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POTENTIAL CONSUMPTION INSURANCE IN DEVELOPING COUNTRIES : THE ROLE OF FOREIGN TRADE, FOOD RESERVE AND INTERNATIONAL AID PROGRAMS

by
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1. *Introduction*

Market completeness, which lies at the heart of the classical Arrow-Debreu paradigm of general equilibrium, essentially means that every good (defined in an extended sense as in Debreu (1959), in order to also account for the time period, state of the world and location in which it is available) can be exchanged against every other good, and competitive prices emerge for all such transactions. For economic agents this means, in turn, that it is always possible to redistribute wealth from locations, dates or states of the world in which it is relatively more abundant to locations, dates or states of the world in which it is relatively less abundant, provided that other agents have opposite needs (i.e., that risk is not aggregate). In other words, we could say that the main implication of market completeness is the possibility for every agent to insure against idiosyncratic shocks.

If the possibility of insuring against idiosyncratic risks is something desirable in all economies, this is particularly true in developing countries, where lack of insurance may lead to more inequality and to lower

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levels of investments, income, consumption and savings (Townsend, 1995a; Greenwood and Jovanovic, 1990; Banerjee and Newman, 1993). Increasing inequality, in turn, may constitute a relevant obstacle to the development of growth processes in such countries (Townsend, 1995a).

Markets can be completed in many ways, both ex-ante and ex-post.

A typical instrument to get complete markets ex-ante would be the opening of a full set of trading posts for contingent (on dates, states of nature and locations) claims or, more plausibly, a complete set of financial markets (where bonds, equities, mutual funds and derivative assets are traded).

However, one can also think of many other ways to complete markets ex-post: various schemes of social and health insurance, family or intergenerational transfers, international trade, foreign aid programs, buffer stock management, etc.

It is worth noticing that complete insurance has an interesting implication for individual consumption: agents can (and under standard assumptions will) smooth consumption across dates and states of nature, which implies that idiosyncratic shocks should not affect consumption, unlike aggregate ones.

This is quite remarkable, as it provides a testable implication of market completeness, which consists in checking that a certain function of individual consumption does not co-vary with idiosyncratic variables, but only with aggregate ones. Many authors have performed such checks, named "consumption insurance" tests, which can be divided, roughly speaking, in two broad categories. One class of tests has dealt only with cross-sectional data, and in particular with microdata, i.e. data referring to small consumption units (households). This was the case of the seminal papers by Cochrane (1991), and, at least in part, by Mace (1991).

In other papers panel data were used, i.e. data featuring both a time-series component and a cross-sectional one. Some of these contributions (Mace, 1991) have used microdata, while many others have dealt with macrodata, both at an inter-regional level and at an international level.

There have also been a number of studies aimed at assessing the degree of consumption insurance in developing countries, such as the seminal works by Rosenzweig (1988) (studying informal risk-sharing arrangements among family members across the ICRISAT villages), Rashid (1990) (for the case of Pakistan), Deaton (1993 and 1994) (analyzing the case of some villages in Côte d'Ivoire), Townsend (1994, 1995b and 1995c) (about villages of Southern India and Thailand), Chaudhuri and Paxson (1994) (Indian villages).

The aim of our work is to apply consumption insurance tests, and in particular the methodology proposed by Asdrubali et al. (1996), to analyze the risk sharing situation of a large number of developing countries. In particular, we would like to evaluate the role played by such factors as foreign trade, reserve management, international aid programs and credit markets in achieving a higher or lower degree of consumption insurance. Under this respect, our work is complementary with respect to the above cited contributions, in as much as it only uses aggregate data and provides a broad picture of consumption smoothing mechanisms for a large group of developing countries.

We will apply consumption insurance tests to a particular category of nondurable goods, namely cereals, whose consumption we use as a proxy for total non durable consumption.

The choice of this category of food has not been casual, but rather dictated by the importance of cereals in all the economies under analysis, and by the fact that all channels of insurance, namely foreign trade, stocks management and aid programs can potentially play a substantial role in explaining the dynamics of cereals' consumption. Just for the sake of comparison, consumption insurance relative to a completely different kind of food, i.e. meat, will be also sketched, to understand up to what extent the intrinsic features of consumption goods may influence the relevance of one or the other channel of risk sharing.

The rest of the paper is organized as follows: Section 2 illustrates the empirical implication of market completeness and the types of tests that can be performed, and introduces the data that have been used in the analysis. Section 3 illustrates a methodology that can be useful to study the functioning of some channels of risk sharing. Section 4 presents the results of the estimation procedures. Section 5 contains the results of a time series regression analysis and illustrates them by means of a principal component analysis. Section 6 contains a few remarks on the role played by some macro variables onto consumption smoothing mechanisms and Section 7 concludes, with some final remarks and policy implications.

2. *Market Completeness and Consumption Insurance*

It is well known that a competitive economy with complete markets satisfies the requirements for the first and second fundamental theorems of welfare economics. In particular, all the allocations are Pareto optimal. This means that we can characterize the allocations of such an economy by simply solving the problem of a planner, who seeks to maximize the weighted sum of agents' utilities. The resulting characterization can easily be seen to coincide with that obtained by solving individual agents' problem of utility maximization under a budget constraint and market clearing equations.

Supposing we consider an economy with I agents living for T time periods, S states of the world in each period, L consumption goods in each state of the world at each period and preferences over consumption of different goods at different periods and states of nature represented by the following utility function:

$$(1) \quad U^i(C) = \sum_t^T \beta^t \sum_s^S \pi_{t,s} \sum_l^L \left\{ \frac{1}{\sigma} \left[\theta_l \exp(\sigma b^i_{l,t,s})(C^i_{l,t,s})^\sigma\right] - \frac{1}{\sigma} \right\}$$

A hypothetical planner wishing to compute a Pareto optimal allocation will solve the problem:

$$(2) \quad \max_{C^i_{l,t,s}} \sum_i^I \lambda^i \sum_t^T \beta^t \sum_s^S \pi_{t,s} \sum_l^L \left\{ \frac{1}{\sigma} \left[\theta_l \exp(\sigma b^i_{l,t,s}) \log(C^i_{l,t,s})^\sigma\right] - \frac{1}{\sigma} \right\}$$

$$sub \quad \sum_i C^i_{l,t,s} = \sum_i e^i_{l,t,s} \quad \text{for all } l, t, s$$

where C is the vector of consumptions at all date-event pairs (i.e. a state of nature in a particular time period), $(1-\sigma)$ is the (common) coefficient of constant relative risk aversion, β^t is the discount factor from time t to time $t+1$, $\pi_{t,s}$ is the (objective) probability of occurrence of state s in period t, θ_l is a commodity-specific weight, $b^i_{l,t,s}$ is an individual preference shift affecting consumption of good l in state s at period t, $C^i_{l,t,s}$ is the quantity of good l consumed by agent i in state s of period t and $e^i_{l,t,s}$ an initial endowment of good l (endowments can vary across periods and states of the world).

