TMD DISCUSSION PAPER NO. 59

FOOD SECURITY AND TRADE NEGOTIATIONS IN THE WORLD TRADE ORGANIZATION: A CLUSTER ANALYSIS OF COUNTRY GROUPS

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ABSTRACT:

An important issue in WTO trade negotiations is whether further liberalization of trade and agricultural policies may help or hinder food security in WTO member countries, especially the developing countries. The WTO recognizes various classifications of countries: developed, developing, least developed (LDC) and net food importing developing (NFIDC). How well do these categories capture issues of food security? This paper employs various methods of cluster analysis (including an approach based on fuzzy sets) and data for 167 countries to identify groups of countries categorized according to five measures of food security: food production per capita, the ratio of total exports to food imports, calories per capita, protein per capita, and the share of the non-agricultural population share. The analysis identifies 12 distinct clusters characterized by similarities and differences across the various measures. The analysis suggests that the LDC category consists of largely food insecure countries, but that there also are food insecure countries that are not LDCs. NFIDCs is less precise as an indicator of food vulnerability, with more than a third of those countries not falling under any of the food insecure groups. Also, the general category of "developing countries" is very heterogeneous and is not very useful if the focus is on issues of food security. Finally, our typology shows that all developed countries are included in food secure categories. This result suggests that the notion of food security introduced as part of the "multifunctionality" of agriculture, or, more generally, among non-trade concerns has a very different meaning in developed and developing countries. In terms of policy implications and the agricultural negotiations, maintaining the same label for two altogether different situations may only obscure the issues being negotiated.

Key words: food security, WTO, cluster analysis, fuzzy classification.

GLOSSARY

Terms

EU	European Union
FAO	Food and Agriculture Organization (United Nations)
FAOSTAT	Food and Agriculture Organization Databases
GATT	General Agreement on Tariff and Trade
GDP	Gross Domestic Product
GNP	Gross National Product
LDC	Least Developed Countries
NFIDC	Net Food Importing Developing Countries
OECD	Organisation for Economic Co-operation and Development
WTO	World Trade Organization

Variables

EXPTOIMP	Total Export to food import ratio (value)
CALCAP	Calories per capita per day
PROTCAP	Proteins per capita per day
PRODCAP	Production per capita per day (value)
NAGRPOP	Non agricultural population to total population ratio

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1. INTRODUCTION

The Agreement on Agriculture negotiated during the Uruguay Round of international trade negotiations stipulated in Article 20 the need to continue agricultural negotiations within the World Trade Organization (WTO), beginning in the year 2000.[1] An important component of the current debate on those negotiations is whether further liberalization of trade and agricultural policies may help or hinder food security in WTO member countries. Although Article 20 only indicates that those negotiations should take into consideration, among other things, "non trade concerns", the preamble to the Agreement mentions as examples of those concerns, "food security and the need to [2] The preamble also indicates that the possible negative effects of the implementation of the reform program on Least Developed countries (LDC) and Net Food Importing Developing Countries (NFIDC) must be taken into account.[3] This issue was the subject of a special Ministerial Decision agreed during the Uruguay Round negotiations.[4]

While usually the preoccupation with economic liberalization and food security has centered on developing countries (Pinstrup-Anderson 1990, Commander 1989, and Sahn et al. 1997), some industrialized countries have also included food security concerns as part of the idea of "multifunctionality" of agriculture, a concept that some WTO members have argued should be considered during the negotiations.[5]

In consequence, the issue of food security and agricultural negotiations within the WTO has been raised in relation to both industrialized and developing countries. For richer countries that are net food importers, the discussion centers, in part, on whether there exists some "adequate" proportion between total domestic food production and the level of trade needed to satisfy food requirements at the national level, and whether the continuation of the negotiating process may place undue constraints on attaining the desired ratio of imports over domestic production (Japan and the Republic of Korea,

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[1] The process began with the first Special Session of the Committee on Agriculture, which was established by the General Council of the WTO to conduct the negotiations, on 23-24 March 2000.

[2] The text of Article 20 indicates that negotiations would take into account: "(a) the experience to that date from implementing the reduction commitments; (b) the effects of the reduction commitments on world trade in agriculture; (c) non-trade concerns, special and differential treatment to developing country Members, and the objective to establish a fair and market-oriented agricultural trading system, and the other objectives and concerns mentioned in the preamble to this Agreement; and (d) what further commitments are necessary to achieve the above mentioned long-term objectives" (GATT 1994, p. 55).

