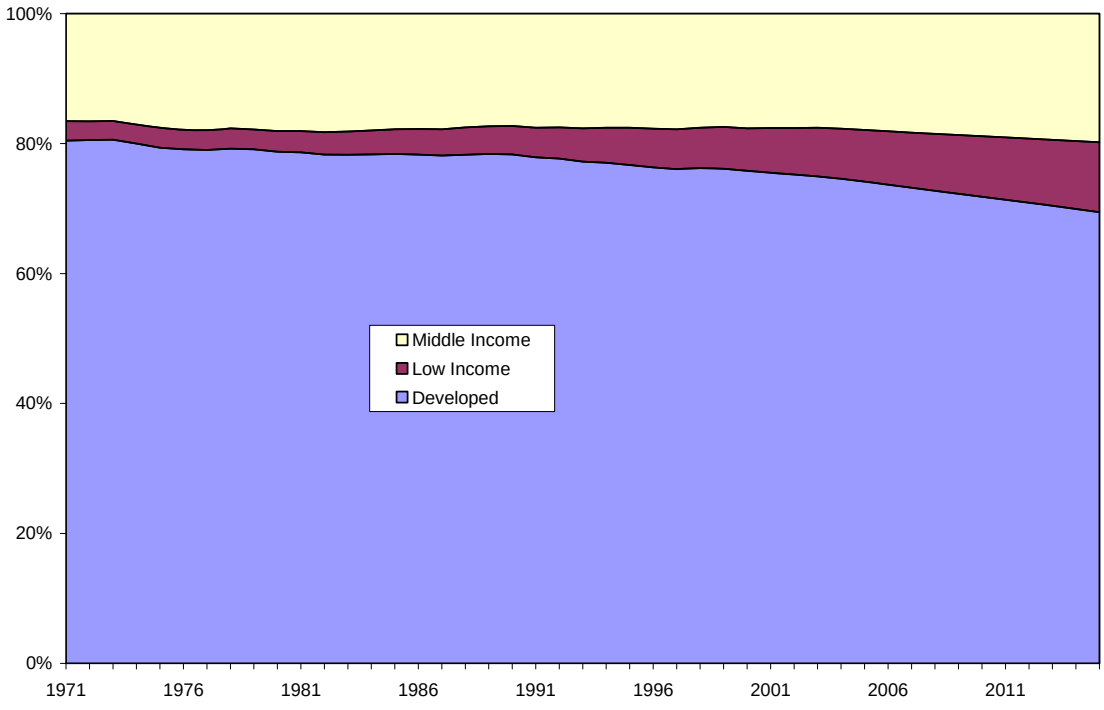
- **Baseline Scenario**--This scenario reflects the ERS baseline projections of income and population growth imposed on the GTAP database to establish a new 2015 projection base;
- **Uniform Labor Productivity Shock**--We shock the productivity parameter of unskilled labor across all industries by 2 percent per year in our low income countries;
- **Economy wide TFP Shock**--We shock TFP by 2 percent per year across all industries in the low income countries;
- **Agricultural TFP Shock**--We shock TFP in primary agriculture by 2 percent per year in the low income countries.

For the purpose of this analysis, we used the following aggregation.[14] We divide the GTAP commodities/sectors into primary agriculture, food industries, resources, other manufacturing, and services. Our country aggregation includes high income countries (HIC), middle income countries (MIC), low income countries (LIC), and 4 specific countries which we break out for illustrative purposes: China, India, Indonesia, and Mexico.

The income and population projections used for this analysis are the ones underlying the USDA/ERS baseline (USDA, 2004). They represent consensus forecasts as interpreted by ERS country analysts. Our regional and world projections are based on individual country projections where available. All countries are covered by the USDA Baseline and background data. Behind the USDA Baseline Population forecasts are those of the United States Bureau of the Census. There are substantial differences in both income and population growth rates across countries and regions. At the high end, China is forecast to have per capita income growth rates of almost 7 percent per year. Vietnam is second with an annual growth rate in excess of 5 percent per year. India is also projected to have a high per capita income growth rate in excess of 4 per cent per year. At the low end are the Sub-Saharan countries with per capita income growth projected at 2.23 percent per year. The develop countries have an annual growth rates projected at around 2 percent per year. In other word, all of the low income country areas are projected to have higher per capita income growth than the developed countries. In terms of overcoming poverty and food insecurity in these poor countries, there could not be a better scenario. These differences show up in the regional aggregations. (fig. 4).

