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# Food Security and Government Interventions: A Study of Indian Grain Markets

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ABSTRACT *This study examines the future of Indian food security in light of possible liberalization of its agriculture sector. Demand for major food grains such as wheat and rice is projected after taking into account possible dietary changes due to income growth, urbanization and other demographic changes. Policy Analysis Matrix (PAM) indicators are constructed to predict changes in supply patterns in the case of reduced government intervention. The projected demand growth suggests faster increases in per capita wheat consumption due to strong income growth and urbanization whereas per capita rice consumption is projected to level off in the next few years and then will likely decline steadily for the remainder of the projection period. This indicates that Indian wheat production may need to grow at a much faster rate than rice production in order to remain self-sufficient in the future. Based on the PAM ranking, this may be possible under reduced or no government interventions because of the comparative advantage of wheat over rice in the major growing regions.*

KEY WORDS: India, comparative advantage, PAM, demand projections

## Introduction

The paper projects future demand growth in grain after taking into account possible dietary changes due to income growth, urbanization and other demographic changes. Policy Analysis Matrix (PAM) indicators are constructed to project possible changes in supply patterns of grains in the future. The results indicate that Indian wheat production may need to grow at a much faster rate than rice production in order to maintain food security in the future.

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Food production in India has grown at an amazing annual rate of 2.5 per cent over the last four decades (Brahmananda, 1997). The Government of India (GOI) has promoted this impressive growth in food production through a complex set of interventions in both domestic and international markets. On the domestic front, the GOI has provided input subsidies along with minimum support prices for most agricultural commodities. The government has effectively maintained these domestic policies with a series of restrictive trade policies such as import licensing, tariffs, quotas and state trading.

These complex domestic and trade restricting policies along with significant investments in agricultural research, extension and infrastructure have enabled India to become one of the leading producers of many crops, including rice, wheat, coarse grains, cotton and lentils, with self-sufficiency in major grains. This self-sufficiency has been achieved at significant costs with annual subsidies of more than $12 billion accounting for approximately 14 per cent of all government expenditures (Landes, 2004). The fertilizer subsidy alone has more than doubled in the last decade, increasing from 60 billion rupees in 1992/93 to 140 billion rupees in 2001/02 (one US dollar equals about 43 rupees). In addition to this and other production subsidies, about $11 billion of bank credit, around 10 per cent of all bank credit in the country, is now tied up by government borrowing to hold wheat and rice stocks (Landes, 2004).

Currently, Indian agriculture is at a crossroad. Income growth, population growth, urban–rural population composition, family size, and other demographic factors are likely to influence food preferences significantly in the coming decades. India is projected to experience strong income growth in the next decade. Macroeconomic forecasters such as the World Bank, WEFA, and Standard and Poor's DRI are now projecting average annual growth of 6 to 8 per cent in India's real GDP in the next decade. In addition to projected strong economic growth, the Indian population is also projected to grow substantially, exceeding that of China by the middle of this century (1.5 billion as compared to 1.4 billion in China). At that time, more than 55 per cent of the Indian population will live in urban locations as compared to 28 per cent in 2003. Even more important, India has more than 200 million middle-class consumers and this number is likely to grow with economic prosperity (Landes, 2004).

On the supply side, restrictive trade policies have, until recently, kept India's agriculture insulated from outside competition. Since 1997, however, India has been removing many licensing and quota restrictions and replacing them with high tariffs as part of its World Trade Organization (WTO) commitments. In addition to trade liberalization, the GOI is also trying to contain the ever-increasing production and food subsidies. These developments indicate that, sooner or later, Indian agriculture will have to come to terms with external trade in agricultural products. With reduced government intervention both in domestic and international markets, changes in the cropping patterns, which are still partly determined by non-market influences such as production subsidies, import restrictions, and high support prices, are likely.

For a country as large as India, changes in supply and demand have significant implications for world markets. This study attempts to measure future growth in food demand and then uses a Policy Analysis Matrix (PAM) to rank various crops in major growing regions based on their comparative advantage to determine if the demand growth is consistent with the potential changes in supply patterns. The remainder of the paper is organized as follows. First, a brief description of Indian grain policies is provided. Following this, the modelling framework for the demand projections and the PAM is discussed. Next, food demand is projected and the competitiveness of Indian grain production is measured. Finally, the results are discussed and policy implications of the findings are provided.

## Indian Grain Policies

Like many other Asian countries, Indian policymakers have defined food security as grain self-sufficiency and have focused their attention on grain markets and trade. Self-sufficiency is usually taken to mean that the country does not import grain but rather obtains the totality of its internal supply from domestic production. Self-sufficiency policies are only necessary if the country does not have a comparative advantage in the staple crop. If it does have a comparative advantage, it would be a net exporter rather than an importer. Thus, in most cases, policies to promote self-sufficiency are inherently protectionist. In high-income countries such as Japan, rice self-sufficiency has been defended on the basis of the potential vulnerability to trade embargoes of an island nation in which rice has great cultural significance. Such protectionist policies have come under attack at the World Trade Organization. Low-income countries enjoy special and differential treatment with respect to protectionism but are increasingly being called upon to make commitments to liberalize markets. India's traditional commitment to self-sufficiency probably has more to do with the distrust of markets associated with the import-substitution policies prevalent in the 1960s and 1970s than with the cultural significance of either wheat or rice.