By taking the first order conditions of the problem and after some algebraic manipulations we get the following expression:

$$(3) \quad \log C^i_{l,t,s} = \log C^a_{l,t,s} + \frac{1}{1-\sigma}(\log \lambda^i - \lambda^a) + \frac{\sigma}{1-\sigma}(b^i_{l,t,s} - b^a_{l,t,s})$$

where $C^a_{l,t,s} = \exp(\frac{1}{I}\sum_i \log C^i_{l,t,s})$, $\lambda^a = \frac{1}{I}\sum_i \log \lambda^i$, $b^a_{l,t,s} = \frac{1}{I}\sum_i b^i_{l,t,s}$.

Equation (3) lies at the heart of our consumption insurance tests, as it says that (the log of) individual consumption at a given date-event pair is just a function of per capita consumption (expressed as a geometric average of individual consumptions), of the difference between the weight imposed by the planner on individual i and an average weight, and finally of the difference between the individual preference shift and the average preference shift for a given commodity, time period and state of the world. It also clearly says that, apart from preference shifts, no other idiosyncratic variables are allowed to play a role in determining an optimal allocation when markets are complete.

To get an even simpler expression, without the planner's weights, we can take the first difference of (3) and get:

$$(4) \quad \log C^i_{l,t+1,s} - \log C^i_{l,t,s} = \log C^a_{l,t+1,s} - \log C^a_{l,t,s} + \frac{\sigma}{1-\sigma} \times \left[(b^i_{l,t+1,s} - b^i_{l,t,s}) - (b^a_{l,t+1,s} - b^a_{l,t+1,s})\right]$$

where it is clear that the logarithmic difference of consumption (for all goods and at arbitrary states of the world) linearly depends on the logarithmic difference of per-capita consumption and on changes in preference shifts.

Based on (4) we can imagine to run the following regression (with cross section, time series or panel data):

$$(5) \quad \log \frac{C^i_{l,t+1}}{C^i_{l,t,}} = \alpha_{t+1} + \beta X^i_{t+1} + \epsilon^i_{t+1} \qquad i = 1, ..., I$$

where X^i_{t+1} is any idiosyncratic shock variable and ϵ^i_{t+1} a white noise disturbance.

Under the null hypothesis of market completeness we expect the coefficient α_{t+1} to be significant (capturing the effect of aggregate consumption, or aggregate risk) and the coefficient β of the individual shock not to be significantly different from 0. Coefficients α and β are totally indeterminate (as for magnitude and sign) under the alternative hypothesis of market incompleteness.

2.1. *The data.* - We are going to implement this kind of consumption insurance test to a novel dataset, consisting of the United Nations FAO (Food and Agriculture Organization) statistical database called "Standardized Food Balance Sheets", describing for each food item, and each country, the sources of supply and different uses (see for a detailed description FAO, 2001). In particular, food balance sheets contain figures for the total quantity of food produced in a country, the net quantity imported or exported, the change in stock that may have occurred since the beginning of the reference year and the total net quantity of international aid supplied to (or from) a given country. All these quantities added together make up the total supply of that particular foodstuff available during a given year.

As for utilizations, the data set distinguishes between quantities exported, fed to livestock, used as seed, put to manufacture for food and non-food uses, lost during storage and transportation and supplied for human consumption. Per capita supply is also provided, and it is computed by simply dividing the respective quantity by the population. Data on per-capita food supply are expressed both in terms of quantity and in terms of caloric value and protein and fat content, by applying suitable food composition factors.

Production and import/export data are taken from national official statistics (either based on direct enquiries or estimated by Government agencies). Data on industrial uses are taken from industrial surveys, whereas feed and seeding rates, as well as losses in industrial processing, are derived from cost of production surveys or estimated by Government agencies. Information on stock changes is taken from various sources, when available, including marketing authorities and factories or farmer stock surveys. However, it should be noticed that for a large number of developing countries information on stock changes is quite rare and somewhat unreliable; that is why FAO statistical office (Basic Data branch) has been keeping track of stock changes for a few decades, and determining them also on the basis of past production levels and inflows-outflows of the particular food item, with an eye to the objective of supply stabilization. This means that in many cases we will not have an "objective" measure of stock changes (i.e. obtained from official sources), but a measure computed out of the history of past stock levels (which, it is worth noticing, implies that stocks cannot become negative) and uses thereof. Food supply measures are then derived by simply summing up sources and uses.

It is important to notice that food balance sheets measure food consumption from a food supply perspective. This will imply, in particular, that our tests will not be, strictly speaking, consumption insurance tests, but rather food availability insurance tests, since they are based upon food availability measures. That is why we have referred in the title of this work to "potential consumption insurance", though this does not make the analysis less interesting and relevant, for at least two reasons. On the one hand food availability smoothing is a necessary condition for consumption smoothing. On the other hand food availability measures can be used to perform cross-country comparisons, whereas food consumption measures could not, in the absence of a comprehensive (and homogeneous) international data set from household surveys.

Of all the primary products contained in the FAOSTAT Food Balance Sheets we concentrated on two categories: cereals (including wheat) and meat. In fact, we chose to deal primarily with cereals consumption because of its quantitative importance among non durable consumption goods. World bank data, for instance, show that for fifty countries out of the ninety-eight examined in this work, the average weight of cereal consumption over all durable consumption is about 27%, which makes cereals consumption a reasonably good proxy for overall non durable consumption. On the other hand, meat consumption was also dealt with, but solely for comparative purposes, in order to highlight the impact of consumption goods' intrinsic features onto consumption insurance analyses.