[14] For the details of our aggregation see Appendix 1.

**Figure 4. Shares of World GDP**




**Source: ERS Macroeconomic Data Set. www.ers.usda.gov/data/macroecnomics/**

Population growth rates have been and are projected to continue to fall almost everywhere. Overall the low income countries are projected to have a 25 percent higher population at the end of the projection period than in 1998. This compares with an overall 131 percent increase in per capita income. There are also regional differences in the projected population growth rates. At the high end are the Sub-Saharan countries with average population growth just over 2 percent a year. This compares with the growth in the developed countries of less than 0.5 percent and China with just over a half a percent per year. South Asian population growth rates are projected to be a low of 1.41 percent a year for India and 2.04 for Bangladesh. The low and declining population growth rates compared with the high and growing income bodes well for reducing poverty and food insecurity.

## Modeling Growth and Structural Change

Structural characteristics of individual economies are used to draw inferences about income distribution. As an economy grows there can be major shifts in sectoral output and

employment across sectors. Growth performance is closely tied to trade performance. The spectacular growth in East Asia was directly related to their strong performance in world trade. Trade is also critical for economic growth in much of the developing world. The global economy is comprised of countries linked by international trade and investment Using a framework that enforces consistency conditions on world production, consumption, and trade is highly desirable for making growth projections. Because of these characteristics, the GTAP model provided a good basis for making growth projections. The model solves for changes in output, factors, consumption, and bilateral trade of individual regions. There have been a number of earlier applications using the GTAP model for analyzing structural change from economic growth. Anderson, Dimeranan, Hertel and Martin (1996) used the GTAP model to project a base from which they analyzed policy reforms in the future. Gehlhar, Hertel, and Martin(1994) used the GTAP model to analyze the impact on agricultural trade and structural adjustments among East Asian economies. These projections are conducted using region-specific exogenous factors of production and pre-specified GDP targets on a region-specific basis.

There are various ways of conducting growth projections. One approach is to shock primary factor endowments and then allow technical change to endogenously adjust to achieve a targeted GDP level. In that case structural adjustments would be affected by factor scarcity. Another approach is to assume unconstrained primary factors where factors of production would have a neutral effect on structural change. This is the approach we use in our 'base' projection. It is carried-out by shocking real GDP and technical change. Structural adjustment is dictated by the consumption-side which in the GTAP model is specified by non-homothetic preferences.

The GTAP model contains equations governing primary factor-augmenting technical change. The variable representing technical change for individual primary factors can be exogenously shocked to control for the rate change in a particular sector. In addition, the model contains variables representing Hicks-neutral technical change for individual sectors. For our purposes we wish to implement separate scenarios that alter labor productivity and TFP for primary agriculture and for the total economy.

## Income Distribution Projections

In this section, we present the implications for income distribution of the USDA-ERS baseline income and population projections. This provides us with an initial base to interpret how much could poverty and food insecurity be reduced it the growth itself occurred without any change in the relative income distribution, i.e., if there all segments of the population grow at the same rate as the overall growth rate.

### The Base Run

In the previous section, we examined what hypothetical growth would do to the income distribution. Here we want to make explicit projections based on currently expected growth rates. Assuming no change in income inequality (holding the order parameters constant) and projecting the implications of population and income growth to the year 2015 gives a very interesting result. Current population and income growth combined imply an approximate 33 percent decline in the FIP. This result comes about because of the particularly high projected income growth rates in Asia, but also the relatively high per capita income growth rates in Sub-Saharan Africa. A decomposition of the outcome between Asia, Africa, and Latin America suggests that the situation will worsen somewhat in Africa, but the results in Asia will more than compensate for the increasing number of FIP in Africa. The number of FIP in Latin America remains approximately the same. In numeric terms, there is an increase in the FIP in Africa of almost 110 million, while there is a decline in the FIP in South Asia of about 250 million, and a decline in China of 190 million.