With self-sufficiency as its goal, the GOI for many years has controlled the country's agriculture by subsidizing and regulating domestic markets. A significant portion of government funds has been used to subsidize such inputs as power, irrigation and fertilizers. In addition to input subsidies, the government also stands ready to buy agricultural products from farmers at the announced support prices. The government has backed up these domestic policies with a series of restrictive trade policies such as import licensing, tariffs, quotas and state trading. These policies have virtually banned the private importation of most agricultural products. For example, when these policies were in full force in 1991, Indian agricultural imports were only $0.8 billion compared to imports of $5 billion in China. The impacts of trade distortions can also be judged from the recent trade liberalizations that helped more than double India's agricultural imports in recent years. As a result of trade liberalization, India is now the world's largest importer of edible oils and pulses (Landes, 2004).

After years of isolation, India has slowly begun opening its door to the world market. In 1991, the GOI initiated significant economic reforms and structural adjustment polices. The policies were targeted primarily at industry and the international trade regime, affecting agriculture only indirectly through reductions in input subsidies. In addition to unilateral liberalization, India, as a signatory of Uruguay Round Agreement of the General Agreement on Tariffs and Trade (GATT), is committed to open up its agriculture to world markets. In earlier years, India had taken advantage of GATT Article XVIII-B, which permits a country to impose or continue to impose quantitative restrictions on imports if there is a problem in the balance of payments (BOP) account. Since 1997, India has replaced certain import licensing and quota restrictions with high tariffs as part of its WTO commitments and in response to threats from trading partners to initiate dispute settlement procedures in the WTO if these quantitative trade restrictions were not removed (Gulati and Kelly, 2000).

## Modelling Framework

In this study, food demand is projected using an income elasticity approach where the growth rate of real expenditure is projected and then the growth rate of demand for food commodities is calculated on the basis of estimates of income elasticities. Food demand will be estimated separately for urban and rural areas. Separate demand projections are justified because of significant variation in food consumption between rural and urban areas and the rapid growth of the urban population that is likely to occur over the next few decades. In addition, consumption levels also vary significantly across different income classes within each of these categories. In order to capture the various consumption responses to income growth, demand projections are made separately for five income groups within each category.

A large number of alternative functional forms are possible for modelling the Engel curve, which is the relationship between food demand and income levels. The double-log specification has been used widely because of its simplicity and readily interpretable properties. However, this functional form is not theoretically desirable because of its limitation that all food consumption is expected to increase with rising income levels. Other functional forms include the semi-log, log-log inverse, and log-quadratic. Let $Y$ represent the quantity consumed and $X$ the income level.

Semi-Log: $Y = a + b\ \ln(X)$ (1)

Income Elasticity $= b/Y$

Log-Log inverse: $\ln(Y) = a + b/X + c\ \ln(X)$ (2)

Income Elasticity $= b/X - c$

Log Quadratic: $\ln(Y) = a + b\ \ln(X) + c\ \ln(X)2$ (3)

Income Elasticity $= b + 2c\ln(X)$

*Measures of Comparative Advantages*

Comparative advantage in agriculture has been measured using different approaches. Many researchers have attempted to measure comparative advantage in agricultural production using fully specified economic models of supply, demand and trade. These models required a large investment in data collection and analysis and discouraged many researchers from following this path (Mucavele, 2000). Hence, efforts have been focused on developing a theoretically correct and easily understandable approach to measure comparative advantage. One analytical approach focuses on the private and social costs of public sector investment using net present value (NPV) and the economic internal rate of return (EIRR) (Nelson and Panggabean, 1991). Other approaches focus on the static effects of price distorting policies using effective protection coefficients (EPC) and the domestic resource cost (DRC). One of the disadvantages of these summary measures is that they may summarize too much, leaving important results of the analysis unnoticed (Nelson and Panggabean, 1991).

The policy analysis matrix (PAM) developed by Monke and Pearson (1989) and augmented by Masters and Winter-Nelson (1995) addresses this problem. The primary strength of the PAM is that it allows varying levels of disaggregation and makes the analysis of policy-induced transfers straightforward. A detailed description of the basic format of the PAM can be found in Monke and Pearson (1989).