3. *Identifying Channels of Consumption Smoothing*

The data available in the Food Balance Sheet dataset could also be used for a richer analysis than the one which consists solely in checking the validity of model (4).

Our main goal was that of verifying the importance of several channels of risk smoothing, namely foreign trade, reserves management, international aid and food processing. To do so we applied a methodology used for the first time by Asdrubali et al. (1996) for the case of risk sharing among states in the United States.

The gist of the analysis lies in the following observation: we can write down the individual (where by *individual* we will intend relative to a single country) production of a single good, say cereals, as follows:

$$(6) \qquad P^i = \frac{P^i}{(P^i+B^i)} \times \frac{(P^i+B^i)}{(P^i+B^i+SC^i)} \times \frac{(P^i+B^i+SC^i)}{(P^i+B^i+SC^i+IA^i)} \times \frac{(P^i+B^i+SC^i+LA^i)}{(P^i+B^i+SC^i+IA^i+FP^i)} \times \frac{(P^i+B^i+SC^i+IA^i+FP^i)}{C^i} \times C^i$$

where P^i stands for domestic production, B^i for imports minus exports, SC^i for stock changes, IA^i for international aid, FP^i for food processing, C^i for human consumption and where the superscript i identifies the individual country. Equation (6) can be read in the following way: domestic production undergoes a series of important transformations before turning into domestic consumption; such transformations (imports, exports, reserve changes, foreign aid, processing) can help smooth consumption and make it insensitive to the dynamics of domestic production.

Starting from equation (6), taking logs and first differences, multiplying both sides by $\Delta \log P^i$ minus its mean and taking expectations we obtain:

$$(7) \quad var[\Delta \log P^i] = cov[\Delta \log P^i, \Delta \log P^i - \Delta \log(P^i+B^i)] +$$

$$+cov[\Delta \log P^i, \Delta \log(P^i+B^i) - \Delta \log(P^i+B^i+SC^i)] +$$

$$+cov[\Delta \log P^i, \Delta \log(P^i+B^i+SC^i) - \Delta \log(P^i+B^i+SC^i+IA^i)] +$$

$$+cov[\Delta \log P^i, \Delta \log(P^i+B^i+SC^i+IA^i) +$$

$$-\Delta \log(P^i+B^i+SC^i+IA^i+FP^i)] + cov[\Delta \log P^i, \Delta \log C^i]$$

which is a decomposition of the variance of logarithmic differences of domestic production.

Dividing both sides of (7) by $var[\Delta \log P^i]$ we obtain:

$$(8) \qquad \beta_{FT} + \beta_{SC} + \beta_{IA} + \beta_{FP} + \beta_U = 1$$

Expression (8) is an identity, as it is derived from the decomposition of variance, in (7); however, it can also receive a different, stochastic interpretation. In fact, the coefficient β_{FT} is also the OLS estimate of the slope in the regression of $\Delta \log P^i - \Delta \log(P^i + B^i)$ on $\Delta \log P^i$, the coefficient β_{SC} is the OLS estimate of the slope in the regression of $\Delta \log(P^i + B^i) - \Delta \log(P^i + B^i + SC^i)$ on $\Delta \log P^i$, the coefficient β_{IA} is the estimated slope in the regression of $\Delta \log(P^i + B^i + SC^i) - \Delta \log(P^i+B^i+SC^i+IA^i)$ on $\Delta \log P^i$, β_{FP} is the estimated slope in the regression of $\Delta \log(P^i+B^i+SC^i+IA^i) - \Delta \log(P^i+B^i+SC^i+IA^i+FP^i)$ on $\Delta \log P^i$ and, finally, β_U is the estimated slope in the regression of $\Delta \log C^i$ over $\Delta \log P^i$.

The intuition underlying each of those regressions is fairly straightforward. Let us take, for instance, the first regression, of $\Delta \log P^i - \Delta \log(P^i + B^i)$ on $\Delta \log P^i$. If international trade did not smooth at any of the variability shown by $\Delta \log P^i$, the left hand variable would be close to zero (i.e., the percentage change in $\Delta \log P^i$ would just be equal to the percentage change in $\Delta \log P^i - \Delta \log(P^i + B^i)$) and the estimated slope in the OLS regression would also be close to zero. On the contrary, if external trade smoothered all the variability in $\Delta \log P^i$, the left hand side variable would just be equal to the right hand side variable, $\Delta \log P^i$, and consequently the estimated slope would be just equal to one. The various β's, therefore, give an idea about the magnitude of the smoothing effect that one can attribute to the various channels of insurance.

Among all the regressions, the last one is particular interesting, in that it constitutes a standard test of consumption insurance based on equation (5). The estimated slope of the regression line (β_U, where the subscript stands for *Uninsured*) represents the amount of variability in the rates of growth of consumption which is explained by the idiosyncratic variable (domestic production).

3.1. *A few remarks on methodology.* - Applying consumption insurance tests to panel data is somewhat risky, as John Cochrane (1991) stressed in his seminal paper; this is because panel data regressions are often affected by consequences of non separability in preferences, of functional form assumptions and of various kinds of preference shocks. For instance, right hand variables in such regressions should be uncorrelated with Lagrange multipliers (relative to resource constraints), as they ultimately enter the disturbance terms. Sometimes this is not the case, as with individual income (quite often a right hand-side variable in this type of studies), which is very likely to be correlated with aggregate income and therefore with the corresponding Lagrange multipliers. The same problem arises with non separability of preferences across goods within each time period; if that is the case, first order conditions will also contain the Lagrange multipliers relative to the other goods, and those multipliers will also enter the disturbance term, if they are not explicitly accounted for. Again, right hand variables might end up being contemporaneously correlated with those multipliers, and consequently with the disturbance term.

The same problem might affect time series regressions, whereas simple cross section regressions (including regressions like (5) involving observations taken at two different points in time, but where time does not play any substantial role) might be thought to be immune (as all Lagrange multipliers, preference shift parameters and the like are captured by the intercept term).