### Changes in Income Distribution

The long term outlook for the FIP depends on the change in the shape of the income distribution. Several factors appear to be particularly associated with worsening income inequality. Economic growth enters in two distinct ways. Neutral growth which shifts the scale parameter to the right reduces the number of FIP. But accelerating income growth particularly in the context of structural change such as transition economies moving toward a market orientation or economies with significant structural reform taking place can led towards

worsening income inequality which can undermine the benefits of growth for low income populations. Countries with patterns of worsening income distributions include the U.S. and the UK, which have gone through periods of deregulation; Poland and Russia, undergoing transition to market orientation; and China, which is experiencing both rapid growth and reform. Most countries with FIP have not, and are not expected to experience significant growth or reform. Thus, we do not expect significant changes in income distribution. A good example of a stable income distribution is India where there has been no discernable pattern of change since the early 1960's.[15]

China, of the low income countries, is a case where changes in income distribution may occur. How would the global FIP change if we assume that the current movement toward income inequality in China continues throughout the projection period? Under that assumption,[16] high rates of income growth in China results in world FIP declining only 20 percent instead of the 33 percent in the base case. This suggests that the food insecure populations of China are not connected to the growth process and rapid growth does not impact on them to any significant degree. In essence, the FIP are similar to street people in the United States.

## GTAP Scenarios

In this section, the implications of the GTAP scenarios introduced previously are explored. Can a general investment strategy or selected investments in unskilled labor productivity or agriculture in low income countries have a positive impact on the FIP? In this section, we consider changes against the baseline.

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[15] The Gini coefficients portrayed in figures 11 through 14 were derived from the Deininger - Squire (1996) compilation of income distributions from around the world.

[16] Moving from an order parameter of approximately 1.7 in 1998 to an order of .78 in 2015. An order parameter of .78 implies an extremely uneven income distribution moving towards one which would be similar to Brazil. Thus this change would have to be considered very unlikely.

General TFP Growth: Of the three scenarios, the most dramatic results occur with the general increase in TFP. In this case, the addition of an economy wide TFP shock of 2 percent a year to low income countries had the impact of reducing the global FIP by an additional 20 percent. Of the additional reduction in FIP from the base run of approximately 200 million, about 2/3 of the reduction comes from Africa. While there is some further reduction in South Asia and China, given the significant declines in FIP in the base case, these additional declines are relatively small. Under this optimistic scenario, the number of FIP in Africa remains approximately the same instead of increasing. The assumption of a 2 percent per year increase in economy-wide TFP has a rather neutral impact on the income distribution. There is some deterioration in the distribution of income. However, the slight decline in the order parameters does not negate the positive impact of income growth in this scenario.

Agricultural TFP Growth: The two other scenarios also had significant positive impacts on reducing FIP, but not of the magnitude of the economy-wide TFP shock. For the case of the agricultural TFP scenario, the FIP is reduced to 640 million by 2015. The outcome occurs in a very different way than from the economy-wide scenario. Income growth is only 10 to 20 percent extra compared with the economy-wide shock, but the order parameter increases substantially for the low income countries and Sub-Saharan Africa. This has the effect of altering the income distribution favorably along with some scale effects. In other words, this is a much more targeted program with resulting positive outcomes.

Labor Productivity Growth: The last scenario, the labor productivity shock of 2 percent per year, falls somewhat between the economy-wide shock and the agriculture only shock. The growth effects average about double those of the agriculture only shock, but the positive order parameter changes, favorable income distribution changes, are less than for the agriculture only case. The outcome in this case is a final FIP in 2015 of 580 million.

## Policy Implications of GTAP Scenarios

The results of the GTAP scenarios provide some preliminary evidence that achieving significant reductions in FIP is possible. Considering the substantial changes in relative growth rates between population and income over the past 10 years has substantially improved the prospects for reducing FIP. However, what does it take to achieve the shocks assumed in the three scenarios and are these realistic possibilities.

Agricultural TFP: The shock which assumes that agricultural TFP grows 2 percent a year faster than otherwise predicted puts the growth in TFP for low income countries in the range of what it has been in the United States and other OECD countries for the past 25 years. That is attainable, but it is not free. It cannot be attained without considerable sustained investment in public and private agricultural R&D in low income countries.[17] The analysis of agricultural productivity growth in the U.S. suggests that it is the accumulated stock of knowledge attained by a long term process of agricultural R&D which generates productivity growth. In the United States, the best fit occurs based on a trapezoidal distribution over 30 years (Shane, Roe, Gopinath, 1998). The maximum impact lag between R&D and productivity growth averages 15 years. Thus if the commitment was made today to try to generate agricultural productivity growth on the order of 2 percent per year as per our assumed scenario, the first effects of that process would only be felt after about 5 years and the full impact would not be felt until after 15 years. This also suggests the resource commitment needed to generate that kind of productivity outcome. In the United States alone, public agricultural R&D is approximately 1 ½ to 2 percent of agricultural GDP. This is supplemented by more than 135 years of cumulative investment in research institutions and infrastructure which allow that R&D expenditure to be productive. The supportive investment is at least several times higher than the level of direct R&D expenditures. Thus a total sustained commitment of about 6 percent of agricultural GDP is required to initiate this process. That is certainly not beyond the means of low income countries if they have the will to accomplish this objective. It is certainly not beyond the capacity if high income donor countries

[17] Investment in both facilities and in human capital is required. Many low-income countries have fewer than 1 scientist or engineer per 10,000 population. (ILO).

are willing to assist in the effort. It is well within the possibilities of the Asian low income countries of South Asia and China. Only in Africa is this a problem.