The PAM framework enables researchers to calculate important indicators for policy analysis. Domestic resource cost (DRC), is one of the most useful of these. It is used to compare the relative efficiency, or comparative advantage, between agricultural commodities. DRC is defined as the shadow value of non-tradable factor inputs used in an activity per unit of tradable value added. The DRC indicates whether the use of domestic factors is socially profitable ($DRC < 1$) or not ($DRC > 1$). However, the DRC may be biased against activities that rely heavily on domestic non-traded factors such as land and labour. A good alternative for the DRC is the social cost-benefit ratio (SCB), which accounts for all costs (Fang and Beghin, 1999). Land is a more restricted factor than other domestic factors in India's crop production. Therefore, another indicator, the SCB without the land-cost (LSB), is used to measure the return to this fixed factor. Higher values of SCB and LSB suggest stronger competitiveness.

## Data and Modelling Assumptions

Data for estimating demand equations for urban and rural consumers were from the 1996/97 consumer expenditure data from the National Sample Survey Organization of India. The data requirements for constructing the PAM include yields, input requirements, and the market prices for inputs and outputs. This data was collected for wheat, rice and other competing crops in four major growing regions, Punjab, Haryana, Gujrat and Andhra Pradesh. Most data were collected from the 2000 edition of Cost of Cultivation of Principal Crops in India, published by the Ministry of Agriculture & Cooperation, Government of India (Government of India 2000). Additional data such as world prices, transportation costs, port charges, storage costs, production subsidies, import/export tariffs and the exchange rate, required to calculate social prices, were collected from various other sources. The US FOB Gulf prices were used as reference prices for wheat, corn, and sorghum. The canola cash price, Vancouver, cotton A-index CIF Northern Europe,[1] raw sugar price FOB Caribbean and US runner, 40 to 50 per cent shelled basis CIF Rotterdam were used as the representative prices for rapeseed, cotton, sugar, and groundnut respectively. These world prices were obtained from various commodity yearbooks published by USDA. Freight rates from Gulf ports and Rotterdam were collected from Pursell and Gupta (2001).

In this study, three alternative functional forms (equations (1) to (3)) of the Engel curve were estimated. All three provide good fits but the log-quadratic functional form appears to be better for most commodities. Consequently, that form was chosen to project demand for each of the five income groups in urban and rural areas with the following macroeconomic assumptions:

(1) Population growth is projected to decline from 1.53 per cent in 2001 to 1.29 per cent in 2010 and declines further to 1.06 per cent by 2020.
(2) Real GDP is projected to grow at an average annual rate of 5.7 per cent between 2002 and 2010, and 5.5 per cent for 2011 to 2020. With declining population growth, this GDP growth is translated into a per capita real GDP growth rate of 4.4 per cent for 2001 to 2010 and increasing to 4.56 per cent for the next ten years.

Generally, expenditure growth is assumed to be the same as GDP growth. However, GDP includes more than just private consumption, i.e. private investments, imports, exports, and government spending. Thus, it is likely that food expenditures will follow private consumption more closely than general economic indicators such as GDP. A recent study by

Lutz and Smallwood (1997) supports this by finding that, in the United States, food spending tends to follow more closely private consumption than GDP. Keeping this in mind, in this study, consumption expenditure growth is calculated from private consumption rather than GDP. Urban and rural per capita expenditure are calculated using national average per capita expenditure, the population share and ratio of expenditures using:

$$E_r = E_a(1 - S_u)/PS_r$$

where $E_r$ = average per capita rural expenditure, $E_a$ = average per capita expenditure, $S_u$ = share of urban in total expenditure, and $PS_r$ = population share of rural area. Further inequality in income distribution is introduced in the five income groups (quintiles 1 to 5) for the rural and urban populations. It is assumed that upper income groups will have a greater share of income growth. Each quintile accounts for 20 per cent of the population and the quintiles are ranked according to income from the poorest (quintile one) to the richest (quintile five).

(3) Private consumption is projected to decline from 55 per cent in 2001 to 52 per cent of GDP by 2010 and further declines to 49 per cent by 2029, which lowers the growth rate of per capita real expenditure from 4 per cent in 2001 to 3.8 per cent by 2020.
(4) Urban population is projected to grow from 27 per cent in 2001 to 35 per cent by 2020.
(5) The ratio of rural to urban expenditure is projected to decline from 59 per cent in 2001 to 51.5 per cent by 2020. With these assumptions, urban per capita expenditures are projected to grow almost 1 per cent higher than rural per capita expenditures.

Total population projections were obtained from the US Census Bureau's international database. Urban population projections were obtained from FAOSTAT database. Finally, GDP projections until 2013 were collected from the FAPRI 2004 US and World Agricultural Outlook (Food and Agricultural Policy Research Institute, 2004). For the remaining period, the GDP growth was held constant at the 2013 level.