Our regressions will certainly make use of panel data (as well as of simple time series), but will be less exposed to the problems cited above because of the nature of the variables involved. In a different way from other studies of consumption insurance we are not going to use income either as an idiosyncratic or as an aggregate shock. As we only use individual countries' production and aggregate production of some foodstuff, it does make sense to assume, even in the case of non separability, that individual countries' productions are not correlated with the Lagrange multipliers associated with the scarcity constraints on other goods, which lessens the relevance of the separability assumption. We can motivate this assumption on at least two sensible grounds. On the one hand, we might say that the effects of all other goods' Lagrange multipliers on the disturbance cancel out, if the dynamics of aggregate production of the various goods (other than cereals or meat) are assumed to be sufficiently different. On the other hand, we are especially interested in the β coefficient, and it is straightforward to check that the average empirical correlation of own production growth and aggregate production of the relevant geographic area is quite low (as low as about 0.19) which, even in the unlikely occurrence of perfect positive correlation of aggregate production growth in cereals (or meat) and other foodstuff's aggregate production growth, would suggest a low (inverse) correlation with the corresponding Lagrange multipliers (and, consequently, with the disturbance term).

One more observation concerning equation (8) is in order: the regressions will be performed by using both panel data and time series data. In the first case many countries will be pooled together, in different ways. In Section 6, however, we will deal with individual countries by performing simple time series analyses. As will become clear from a quick inspection of data, there are cases in which decomposition (8) is not perfect, in the sense that coefficients do not sum up exactly to unity (although we always get something fairly close to one). There are two reasons why this might be the case: on the one hand our regressions will not include a standard intercept, which is required for (8) to hold, but a time specific one. In that respect, one can show that panel estimates are simply time averages of the corresponding cross sectional estimates; this should cause no problem, in as much as cross sectional estimates of our coefficients sum up to one. There is also another reason why we should not expect expression (8) to hold exactly on all occasions: the decomposition of variance that we performed in (7) is exact only when averages are taken with respect to the same number of observations. Now, this is often impossible, as many series contain zero values which, in turn, generate missing values when one takes logarithms (in any case they cannot be used, as each variable appears in the numerator and in the denominator of (6)). Therefore there will be, here and there, missing pieces in (6), which prevent (8) to be exactly equal to one. As the regressions' results will show, however, this will not be a serious problem. In fact, summing up the relevant coefficients of our cross sectional estimates we reassuringly obtain something in between 0.996 and 1.

4. *Empirical Results*

Following the methodology outlined in the previous section we ran a set of panel regressions of the following types:

$$\begin{aligned}\Delta \log P_t^i - \Delta \log(P_t^i + B^i) &= \alpha_{FT,t} + \beta_{FT}\Delta \log P_t^i + \epsilon_{FT,t}^i \\ \Delta \log(P_t^i + B^i) - \Delta \log(P_t^i + B^i + SC_t^i) &= \alpha_{SC,t} + \beta_{SC}\Delta \log P_t^i + \epsilon_{SC,t}^i \\ &\vdots \\ \Delta \log C^i &= \alpha_{U,t} + \beta_U \Delta \log P_t^i + \epsilon_{U,t}^i.\end{aligned}$$

Although we performed both balanced (i.e. when observations for which values of one or more variables are missing for a single cross-sectional unit are eliminated from the regression) and unbalanced (using all observations) panel regressions, for the entire panel we will only present results relative to the latter. There are only a few cases in which results are quantitatively different, but we chose to stress the importance of estimates obtained by a larger (sometimes much larger) data set.

The $\alpha_{\cdot,t}$'s in the regressions are time specific effects, which should capture the effects of aggregate fluctuations.

In Table 1 we present the results of total panel regressions for cereals and meat, respectively.

Table 1. Estimated coefficients of "consumption smoothing" for the whole panel

	β_{FT}	β_{SC}	β_{SA}	β_{FP}	β_U
All Countries Cereals	0.431 (0.00)	0.411 (0.00)	0.084 (0.00)	0.050 (0.00)	0.022 (0.18)
All Countries Meat	0.256 (0.00)	0.046 (0.04)	0.002 (0.50)	0.009 (0.07)	0.686 (0.00)

A cursory inspection of the row of the table concerning cereals' consumption reveals something unexpected; first of all, the amount of consumption insurance is extremely high on average (the coefficient of missing insurance is equal to a tiny 0.02). Even more surprisingly, the coefficients on trade and buffer stocks are almost identical and quite large, pointing at the importance of international trade and buffer stocks management in achieving a large degree of consumption insurance. On the contrary, the coefficients of international aid and processing are very small.

Just for comparative purpose, we also present results of total panel regressions for meat products. Here the situation is dramatically different: overall insurance is quite low (the coefficient of missing insurance is equal to about 0.69) and buffer stocks do not play almost any role, unlike foreign trade. This is a consequence of the different intrinsic features of meat vs. cereal products, and in particular of the fact that stocking (and transporting) meat is much more costly. In any case, as explained in the previous section, we choose to focus upon cereals, and all of the following analysis will be performed in terms of cereals.

The regression analysis performed on the total panel, as an average over potentially very different countries, might conceal important information. That is why we divided countries according to five main geographical areas: **East Asia and the Pacific** (including Cambodia, China, Fiji Islands, Indonesia, Korea (both), Laos, Macau, Malaysia, Mongolia, Papua New Guinea, Philippines, Solomon Islands, Thailand, Vietnam), **Latin America and the Caribbean** (including Argentina, Bahamas, Barbados, Belize, Bolivia, Brazil, Chile, Colombia, Costarica, Cuba, Dominican Republic, Ecuador, El Salvador, Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Suriname, Trinidad and Tobago, Uruguay, Venezuela), **Middle East and North Africa** (including Algeria, Egypt, Iran, Iraq, Israel, Jordan, Lebanon, Libya, Morocco, Saudi Arabia, Syria, Tunisia, United Arab Emirates, Yemen), **South Asia** (including Afghanistan, Bangladesh, India, Nepal, Pakistan and Sri Lanka) and **Sub-Saharan Africa** (including Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Capo Verde, Central African Republic, Chad, Comoros, Congo, Côte d'Ivoire, Djibouti, Ethiopia, Gabon, Gambia, Ghana, Guinea Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, Sierra Leon, Somalia, Southafrica, Sudan, Swaziland, Tanzania, Togo, Uganda, Zambia, Zimbabwe).