Labor Productivity: The scenario to increase labor productivity on a sustained basis by 2 percent a year is a more difficult outcome to accomplish. The same problems exist with trying to generate sustained increases in labor productivity as for agricultural productivity, namely that there are substantial lags involved in initiating such a process and generating productivity. In this case, the lag is at least as long as for agricultural productivity growth and perhaps even longer. Labor productivity growth comes about because of growth in human capital. This is really a result of improved education and training, capital investments to augment labor, and programs to retrain, redirect, and refocus human energies. Public expenditures on education in the United States exceed 5 percent of GDP.

**Figure 5. Percent of Secondary School Enrollments**

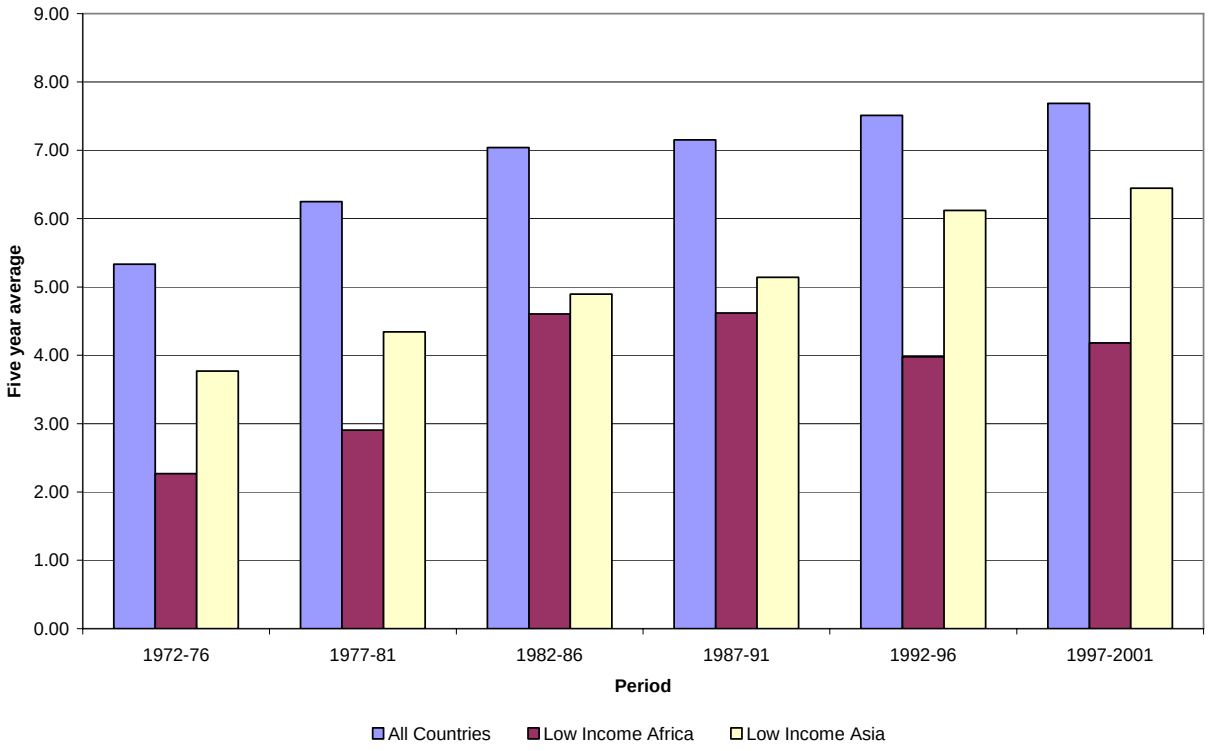


Figure 5 present the percent of the population in secondary education. As you can see from the

chart, there has been a significant increase in the share of secondary school enrollments for all reporting countries, and for low income Asia and African countries. Low income African countries have lagged in the latest two periods (1992-96 and 1997-2001). None the less, there has clearly been a movement towards investing in education in low income countries. Further investments would be required, but the foundation has been laid for significant impacts from previous investments in education. A program to generate a sustained increase in labor productivity of 2 percent a year probably would take a public commitment towards that effort, but also a commitment of an additional 5 GDP of low income countries. Given the experience of Asian countries in raising their saving rates once sustained growth has been established, it does not look like such an investment program is beyond the capacity of Sub-Saharan African countries and is probably already being made by the Asian low income countries.