As noted above, the rationale for conducting separate analyses for rural and urban populations is the expectation that consumption patterns would differ between these groups. Urban incomes are generally higher than rural, and urban consumers face different constraints related to time and food preparation technologies than their rural counterparts. It is true that most of the large cities in India are surrounded by shanty towns inhabited by low-income families that may still engage in artisanal activities such as gardening and handicrafts. For these families, lifestyles and consumption patterns may be more similar to those of rural populations than to the modern, industrial groups at the centre of India's major cities. Including these households as part of the urban population could undermine the rationale for carrying out separate analyses. It should be noted, however, that the growing middle class in India resides primarily in the large cities and it is likely that urban consumption patterns, even if they include the peripheral, low-income populations, will differ substantially from what is observed in purely rural areas.

In the next step, the PAM is constructed after estimating social prices for outputs and inputs and decomposing inputs into their tradable and non-tradable components. To compute social prices for various commodities including both outputs and inputs, world prices are used as the reference prices. The world prices are adjusted for transportation costs and marketing costs to be comparable at the farm gate. For imported commodities, social prices at the farm gate are calculated by adding marketing costs from the respective CIF Mumbai prices[2] in domestic currency. Similarly, for exported commodities, social prices at the farm gate are calculated by adding marketing costs from the respective world reference prices in the domestic currency. Freight rates from Gulf ports and Rotterdam are added to the FOB Gulf and CIF Rotterdam prices. These prices are converted to domestic currencies using market exchange rates and, finally, marketing costs are added to compare with farm gate prices. Following Purshell and Gupta (2001), marketing costs consist of an interest charge for two months at an 18 per cent rate applied to the CIF prices plus Re 10 per metric ton to represent other marketing expenses. Similar procedures are used for calculating input shadow prices for fertilizers and pesticides.

## Results

The three alternative functional forms of the Engle curve were estimated through regression analysis using the data from 1996–97 consumer expenditure data. The particular functional form used to represent the Engel curve is usually chosen based on the goodness of fit. After testing all the functional form, the log-quadratic functional form was found to provide a marginally better fit as compared with the others. In addition, this functional form has the advantage of allowing income elasticities to decline or even become negative with increasing incomes. This is extremely important for this study because rice and coarse grains are becoming inferior goods with the rise of income. Estimates of the log-quadratic form of the Engle equations for rural population are given in Table 1 and for urban population in Table 2.[3]

The income elasticities for five different income groups (quintiles one to five) in urban and rural areas are reported in Tables 3 and 4 respectively. The quintiles are arranged from the poorest (quintile one) to the richest (quintile five). As expected, income elasticities are higher for rural than for urban consumers across all commodities and income groups and decrease as the income level rises. For example, the income elasticity of quintile one for wheat is 0.495 and 0.316 for rural and urban respectively. As income rises,

**Table 1.** OLS estimates of Engle equation for rural population

| *Commodity* | *Constant* | *ln(income)* | *ln(income)²* | $R^2$ |
|---|---|---|---|---|
| Rice | −21.01 (0.07) | 6.11 (0.95) | −0.37 (0.06) | 0.90 |
| Wheat | −0.57 (0.04) | 0.65 (0.61) | −0.01 (0.02) | 0.98 |
| Corn | 16.61 (0.09) | −3.29 (1.32) | 0.18 (0.08) | 0.84 |
| Sorghum | 26.87 (0.07) | −5.54 (1.05) | 0.31 (0.06) | 0.96 |
| Other Grains | −10.65 (0.08) | 3.23 (1.13) | −0.20 (0.07) | 0.99 |

**Table 2.** OLS estimates of Engle equation for urban population

| *Commodity* | *Constant* | *ln(income)* | *ln(income)²* | $R^2$ |
|---|---|---|---|---|
| Rice | −11.93 (0.08) | 3.77 (0.87) | −0.22 (0.05) | 0.77 |
| Wheat | −3.97 (0.02) | 1.72 (0.22) | −0.09 (0.01) | 0.97 |
| Corn | 3.05 (0.35) | −0.02 (4.03) | −0.04 (0.23) | 0.67 |
| Sorghum | 24.32 (0.17) | −4.3 (1.89) | 0.19 (0.11) | 0.95 |
| Other coarse grains | −39.78 (0.09) | 10.23 (1.10) | −0.64 (0.06) | 0.97 |

**Table 3.** Income elasticities for different income groups in rural areas at the mean expenditure level

| *Commodity* | *Quintile one* | *Quintile two* | *Quintile three* | *Quintile four* | *Quintile five* |
|---|---|---|---|---|---|
| Wheat | 0.495 | 0.489 | 0.484 | 0.479 | 0.469 |
| Rice | 0.715 | 0.471 | 0.307 | 0.120 | −0.210 |
| Sorghum | −0.958 | −0.750 | −0.611 | −0.453 | −0.172 |
| Corn | −0.625 | −0.505 | −0.424 | −0.332 | −0.169 |
| Other coarse grains | 0.303 | 0.171 | 0.082 | −0.019 | −0.198 |