The results of the OLS panel estimations are presented in Table 2 (the number in parenthesis are probability levels associated to the null hypothesis of zero coefficients).

A few things are immediately evident when we go through Table 2. First of all, the enormous difference in food availability smoothing for cereals is striking. For almost all five areas (with the remarkable exception of South Asia) the degree of insurance for cereals is virtually complete. The dynamics of food availability does not depend almost at all on countries self-production, and this is due to foreign trade and stock changes, mostly, and in some cases also to food processing (as in Latin America and the Caribbean) and to international aid (as is the case for Subsaharan Africa).

Table 2. Cereals (excluding beer)

Areas	β_{MX}	β_{SC}	β_{AID}	β_{UT}	β_{U}
East Asia and Pacific	0.203 (0.02)	0.551 (0.00)	0.064 (0.02)	0.140 (0.00)	0.040 (0.08)
Latin America and Caribbean	0.319 (0.00)	0.441 (0.00)	0.068 (0.37)	0.123 (0.00)	0.047 (0.00)
Middle East and North Africa	.0.660 (0.00)	0.315 (0.00)	0.000 (0.87)	0.020 (0.03)	0.003 (0.52)
South Asia	0.139 (0.42)	0.605 (0.00)	0.001 (0.99)	0.033 (0.00)	0.220 (0.00)
Sub-Saharan Africa	0.306 (0.00)	0.461 (0.00)	0.156 (0.00)	0.050 (0.00)	0.026 (0.01)

These results are partly surprising, in that we did not expect perfect insurance to be revealed from data, albeit only for one category of consumption. Also surprising is the decisive role played by reserves management, which helps insure as much as 61% of cereals consumption (as for example in the case of South Asia).

The analysis of food reserves and their utilization for food safety has largely been addressed by the literature concerning food problems in underdeveloped countries. However, it seems fair to say that even though all authors stress the relevance of stocks for food insurance, no attempt has been made, to our knowledge, to quantify this relevance.

The great majority of the contributions dealing with this issue has focused upon the techniques of management of such stocks, and in so doing they have been largely drawing from the literature on portfolio choices (see, for example, Adelman and Berck, 1991; Bigman, 1985; Nath, 1989; Pal and Singh, 1986; Reinsel, 1993a, b; Sahn, 1989); other contributions have analyzed the role of stocks in the stabilization of food prices (see, for instance, Bigman and Reutlinger, 1979; Ferto, 1995), or the relationship between food insurance and international aid (see, for example, Parikh, 1994; Sarris and Taylor, 1976).

One more interesting piece of information can be obtained by the panel data analysis. The time specific intercepts of the regressions are almost never significant at conventional probability levels (the information has not been included in Tables 1 and 2). This would mean, if we are to believe the results of the analysis, that aggregate risk (at the level of each macroarea) does not have any particular influence on the dynamics of consumption. The redistribution channels available to the various countries are, on average, sufficient to insure against the aggregate risk of the corresponding area.

Once again, a caveat is in order: the panel regressions make use of data of a large number of countries (even within single areas) which might hide individual performances that cannot be represented by the average performance.

The following section will illustrate alternative time series regressions, in which will be analyzed the risk sharing performances of individual countries.

5. *Time Series Regressions and a Principal Component Representation*

We ran separate sets of regressions for each country, each set of regressions being of the type illustrated at the beginning of Section 4.

As a result, we got a very large set of estimated coefficients, that we summarize in Table 3; rows represent countries and columns contain the estimated values of the five coefficients representing the various channels of smoothing (foreign trade, reserve changes, international aid and processing) and the coefficient of no insurance.

From a cursory look at summary statistics in Table 4 we can immediately notice that stock management constitutes the most important source of insurance, with an average coefficient of 0.49, and that foreign trade, as it was expected, also constitutes an important instrument of stabilization.

It is also useful and interesting to give a look at Table 5, the correlation matrix of the five variables under examination.

Once again, we notice a negative correlation among practically all variables, which can be taken as a clear sign of substitutability of the different channels of insurance.

Table 3. Single country regression analysis

	Smoothing channels coefficients				
	External trade	Stock change	Aid	Processing	No insurance
Afghanistan	0.205	0.000	0.040	−0.058	0.813
Algeria	0.819	0.155	0.000	0.032	−0.006
Angola	0.281	0.414	0.110	0.040	0.156
Argentina	−0.374	1.180	0.000	0.137	0.057
Bangladesh	−0.556	1.138	0.260	0.040	0.118
Barbados	1.218	−0.039	0.002	0.018	−0.199
Belize	0.502	−0.023	−0.044	0.439	0.126
Benin	0.173	0.880	−0.008	0.211	−0.261
Bolivia	0.037	0.392	0.318	0.223	0.030
Botswana	0.768	0.173	0.048	0.004	0.007
Brazil	0.261	0.366	−0.003	0.394	−0.018
Burkina Faso	−0.003	0.876	0.029	0.017	0.080
Burundi	0.430	−0.038	0.164	0.035	0.409
Cambodia	−0.124	0.875	0.180	0.111	−0.042
Cameroon	0.237	0.639	0.003	0.039	0.082
Central African Rep.	0.116	0.775	0.000	0.064	0.045
Chad	−0.152	0.754	0.191	0.041	0.166
Chile	0.727	0.259	−0.061	0.088	−0.012
China	−0.302	1.101	0.000	0.100	0.101
Colombia	0.290	0.520	0.005	0.091	0.094
Comoros	1.710	−0.580	0.000	0.090	−0.230
Congo, De. Rep.	−0.244	0.894	0.000	0.120	0.230
Congo, Rep. of	0.821	0.004	0.166	0.002	0.006
Costa Rica	−0.054	0.108	0.749	0.088	0.108
Côte d'Ivoire	0.545	0.610	0.010	0.142	−0.307
Cuba	0.789	−0.022	0.001	0.159	0.073
Djibouti	0.445	0.607	−0.021	0.002	−0.033
Dominican Rep.	0.430	0.285	0.086	0.159	0.040
Ecuador	0.324	0.327	0.000	0.039	0.310
Egypt	0.520	0.380	−0.060	0.040	0.120
El Salvador	0.211	0.607	0.038	0.088	0.056
Ethiopia PDR	0.036	0.704	0.065	0.041	0.154
Gabon	1.065	−0.118	−0.15	0.068	0.134
Gambia	0.068	0.593	0.105	0.032	0.201
Grenada	0.127	0.820	0.000	−0.052	0.105
Guatemala	0.269	0.334	−0.005	0.077	0.325
Guinea	0.330	0.690	−0.070	0.120	−0.080
Guinea-Bissau	0.776	−0.012	0.000	0.069	0.166
Guyana	−0.346	1.281	−0.074	0.113	0.026
Haiti	0.620	0.450	−0.120	0.090	−0.040
Honduras	0.021	0.788	0.043	0.055	0.093