[3] Note that LDC refers here to least developed countries. In the past, LDC has been used to refer to "less developed" countries, but now the general term is "developing" countries.

[4] It is called the "Decision on Measures Concerning the Possible Negative Effects of the Reform Program on Least-developed and Net Food-Importing Developing Countries" (GATT 1994, p.448-449).

[5] The basic idea of multifunctionality is that agriculture, in addition to supplying the obvious direct products, also generates positive externalities including food security, environmental conservation, rural landscape, employment, and vital rural communities. A policy conclusion from this line of analysis is that the government could justifiably intervene with subsidies and protection to agriculture to ensure an adequate supply of the postulated externalities. The notion of multifunctionality has led to some controversy, including the fact that other productive sectors may also have multifunctional properties and the nature of the policies that may help generate the postulated externalities without affecting other countries (for a general discussion, see FAO 1999b; for country perspectives see Abare 1999, European Union 2000, Norway 1998, and USDA 1999).

2000). Those ratios may be linked to some notion of insurance in an uncertain world, and/or national autonomy to be able to confront outside pressures. It is much less clear what would be the basis for claiming food security concerns in the case of industrialized countries that are net exporters of different food products.

In the case of developing countries, the discussion is broader, including whether important policy objectives such as elimination of poverty and hunger (as cause and consequence of food insecurity) may have been helped or hindered by the current Agreement on Agriculture, and whether further negotiations may improve upon the existing text or will further compromise the attainment of those objectives in poor countries. These various claims and circumstances suggest the need for differentiating among the approaches and status of countries in relation to food security, both in general and in the context of WTO negotiations.

An obvious starting point is the difference between developed and developing countries. As of November 2000, there are 140 WTO members**,** and 32 observers[6]. About 82 percent of the members and 90 percent of the observers can be considered developing countries (including some of the republics that were part of the former Soviet Union). The distinction between developed and developing countries is part of the WTO legal framework and the two categories of countries have some differences in treatment under specific components of the WTO legal framework, including, among others, the Agreement of Agriculture. In spite of the legal implications, there is no formal definition of either group, and the process works through self-identification and negotiation with other member countries of the WTO. Additionally, a country can be considered as developing under some WTO legal texts but not under others, depending on the negotiations among member countries.

Further differentiations within developing countries include the category of Least Developed Countries and the Net Food Importing Developing Countries. The LDCs are defined as such by the General Assembly of the United Nations. This category has several legal implications under the WTO framework, while, as indicated, both types of countries were considered in a special Ministerial Decision approved at the end of the Uruguay Round.[7] Currently there are 48 LDCs, 29 of which have become WTO Members and 10 are WTO observers (within the observers, six countries are in the process of accession). [8] The criteria originally used to determine the countries in greatest need were per capita GDP, share of manufacturing in total GDP, and the adult literacy rate. Subsequently, the criteria were revised to include the augmented quality of life index, the economic diversification index and population size.[9]

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[6] Refer to Table 8 for a complete classification of WTO members and observers.

[7] A summary discussion of the legal treatment of LDCs and NFIDCs can be found in Díaz-Bonilla, Piñeiro, and Thomas (1999).

[8] The LDCs are: Angola, Bangladesh, Benin, Burkina Faso, Burundi, Central African Republic, Chad, Democratic Republic of the Congo, Djibouti, Gambia, Guinea, Guinea Bissau, Haiti, Lesotho, Madagascar, Malawi, Maldives, Mali, Mauritania, Mozambique, Myanmar, Niger, Rwanda, Sierra Leone, Solomon Islands, Tanzania, Togo, Uganda, and Zambia. Observers in process of accession: Cambodia, Laos, Nepal, Samoa, Sudan and Vanuatu. Rest of Observers: Bhutan, Cape Verde, Ethiopia and Yemen. Non-WTO members include Afghanistan, Comoros, Eritrea, Kiribati, Equatorial Guinea, Liberia, Somalia, Sao Tome Principe, and Tuvalu.

[9] The population criterion established an upper limit to be considered as an LDC. The result is that except for some of the original LDCs, like Bangladesh, this category mostly includes countries of middle to small size in terms of total population.