**Table 4.** Income elasticities for different income groups in urban areas at the mean expenditure level

| *Commodity* | *Quintile one* | *Quintile two* | *Quintile three* | *Quintile four* | *Quintile five* |
|---|---|---|---|---|---|
| Wheat | 0.316 | 0.247 | 0.194 | 0.133 | 0.035 |
| Rice | 0.386 | 0.221 | 0.094 | −0.053 | −0.287 |
| Sorghum | −1.382 | −1.239 | −1.129 | −1.003 | −0.801 |
| Corn | −0.598 | −0.626 | −0.648 | −0.673 | −0.713 |
| Other coarse grains | 0.451 | −0.027 | −0.395 | −0.818 | −1.495 |

the income elasticity for wheat in rural areas declines from 0.495 to 0.469 and from 0.316 to 0.035 in urban areas. The income elasticity for rice is positive for lower income groups but becomes negative for higher income groups, both in urban and rural areas. Other grains such as corn and sorghum have negative income elasticities across most income groups, with the exception of some positive income elasticities for lower income groups in the case of other coarse grains.

Strong income growth and urbanization are expected to significantly change the composition of the food basket. A shift in diets from rice and other coarse grains to wheat is likely to drive up per capita wheat consumption steadily throughout the projection period from approximately 60 kg in 2000/01 to 73.3 kg by 2020 (Figure 1). An in depth examination of wheat consumption among different income groups suggests that per capita wheat consumption of different income classes, both in the urban and rural locations, will grow at different rates in the future. For example, as shown in Figure 2, per capita wheat consumption of the lower income groups in urban areas is projected to increase at a much higher rate than for the upper income groups. Per capita wheat consumption of the top three income classes even starts declining toward the latter part of the projection period. This differs from rural consumption, where per capita wheat consumption for different income groups increases throughout the projection period with lower income groups increasing at a faster rate than the upper income groups.

Average urban per capita wheat consumption, which is slightly higher than rural wheat consumption in 2000/01, is projected to grow at a much slower rate during the next two decades as compared to rural per capita wheat consumption. By 2020, rural per capita wheat consumption is projected to be 10 kg higher than the urban level. The difference in the growth rate in per capita wheat consumption between rural and urban locations makes sense because, as income increases, urban consumers diversify their diets to include