(continues)

Table 3. *(continued)* Single country regression analysis

	Smoothing channels coefficients				
	External trade	Stock change	Aid	Processing	No insurance
India	−0.020	0.790	0.060	0.190	−0.010
Indonesia	−0.210	0.810	0.110	0.120	0.170
Israel	1.008	0.019	0.012	−0.045	0.006
Jamaica	0.691	−0.073	0.397	−0.011	−0.004
Jordan	0.756	0.311	−0.030	−0.039	0.002
Kenya	−0.006	0.662	0.113	0.013	0.218
Korea, DPR	0.146	0.350	0.000	0.390	0.114
Korea, Rep. of	0.345	0.535	0.053	−0.040	0.108
Laos	0.052	0.634	0.046	0.109	0.159
Lebanon	1.065	−0.123	0.029	−0.053	0.082
Lesotho	0.625	0.296	0.018	0.055	0.006
Liberia	0.154	0.222	0.553	0.026	0.135
Libyan Arab Jamahiriya	0.768	0.166	0.000	0.062	0.003
Madagascar	0.150	0.160	0.180	0.210	0.310
Malawi	−0.198	0.792	0.283	0.048	0.075
Malaysia	0.730	0.260	0.000	−0.080	0.100
Mali	−0.051	0.768	0.110	0.040	0.133
Mauritania	0.066	0.111	0.796	0.025	−0.036
Mexico	−0.266	0.800	0.000	0.493	−0.027
Mongolia	0.129	0.584	0.000	0.294	−0.008
Morocco	0.507	0.470	0.001	0.035	−0.013
Mozambique	0.315	0.027	0.615	0.008	0.035
Namibia	0.831	0.123	0.000	0.004	0.042
Nepal	−0.096	0.635	0.042	0.054	0.365
Nicaragua	−0.225	0.936	0.192	0.073	0.024
Niger	−0.551	1.245	0.265	0.041	0.001
Nigeria	0.171	0.694	−0.002	0.129	0.008
Pakistan	−0.391	1.231	0.119	0.053	−0.011
Panama	0.332	0.174	−0.115	0.191	0.418
Papua New Guinea	0.895	−0.068	0.000	−0.003	0.176
Paraguay	0.185	0.529	−0.061	0.290	0.057
Peru	0.807	0.092	−0.038	0.069	0.070
Philippines	0.130	0.500	0.190	0.160	0.020
Rwanda	−0.080	0.408	0.473	−0.067	0.320
Saudi Arabia	0.749	0.176	0.000	0.034	0.041
Senegal	0.291	0.892	−0.014	0.002	−0.171
Sierra Leone	0.488	0.997	0.178	−0.235	−0.428
Solomon Islands	0.954	0.073	0.000	0.011	−0.039
Somalia	−0.236	0.645	0.426	−0.002	0.168
South Africa	0.368	0.596	0.000	−0.003	0.039

(continues)

Table 3. *(continued)* Single country regression analysis

	Smoothing channels coefficients				
	External trade	Stock change	Aid	Processing	No insurance
Sri Lanka	0.238	0.637	0.012	0.022	0.092
Sudan	−0.359	1.230	0.050	0.064	0.015
Suriname	0.418	1.044	−0.889	0.382	0.045
Swaziland	0.132	0.150	0.349	0.376	−0.008
Syrian Arab Rep.	0.125	0.826	0.005	0.058	−0.013
Tanzania, Un. Rep.	0.161	0.382	0.086	0.084	0.286
Thailand	−0.719	1.614	−0.002	0.117	−0.009
Togo	0.178	0.921	−0.169	0.063	0.007
Trinidad and Tobago	0.816	0.179	0.000	0.009	−0.004
Tunisia	0.726	0.249	0.018	0.009	−0.003
Uganda	0.002	0.963	0.006	0.216	−0.187
Un. Arab Emirates	0.957	0.027	0.000	0.027	−0.012
Uruguay	−0.469	1.268	0.073	0.121	0.007
Venezuela	0.622	0.207	0.000	0.134	0.037
Viet Nam	0.260	0.370	0.070	0.080	0.220
Yemen	0.695	0.282	−0.015	0.034	0.005
Zambia	0.089	0.472	0.256	0.151	0.032
Zimbabwe	0.207	0.521	0.204	0.037	0.031

Table 4. Cereals: summary statistics

Variable	Mean	Standard Deviation	Variance	No. of countries
External	0.288	0.439	0.192	99
Stock	0.494	0.402	0.162	99
Aid	0.071	0.196	0.038	99
Processing	0.083	0.115	0.013	99
No insurance	0.065	0.156	0.024	99

Table 5. Correlation matrix

	External	Stock	Aid	Processing	No insurance
External	1				
Stock	−0.818	1			
Aid	−0.273	−0.139	1		
Processing	−0.223	0.094	−0.238	1	
No insurance	−0.204	−0.171	0.057	−0.058	1

We decided to summarize the results of individual analyses by means of the so called "principal component" analysis, which is a statistical methodology of multiway analysis aimed at reducing the original number of variables (five coefficients in our case) to a smaller set of latent variables or "factors", which are linear combinations of the former, such that: 1) they are mutually uncorrelated, 2) each of them explains the highest percentage of variance.