Economy-wide TFP: The scenario that added 2 percent to economy wide TFP, is an even more ambitious program. Again any such domestic program to accomplish this would involve long lags. Since any such program would need the formation of significant institutions and human capital development before any significant outcomes could be expected, the lag times may be up to twice what would be required for an agricultural TFP program. This suggests that the full impact of undertaking such a program would not be felt for up to 30 years, which takes us well beyond the 20 year time frame of our scenarios. However, since the technological basis of low income countries is so far behind that of the developed countries, it might be possible to achieve high rates of TFP growth by encouraging large inflows of direct foreign investments and thus doing so initially with technical transfer. This involves a radical change in public policy which would open the country up to foreign investment and make the social infrastructure investments such as roads, port facilities, and communications that would make direct foreign investments profitable. There is evidence that both China and India have been doing so. The high rates of TFP achieved in both these countries in recent years have been the backbone of the unprecedented high rates of GDP growth that both have been experiencing. Although a change in political philosophy is difficult to undertake, it is not beyond the realm of possibility that this could occur. There is, indeed, some evidence that the increasing growth in African countries as

well as those in Asia imply a start to this process.

## Conclusions

What can we expect with regard to overcoming food insecurity? First, if the ERS baseline projections for income growth and population are realized substantial reduction in FIP is likely. The combination of increasing per capita income growth in low income countries along with decelerating population growth leads to a reduction in FIP of around one third. Our three proposed scenarios for further reducing the FIP by stimulating either agricultural TFP growth, labor productivity growth, or economy wide TFP growth all led to further improved FIP outcomes in 2015. The labor productivity and economy wide TFP growth scenarios led to outcomes which reduce FIP by around half.

Our preliminary analysis of the programs to achieve productivity growth suggests that the scenarios are all within the bounds of possibilities. Domestic programs to accelerate productivity growth involve lags that may be longer than our analysis period (20 years) and requires substantial national and international resources. However, utilizing international markets and technical transfer can lead to significant benefits even in the relatively short run. Substantial changes in the attitudes of the leaders of low income countries are required. This may turn out to be the most difficult part of the transformation process. The turn around requires a restructuring of the incentives to save and invest. Public investment must overcome inadequate physical and social infrastructure and deficient human capital. And the leadership agenda in these countries must move toward the remediation of market failures and away from rent seeking.

What the Asian growth experience and the China growth experience has taught us is that GDP growth rates thought unattainable, can be realized with firm public commitments to growth. The means for overcoming poverty and food insecurity is available. Whether the will is there is still to be determined.

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Appendix Table 1: GTAP Commodity Aggregation: Commodity by Commodity Conversions