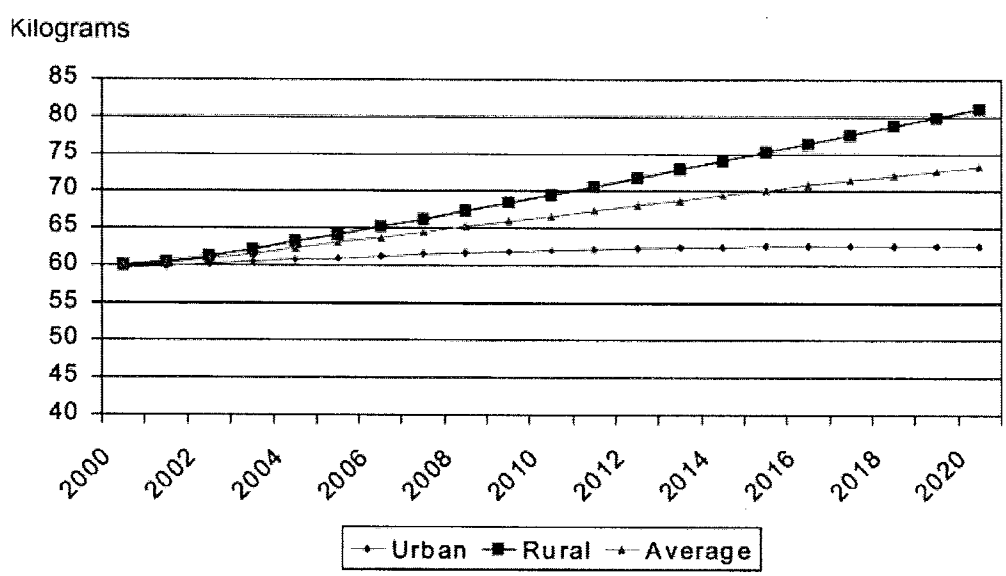



**Figure 1.** Average per capita wheat consumption: urban versus rural

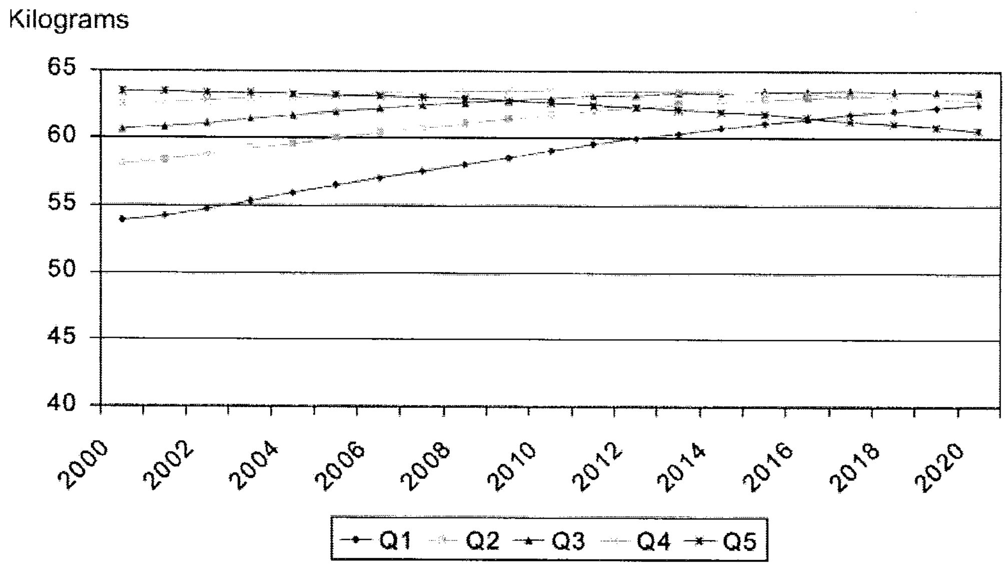



**Figure 2.** Urban: per capita wheat consumption by income groups

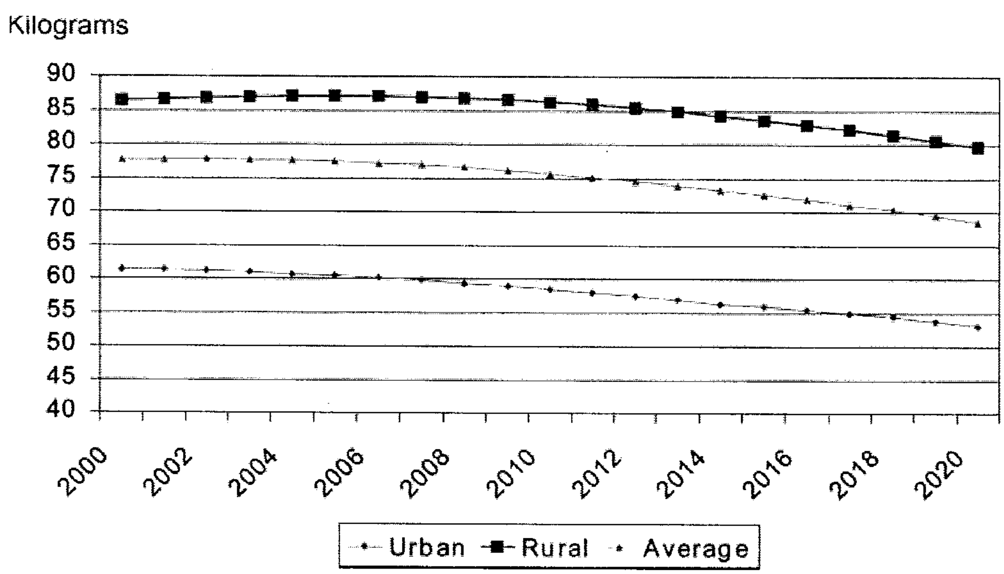



**Figure 3.** Average per capita rice consumption: urban versus rural

more non-grain products such as dairy products, meat, fruits and vegetables. In contrast, rural consumers have fewer choices so income increases are spent on increased grain consumption.

Unlike wheat, average per capita rice consumption is likely to increase slightly in the next few years and then to begin declining from 77.67 kg in 2003 to 68.5 kg in 2020 (Figure 3). This is caused primarily by declining urban rice consumption across the various income groups in the next two decades (Figure 4). Even rural per capita rice consumption for middle and