Apart from technicalities, the procedure we follow is quite straightforward: once computed the factors, it is crucial to attribute an economic meaning to the first two or three factorial axes. This can be done through the examination of the position of the original variables with respect to those axes. In this way it will be possible to interpret the first two (or three, if we want to obtain a three dimensional representation) factor axes as new, "sinthetic" variables, representing useful benchmarks for the various observations, which will be quite simply described in terms of the coordinates they take in the new space of factors.

We applied this methodology to the matrix containing the estimated coefficients of our regression models (Table 3).

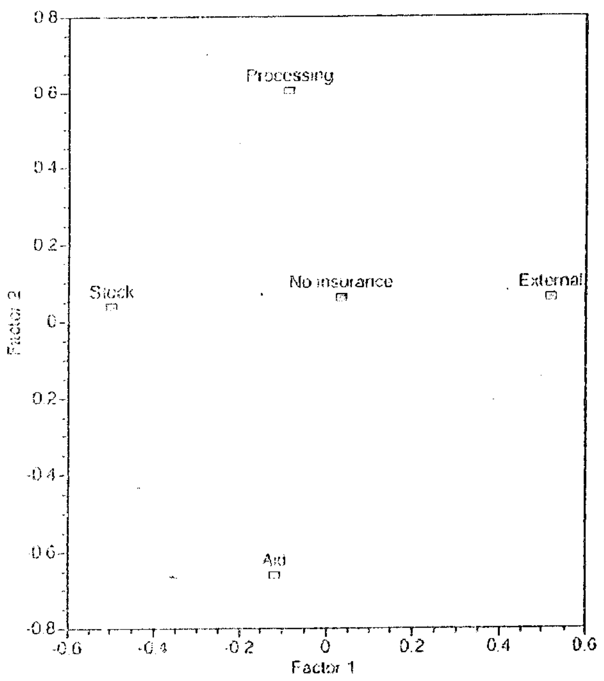
Table 6. Eigenvalues and percentage of variance explained

Factor	Eigenvalue	% Variance explained	% cumulative
1	1.878	37.6	37.6
2	1.312	26.2	63.8
3	1.018	20.4	84.2

Table 6 contains the figures relative to the percentage of total variance captured by the first three factors. The relevance of each factor has been assessed on the basis of the explanatory power (the percentage of total variance explained) expressed through the eigenvalues of the data matrix.

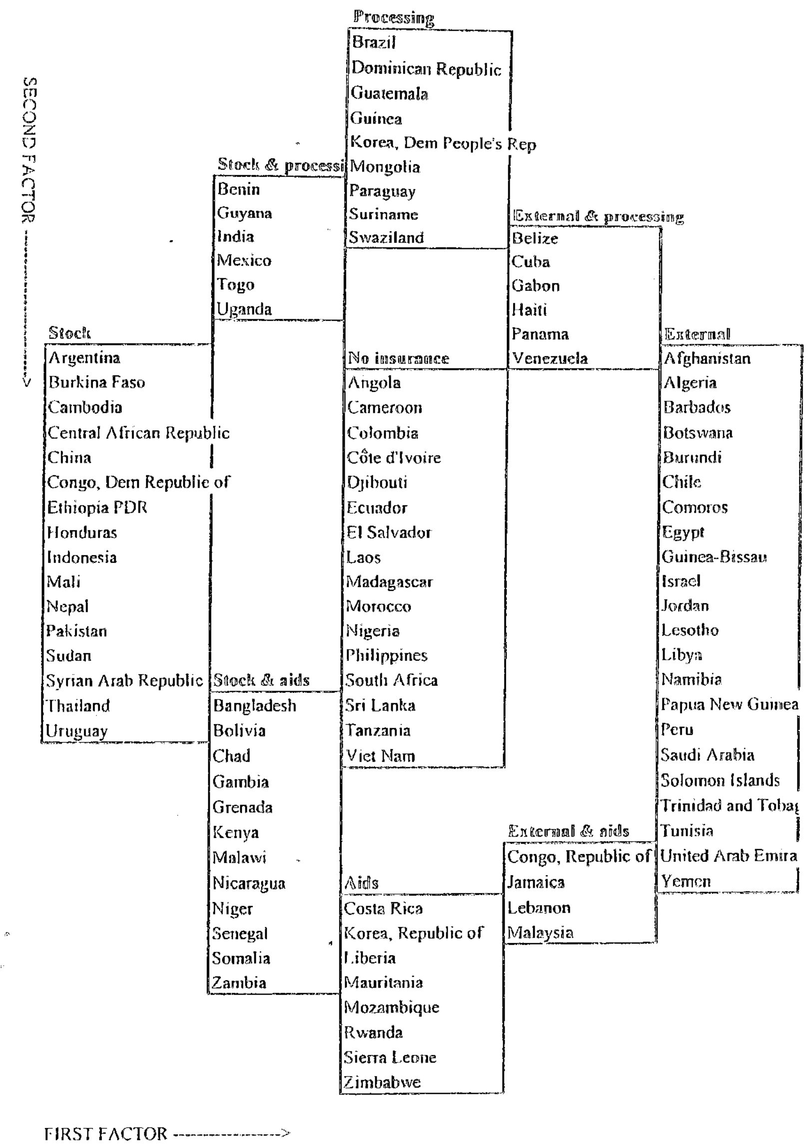
We can immediately notice that the first two factors manage to capture quite a high percentage of total variance (around 63.8% for cereals).

Interpreting the meaning of latent variables is made easy by a visual inspection of Graph 1, where we might interpret the first factor, represented on the X axis, as the trade-off between trade and reserve management as smoothing channels, whereas the factor on the Y-axis is seen to represent the trade-off between aid and food processing.



Graph 1. Coefficient scores. Factor 1 vs. Factor 2 (Cereals)

The last step of the analysis consists in placing all our observations (in our case the different countries) on the graph, by taking into account the corresponding coordinates in terms of the two factors. By looking at the position taken by a given country it will then be possible to obtain a clearer insight as to the functioning and the structure of consumption smoothing for that particular country. This is done in Graph 2 below,



Graph 2. Countries position according to the first two factor axis (Cereals)

in which countries are classified according to nine positions with respect to factorial axes. Each position has a label, which gives an idea of the smoothing channels which play the most important role for the given set of countries.