| Commodity Abbreviation | Commodity | Industry Abbreviation | Industry |
|---|---|---|---|
| pdr | Paddy rice | pag | Primary Agriculture |
| wht | Wheat | pag | Primary Agriculture |
| gro | Cereal grains nec | pag | Primary Agriculture |
| v_f | Vegetables, fruit, nuts | pag | Primary Agriculture |
| osd | Oil seeds | pag | Primary Agriculture |
| c_b | Sugar cane, sugar beet | pag | Primary Agriculture |
| pfb | Plant-based fibers | pag | Primary Agriculture |
| ocr | Crops nec | pag | Primary Agriculture |
| ctl | Bovine cattle, sheep and goats, horse | pag | Primary Agriculture |
| oap | Animal products nec | pag | Primary Agriculture |
| rmk | Raw milk | pag | Primary Agriculture |
| wol | Wool silk-worm cocoons | pag | Primary Agriculture |
| for | Forestry | res | Resources |
| fsh | Fishing | res | Resources |
| col | Coal | res | Resources |
| oil | Oil | res | Resources |
| gas | Gas | res | Resources |
| omn | Minerals nec | res | Resources |
| cmt | Bovine cattle, sheep and goat, horse | fod | Food Industries |
| omt | Meat products nec | fod | Food Industries |
| vol | Vegetable oils and fats | fod | Food Industries |
| mil | Dairy products | fod | Food Industries |
| pcr | Processed rice | fod | Food Industries |
| sgr | Sugar | fod | Food Industries |
| ofd | Food products nec | fod | Food Industries |
| b_t | Beverages and tobacco products | fod | Food Industries |
| tex | Textiles | mnf | Other Manufacturing |
| wap | Wearing apparel | mnf | Other Manufacturing |
| lea | Leather products | mnf | Other Manufacturing |
| lum | Wood products | mnf | Other Manufacturing |
| ppp | Paper products, publishing | mnf | Other Manufacturing |
| p_c | Petroleum, coal products | mnf | Other Manufacturing |
| crp | Chemical, rubber, plastic products | mnf | Other Manufacturing |
| nmm | Mineral products nec | mnf | Other Manufacturing |
| i_s | Ferrous metals | mnf | Other Manufacturing |
| nfm | Metals nec | mnf | Other Manufacturing |
| fmp | Metal products | mnf | Other Manufacturing |
| mvh | Motor vehicles and parts | mnf | Other Manufacturing |
| otn | Transport equipment nec | mnf | Other Manufacturing |
| ele | Electronic equipment | mnf | Other Manufacturing |
| ome | Machinery and equipment nec | mnf | Other Manufacturing |
| omf | Manufactures nec | mnf | Other Manufacturing |
| ely | Electricity | sev | Services |
| gdt | Gas manufacture, distribution | sev | Services |
| wtr | Water | sev | Services |
| cns | Construction | sev | Services |
| osp | Financial, business, recreational ser | sev | Services |
| t_t | Trade, transport | sev | Services |
| osg | Public admin and defense, education | sev | Services |
| dwe | Dwellings | sev | Services |

## Appendix Table 2: GTAP Aggregation--Country Classification

| Country Abbreviation | Country | Group Abbreviation | Group |
|---|---|---|---|
| AUS | Australia | HIC | High Income Countries |
| NZL | New Zealand | HIC | High Income Countries |
| JPN | Japan | HIC | China |
| KOR | Republic of Korea | HIC | High Income Countries |
| IDN | Indonesia | IDN | Indonesia |
| MYS | Malaysia | MIC | Middle Income Countries |
| PHL | Philippines | MIC | Middle Income Countries |
| SGP | Singapore | MIC | Middle Income Countries |
| THA | Thailand | MIC | Middle Income Countries |
| VNM | Vietnam | MIC | Middle Income Countries |
| CHN | China | CHN | China |
| HKG | Hong Kong | HIC | China |
| TWN | Taiwan | HIC | China |
| IND | India | IND | India |
| LKA | Sri Lanka | LIC | Low Income Countries |
| RAS | Rest of South Asia | LIC | Low Income Countries |
| CAN | Canada | HIC | High Income Countries |
| USA | United States of America | HIC | High Income Countries |
| MEX | Mexico | MEX | Mexico |
| CAM | Central America and Caribbean | LIC | Low Income Countries |
| VEN | Venezuela | MIC | Middle Income Countries |
| COL | Colombia | LIC | Low Income Countries |
| RAP | Rest of Andean Pact | MIC | Middle Income Countries |
| ARG | Argentina | MIC | Middle Income Countries |
| BRA | Brazil | MIC | Middle Income Countries |
| CHL | Chile | MIC | Middle Income Countries |
| URY | Uruguay | MIC | Middle Income Countries |
| RSM | Rest of South America | MIC | Middle Income Countries |
| GBR | United Kingdom | HIC | High Income Countries |
| DEU | Germany | HIC | High Income Countries |
| DNK | Denmark | HIC | High Income Countries |
| SWE | Sweden | HIC | High Income Countries |
| FIN | Finland | HIC | High Income Countries |
| REU | Rest of European Union | HIC | High Income Countries |
| EFT | European Free Trade Area | HIC | High Income Countries |
| CEA | Central European Associates | MIC | Middle Income Countries |
| FSU | Former Soviet Union | MIC | Middle Income Countries |
| TUR | Turkey | MIC | Middle Income Countries |
| RME | Rest of Middle East | MIC | Middle Income Countries |
| MAR | Morocco | MIC | Middle Income Countries |
| RNF | Rest of North Africa | MIC | Middle Income Countries |
| SAF | South African Customs Union | MIC | Middle Income Countries |
| RSA | Rest of Southern Africa | RSA | Rest of Southern Africa |
| RSS | Rest of Sub Saharan Africa | RSA | Rest of Southern Africa |
| ROW | Rest of World | MIC | Middle Income Countries |