As a group, LDCs have a population of about 605 million people, with an income per capita in 1997 of US$270 compared to US$1,320 for developing countries and US$5,180 for the world average. For all LDCs, gross agricultural production per capita has been on a downward trend for the last four decades (it was 20 percent lower in the second half of the nineties compared to the same period in the sixties), while for all developing countries it has increased by about 40 percent in the same period. LDCs represent a very small fraction of world trade (less than half of one percent for total trade, and about two percent for trade in agricultural products). As a group they had a positive (although declining) net agricultural trade balance until the mid 1980's when it turned negative (Díaz-Bonilla, Piñeiro, and Thomas 1999).

The NFIDCs, which, as of August 2000, included 19 countries, are selected through a procedure that takes place in the Committee on Agriculture of the WTO: countries wanting to be considered in that category must present data showing that they are net food importing countries and the other WTO members accept (or not) the petition based on that evidence.[10] Those 19 developing countries have a population of some 380 million people, and an average GNP per capita of US$1,127 (1997) nearly five times that of the LDCs average, but much lower than the world average. They constitute a very diverse group, with four countries classified as upper middle income by the World Bank, nine as lower middle income, and six as lower income countries. The NFIDCs, as a group, turned into net importers of food in the mid 1970s, a condition that has persisted, almost uninterruptedly, until now (Díaz-Bonilla, Piñeiro, and Thomas 1999).[11]

For the coming negotiations to consider in greater detail food security concerns under WTO rules, there are two issues that need to be addressed. The first is the relevance of the current classification of countries (developed/developing, LDCs, and NFIDCs) [12] with respect to their food security status. Of these categories, only the NFIDCs are defined with respect to a particular food security indicator, although, as will be argued below, it may not necessarily be the most appropriate.

The second issue is whether the current legal texts, which define WTO commitments on the basis of those categories of countries, really address the issue of food security through that differential treatment. Both questions are related: if the categories are badly defined to capture food security concerns, then it is unlikely that the differential treatment under WTO rules will deal with those concerns in a meaningful way. But even if these categories capture the variety in the situations of food (in)security, the question regarding the adequacy of current and future WTO rules and commitments to adequately treat those differences must still be answered.

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[10] The NFIDCs are: Barbados, Botswana, Côte d'Ivoire, Cuba, the Dominican Republic, Egypt, Honduras, Jamaica, Kenya, Mauritius, Morocco, Pakistan, Peru, Saint Lucia, Senegal, Sri Lanka, Trinidad and Tobago, Tunisia, and Venezuela.

[11] Some of them, like Cuba, Côte d'Ivoire, Honduras, and Mauritius, under the broader definition of food followed by FAO in FAOSTAT, have been food exporters on average for the period 1995-1998. However, they are importers of a narrower list of basic food products, and on this basis they have been included in the group.

[12] Another category of countries is considered in Article 29 of the Agreement on Subsidies and Countervailing Measures, which mentions "members in the process of transformation from a centrally-planned into a market, free-enterprise economy". This category of countries, however, is not relevant for the analysis of food security conducted here.

This paper contributes to the first issue of the adequate classification of countries, as an input to the second, and separate discussion, of the specific rights and obligations under the WTO and their implications for food security. A categorization of countries is presented based on various dimensions of the notion of food security and on the application of cluster analysis, a classification technique. The paper also draws some general implications for policy analysis and for the agricultural negotiations in the WTO, based on the typology presented. The rest of the paper is organized as follows. The framework for the food security analysis is presented in the next section, including a rationale for the selection of food security indicators considered in the typology. The third section briefly describes the three approaches to cluster analysis utilized in this paper (hierarchical, k-means, and fuzzy), and presents the results of the cluster analysis, ending with a classification of countries according to the food security framework defined.[13] In the fourth section, the suggested typology of countries is discussed in greater detail considering the variety of country situations. Finally, the last section concludes with some implications from the food security profiles identified in this study for a better definition of the trade rules in the current WTO negotiations. Some issues for further research are also discussed.