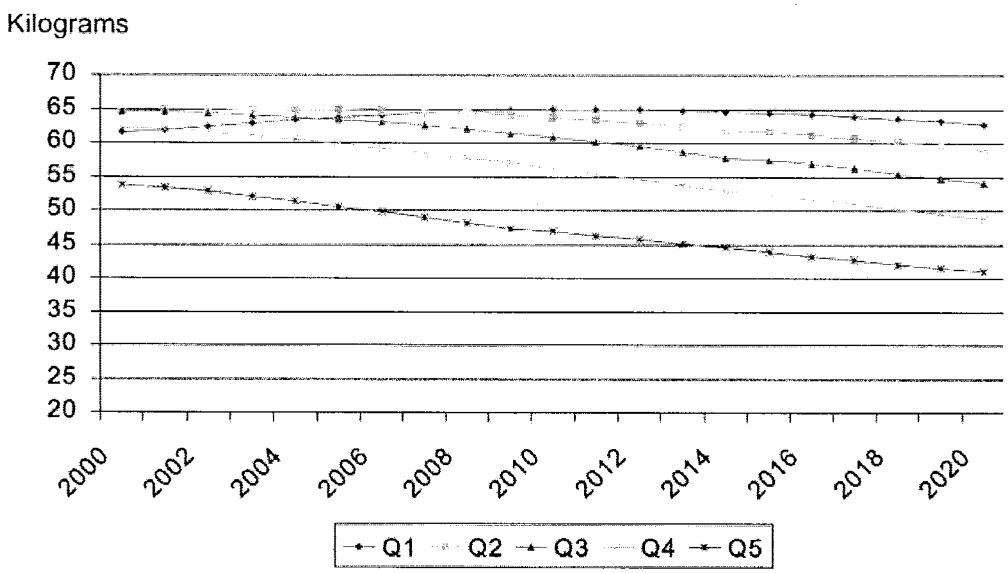
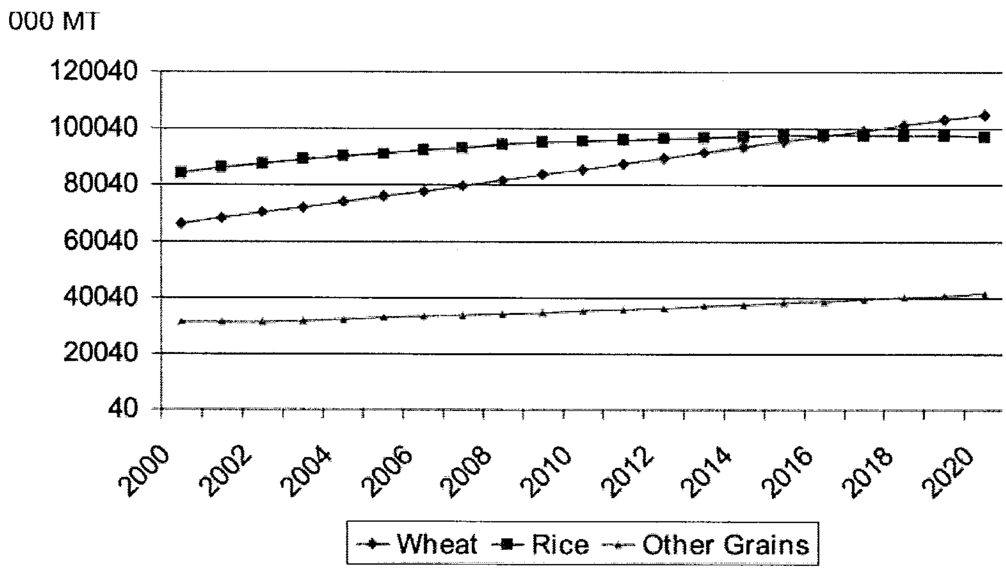



**Figure 4.** Urban: per capita rice consumption by income groups




*Other grains include corn, sorghum and millets

**Figure 5.** Projected domestic utilizations of various grains

upper income groups is projected to decline towards the later part of the projection period.

As shown in Figure 5, total domestic utilization of wheat, approximately 18 million metric tons (mmt) less than rice in 2000, is projected to increase at a much faster pace and even exceed rice utilization in 2017. Over the next two decades, total wheat consumption increases from 66.4 mmt to in 2000 to 105 mmt in 2020. Unlike wheat, total rice consumption is estimated to grow from 84 mmt in 2000 to 97 mmt in 2017 and starts declining afterwards. Overall, the demand projections suggest that India may need to expand its wheat production at a much faster rate in order to maintain food self- sufficiency in the future. If current policies are continued, India is likely to import wheat and export rice.

In the next step, PAM indicators are used to measure the comparative advantage of crop production in the major producing regions. PAM indicators such as the DRC, SCB and LSB for wheat and rice along with competing crops in each state are reported in Table 5 and their rankings are reported in Table 6. The DRC values for rice in each of the growing states are much larger than their respective competing crops and even greater than one in two of the states. In Punjab, the DRC value for rice is found to be slightly less than one. Unlike rice, DRC values for wheat are much less than one and also the lowest among their competing crops in the two top wheat producing states, Punjab and Haryana. However, the DRC value for Gujarat, the third wheat producing state included in this study is greater than one and also higher than competing crops. This is primarily because of low wheat yield in Gujarat, which is on average 40 per cent lower than the wheat yields in Punjab and Haryana. The above results imply that wheat has an obvious comparative advantage both in Punjab and Haryana, whereas

**Table 5.** Results of the state indicators for wheat, rice and competing crops

| *Commodity* | *Indicators* | *Punjab* | *Haryana* | *Gujarat* | *Andhra Pradesh* |
|---|---|---|---|---|---|
| Wheat | DRC | 0.41 | 0.39 | 1.12 | |
| | SCB | 0.49 | 0.46 | 1.10 | |
| | LSB | 23,634 | 21,356 | 8547 | |
| Rice | DRC | 0.91 | 1.37 | | 1.42 |
| | SCB | 0.93 | 1.24 | | 1.3 |
| | LSB | 7103 | 91 | | 841 |
| Cotton | DRC | 0.65 | 0.96 | 0.55 | 0.78 |
| | SCB | 0.72 | 0.97 | 0.60 | 0.82 |
| | LSB | 7141 | 11,017 | 15,781 | 19,265 |
| Sugarcane | DRC | | | | 0.46 |
| | SCB | | | | 0.49 |
| | LSB | | | | 67,283 |
| Rapeseed | DRC | | 0.44 | 0.88 | |
| | SCB | | 0.47 | 0.89 | |
| | LSB | | 14,124 | 13,291 | |
| Corn | DRC | | | | 0.36 |
| | SCB | | | | 0.44 |
| | LSB | | | | 10,698 |
| Groundnut | DRC | | | 0.44 | 0.27 |
| | SCB | | | 0.51 | 0.36 |
| | LSB | | | 20,223 | 16,182 |