What immediately pops up from a rapid inspection of Graph 2 is a fairly dispersed image, in which it is hardly possible to recognize any geographical pattern, apart from the case of South Asia, whose countries tend to concentrate in the no insurance and stock area, and the countries of Sub Saharan Africa, which tend to concentrate between the aid and no insurance areas. In most cases, however, the fact of belonging to one group or another will rather reflect individual productive and structural characteristics.

The conclusion we can get from the time series and principal component analysis is twofold. On the one hand we can largely confirm the impressions we got from the panel analyses. In particular, the better performance of stock management as a risk sharing tool relative to the other channels (in particular foreign trade) was even reinforced. Finally, the principal component analysis of time series coefficients suggests that consumption insurance mechanisms cannot really be characterized in geographical terms.

6. *Further Remarks on the Role of Liquidity, Credit and Trade on Consumption Smoothing Mechanisms*

To push a little further our investigation on the working and relative efficacy of different smoothing channels, we will do one more exercise. We will perform simple OLS regressions of countries' smoothing coefficients (in particular the coefficients of no insurance and of buffer stocks management) on a few macroeconomic variables: per capita GNP at constant 1995 prices, the quantity of money (following the M2 definition) circulating in a country as a percentage of GDP, the percentage of domestic credit to GDP, the quantity of total credit to the private sector as a percentage of GDP and, finally, the degree of international opening of the various economies, as measured by the ratio of the sum of imports plus exports to GDP. These regressions have been performed on the whole set of countries and on separate subsets including respectively only African, Asiatic and Latin American countries.

Table 7. The impact of liquidity, size, credit and international openness

	M2	GNP95 (p.c.)	DC	CPS	DO
Africa					
No insurance	−0.740 (0.18)	−0.300 (0.28)	0.980 (0.16)	−1.090 (0.06)	−1.160 (0.06)
Buffer stock		−0.410 (0.05)	−0.260 (0.37)	−0.410 (0.08)	−1.040 (0.00)
Trade					0.860 (0.07)
Asia					
No insurance	−1.160 (0.05)	0.490 (0.10)	−1.290 (0.03)	−0.380 (0.41)	−1.480 (0.03)
Buffer stock		−0.630 (0.00)	−0.230 (0.69)	−0.150 (0.75)	−1.060 (0.01)
Trade					1.540 (0.00)
Latin America					
No insurance	−0.150 (0.81)	0.020 (0.96)	−0.570 (0.28)	0.440 (0.49)	0.130 (0.79)
Buffer stock		−0.180 (0.43)	0.890 (0.03)	−0.680 (0.12)	0.000 (0.98)
Trade					0.080 (0.87)
Total					
No insurance	−0.650 (0.03)	−0.200 (0.16)	−0.430 (0.14)	−0.240 (0.32)	−0.890 (0.01)
Buffer stock		−0.320 (0.00)	−0.120 (0.53)	−0.270 (0.07)	−0.770 (0.00)
Trade					0.750 (0.01)

The estimated coefficients of our regressions, accompanied by the corresponding probability levels, are displayed in Table 7. What becomes clear from a rapid inspection of the table is that the size of an economy, as measured by per capita GDP, does not play any particular role in explaining the degree of potential consumption insurance. This is true both when we average across all countries and when we only consider countries belonging to a single continent. On the other hand, the degree of international opening seems to play a key role in determining insurance, except for the case of Latin American economies. As a further confirmation of the importance of opening towards international trade we can observe that the coefficient of external trade (as a channel of consumption insurance) is almost always (again, with the only exception of

Latin American countries) directly and strongly related to the degree of opening.

Domestic credit, or credit to the private sector, plays an important role in explaining the degree of consumption insurance in African and Asian countries: the higher the percentage of credit to GDP, the lower the coefficient of no insurance, which highlights the fundamental role played in most countries by credit institutions in achieving a better redistribution of risks. Again, no evidence of any link between credit and consumption insurance is found for countries in Latin America.

We also ran regressions of the reserve management coefficients on the same macroeconomic variables. As a result, we definitely got a negative relationship between buffer stock management and the degree of openness, which stands as a further confirmation of one of the results of the factor analysis we presented in the previous section. Moreover, the importance of buffer stocks is strongly and inversely related to GNP per capita and to the use of credit, again with the exception of Latin American countries, where credit to the private sector seems to work in the opposite direction (as a complement rather than a substitute for buffer stocks).

7. *Concluding Remarks*

Our goal in this work was to apply some consumption insurance tests to a large number of developing economies, by using data on the food balance sheet of cereals provided by United Nations FAO. The aim of the exercise was to check in a consistent way the assumption of market completeness for about a hundred developing countries. The structure of the tests was such to reveal, in addition to the degree of risk sharing, the importance of various different channels of consumption smoothing. The main finding of the analysis is that both foreign trade and stock management play a substantial (almost equivalent) role in redistributing risk, and that it is hardly possible to recognize any geographical pattern in the coefficients of the various channels of consumption insurance.

Conclusions in terms of policy are not unambiguous. In particular, one might be interested in understanding whether policy efforts should be directed at improving on buffer-stocks technologies, or rather concentrating on alternative channels of risk sharing, such as trade. Our

analysis only suggests that, in the last thirty years or so, buffer stocks have potentially been more effective in providing consumption insurance (for a very important class of consumption goods, for which stocking is possible at relatively low cost), which does not say anything about the relative welfare implications. Some additional information could be obtained by linking the risk sharing performance (and the relative importance of smoothing channels) to price stabilization, which is often thought to be a desirable objective for developing countries. This constitutes, indeed, subject for future research.

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ABSTRACT

This work constitutes an attempt to implement some consumption insurance tests to developing economies. The tests will reveal, in addition to the extent of consumption insurance, the relative importance of various channels of risk sharing. In particular, the crucial role of buffer stocks management will be evident. A geographical characterization of risk sharing mechanisms is also looked for, but does not emerge from the data.

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