2. THE FRAMEWORK FOR FOOD SECURITY

2.1. General Considerations

Food security can be analyzed at the global, national, regional, household, and individual levels. Figure 1 (modified from Smith 1998) shows these different levels of analysis. The history of food security definitions shows that, since the World Food Conference of 1974, the focus has moved from the global and national perspectives to the household and individual levels, where the problem of food security emerges in a more concrete way (Maxwell 1996). At the same time it was recognized that the main obstacle to access to food was poverty and lack of income opportunities rather than food supply (Sen 1981). The issues of variability around the trend of both food supply and access, and their sustainability over time, were also increasingly highlighted (Maxwell 1990). It was also recognized that food intakes must go beyond what was needed for simple survival to also support an active and healthy life (Maxwell and Frankenberger 1992). The 1996 World Food Summit included several of those different components when it asserted that "food security exists when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO 1996).

But availability and access are only preconditions for adequate utilization of food. In fact, food availability and even access do not determine unequivocally the more

[13] While the first two methods are well known, fuzzy clustering is a more novel approach, and it is explained in greater detail in Appendix I. Other applications of fuzzy analysis include identification of rules of thumb for more complex decision-making processes (Cattaneo and Robinson 2000). More general discussions can be found in Ross (1995), and Yen and Langari (1999).

substantive issue of malnutrition or nutrition insecurity at the individual level (Smith 1998, and Smith and Haddad 2000). The Food and Agriculture Organization (FAO)'s recent report on the state of food insecurity in the world distinguishes between malnourishment linked to food intake and malnutrition, a physiological condition also related to food intake but affected by other determinants as well. The FAO's report concentrates on malnourishment in developing countries (covering 99 of them), utilizing an indicator of food availability at the national level, which is doubly corrected by the gender and age structure of the population, and by the consumption or income distribution profile of the country (FAO 1999a).

However, the indicators of malnutrition per country so defined, although showing an almost perfect and highly significant correlation with national food availability measured by national consumption of calories per capita, are far more weakly correlated with "deeper" measures of malnutrition, such as the percentage of child malnutrition based on anthropometrical measures (Smith 1998). Analyzing nutrition insecurity at the individual level (utilizing child malnutrition as the indicator) requires the consideration of household and individual food access, as well as other determinants such as the health environment, women's education, and women's relative status in the society (Smith and Haddad 2000).

This paper, acknowledging that the deeper issue of nutrition insecurity requires analyses at the household and individual levels, takes nonetheless a national perspective (the level at which the negotiating categories are defined) and focuses mainly on food availability issues, utilizing consumption, production, and trade measures (Figure 1). Obviously, trade and trade policies influence both world food availability, as well as production and food imports (including food aid) at the national level (the latter two aspects defining national food availability).[14] But trade and trade policies may also have an impact on the rate and variability of growth, as well as its "quality" (i.e. the employment, income distribution, and poverty effects). There is a long literature and a variety of perspectives on the relationship between different trade policies, growth, income distribution, and poverty, which will not be reviewed here (Winters 2000a and 2000b**,** World Bank 2000a, Morley 2000, and Dollar and Kraay 2000). Another important channel of influence of trade and trade policies is through government revenues, directly as collection of trade taxes and indirectly through the impact of the rate and quality of growth on general tax collection. The level of government revenues affects the possibility of implementing transfer policies (like food subsidies or other poverty-oriented programs) and to finance public services and investments in health, education, and related areas. For our purposes, which are basically classificatory, it suffices to note the links.

[14] It should be noticed that the Agreement on Agriculture of the WTO, covers not only agricultural trade policies but also domestic agricultural policies. Therefore, the "Trade" circle in Figure 1 can be understood as including in addition to trade and trade policies, the legal framework for domestic agricultural policies, as embedded in the WTO obligations.

2.2. Food Security Indicators at the National Level

The indicators utilized in this study are considered proxies for three elements of food security at the national level: food availability, access, and utilization.

Food production per capita (PRODCAP) is an indicator of the ability of countries to feed themselves. It tries to address both the notion of insurance and national autonomy, used mainly in some developed countries, as well as the more pressing problems of poverty and hunger in developing countries. This variable is calculated by the FAO as the vector of quantities of total food production in every year multiplied by the 1989-1991 world price in U.S. dollars, and then divided by total population of the corresponding year. Therefore, all values are in constant dollars of 1989-91.[15] The definition of food is the one followed by FAOSTAT, which includes cereals, oils, and livestock products, but also other products such as fruits, pulses, roots and tubers, other vegetables, cocoa, and sugar. In terms of the contribution to calories, proteins, and micronutrients, the FAO category appears to be more adequate than narrower definitions of food, particularly those based only on cereals.[16]