**Table 6.** Comparative advantage ranking by crop

| *State* | *Commodity* | *DRC* | *SCB* | *LCB* |
|---|---|---|---|---|
| Punjab | Wheat | 1 | 1 | 1 |
| | Cotton | 2 | 2 | 2 |
| | Rice | 3 | 3 | 3 |
| Haryana | Wheat | 1 | 1 | 1 |
| | Rapeseed | 2 | 2 | 2 |
| | Cotton | 3 | 3 | 3 |
| | Rice | 4 | 4 | 4 |
| Gujarat | Groundnut | 1 | 1 | 1 |
| | Cotton | 2 | 2 | 2 |
| | Rapeseed | 3 | 3 | 3 |
| | Wheat | 4 | 4 | 4 |
| Andhra Pradesh | Groundnut | 1 | 1 | 3 |
| | Corn | 2 | 2 | 4 |
| | Sugarcane | 3 | 3 | 1 |
| | Cotton | 4 | 4 | 2 |
| | Rice | 5 | 5 | 3 |

rice is the least competitive crop produced in these two states. Virtually free irrigation water and a prolonged cooler climate make wheat the most competitive crop in both Punjab and Haryana. In these two states, more than 95 per cent of the wheat area is irrigated.

If government market interventions are eliminated, crop area is likely to be diverted from rice to wheat with some land moving to other more competitive crops. Surprisingly, rice is also not competitively produced in the southern state of Andhra Pradesh, one of the major rice producing states in India. The results are strengthened by the fact that both DRC and LSB indicators give rise to more or less similar rankings. However, for one state, Andhra Pradesh, the LSB indicators show a slightly different commodity ranking from that based on the DRC indicators.

Overall, the PAM results suggest that rice production is not competitive at all in all the four states included in the study. However, wheat is found to have a comparative advantage in two of the top wheat producing states in the country. The lack of competitiveness of rice is not surprising in the face of heavy government interventions in the rice sector to achieve food security. Wheat is competitive in the wheat belt of northern Indian states because of higher yields. Wheat yields in both Punjab (4.6 mt/hectare) and Haryana (4.17 mt/hectare) are comparable to average wheat yields for the world.

Based on the PAM indicators, it may be concluded that any unilateral or multilateral trade liberalization of the agricultural sector will lead to higher wheat production and lower rice production in India. This is consistent with India's future food demand growth, which suggests faster increases in Indian per capita wheat consumption than rice consumption because of changes in consumption patterns induced by strong income growth and urbanization. In other words, the results suggest that liberalization of agriculture may in fact help to bolster food security. At the same time, a continuation of current policies may result in surplus rice production and a shortage in wheat production, making India a significant net importer of wheat to meet domestic demand. In addition, India will have either to store the excess rice or to find foreign markets to dispose of it. From a policy perspective, the results provide vital insights for the future planning process.

## Concluding Remarks

This study attempts to examine the future of Indian food security as its agricultural sector is liberalized. The results suggest that improved food security can be achieved through market liberalization while a continuation of current self-sufficiency polices could result in costly market distortions. The projected demand growth suggests a faster increases in per capita wheat consumption due to strong income growth and urbanization, whereas per capita rice consumption is projected to level off in the next few years and is then likely to decline steadily for the remainder of the projection period. This suggests that Indian wheat production needs to grow at a much faster rate than rice to maintain a degree of self-sufficiency in cereal grains.

On the supply side, the PAM indicators show a competitive advantage for wheat production in the major wheat producing regions. These indicators also suggest that rice is not competitive in all the regions included in this study. Based on these results, it may be concluded that areas under wheat and other cash crops, such as sugarcane, groundnut and rapeseed, will expand at the expense of rice in the event of reduced government interventions.

As the PAM is a static model that cannot capture the potential changes in prices and productivity, these rankings are subject to change with market conditions. For example, changes in either international prices or parity prices of tradable inputs can change the values of DRCs for different crops and in turn affect the rankings. Therefore, any policy implications derived from these protection indicators should be interpreted with caution.

## Notes

[1] An average of the cheapest five types of cotton offered in the European market.

[2] Calculated by adding ocean freight charge to the FOB price.

[3] The estimation results for the other functional forms are available from the author upon request.

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