The ratio of total exports to food imports (EXPTOIMP) is an indicator of the ability of different countries to finance their food imports out of total export revenues (i.e. a measure of access to world food supply by individual countries).[17] Total exports include merchandise and services, such as tourism. This indicator, which has been utilized in different early studies of food security (see for instance Valdes and Konandreas 1981), is more relevant for food security analysis than the net food trade position (i.e. food exports minus food imports), currently utilized to determine the category of NFIDC in the WTO. This last indicator only reflects the fact that a country is a food importer or exporter, but not how much does it cost to access that food, and therefore how vulnerable it may be to changes in food prices and international food availability. A country that is a net food exporter but for which the total food bill takes a larger percentage of total exports (for example Mali, with a food bill of about 15 percent of total exports) is likely to be more vulnerable than a country that is a substantial net food importer but whose food bill takes only a small percentage of its total exports (for example Venezuela spends about five percent of total exports, which include substantial oil sales, on imported food).

The ratio of the food import bill over total exports also presents a broader and more adequate picture of the role of trade, and the possible impact of trade negotiations, on food security. Focusing only on the value of the food import bill (gross or net) does

[15] We thank the Statistical Division of the FAO for supplying the unpublished data utilized to construct this indicator.

[16] FAO data for food production does not include fish and fish products. These food items are not part of the product coverage of the Agreement on Agriculture but their importance for food security may be high, particularly for some developing countries and social groups (Delgado et al. 1998 discuss the importance of fisheries in developing countries).

[17] This variable is usually measured as food imports over total exports, i.e. the inverse of the ratio utilized here. As calculated in this paper, higher (lower) values would indicate more (less) food security and the variable could be interpreted similarly as consumption of calories and proteins, and food production. This makes the charts utilized in this analysis easier to read.

not take into account the broader contribution of trade to food security, which is not only the availability of food in world markets, but also the generation of export income to finance those imports. A country whose food import bill goes up may still be less vulnerable if at the same time its total exports have gone up by a larger amount. Conversely, a country may be more vulnerable even with declining food import bills, if exports receipts have dropped even more. Therefore, in the context of trade negotiations the important issue is whether total exports have gone up as a result of those negotiations by more than the food import bill.

Figure 2 shows the ratio of the food bill to total exports for the world, developing countries, LDCs, and NFIDCs. While in the early 1960s the ratios for all groups of countries were similar, ranging from 15 to 20 percent, they declined for both the world and developing countries (reaching around six percent in 1998), stayed relatively flat for NFIDCs (between 15 percent and 20 percent), but increased substantially for LDCs, to above 30 percent during the 1980s, before declining below 25 percent in the 1990s.

In terms of trade and food security, a point to be noticed is that the decline in the ratio during the last decade for LDCs and NFIDCs has been related to the expansion of total trade, and not to a decrease in food imports, which have been growing (but at a slower rate than total exports). Figures 3 and 4 show the values of the food bill and total merchandise exports (measured in current dollars) for LDCs and NFIDCs, respectively. Although the cost of food imports has increased over time both for LDCs and NFIDCs, the value of total merchandise exports has grown even more. The jump in food prices during 1995-1996, which generated widespread concern at the time (Friedberg and Thomas 1997, and FAO 1996), is barely perceived, if at all, in the data presented. Although there was an increase in the value of food imports for LDCs and NFIDCs (UNCTAD 2000), the volume and value of all exports increased even more during those years, as a result of buoyant economic conditions at the world level. Conversely, with declining food prices after the 1997 Asian crisis (and further reverberations in Russia during 1998 and Brazil in 1999), the ratio clearly went up (showing a deterioration of the ability to finance food imports), basically because total value of exports declined.

Although the ratio of food imports to total exports in LDCs and NFIDCs has declined in the 1990s compared to the 1980s, the burden of the food import bill is still very high in those countries. Furthermore, the increase of total exports by LDCs and NFIDCs has been slower than the expansion of aggregate world trade. If those countries had been able to participate in world trade as the average developing country, the food import bill would have been 14 percent and 9 percent in 1998, respectively, instead of the current values of 23 percent and 18 percent.

In summary, these observations underscore the importance of looking at food imports in the context the evolution of trade in general. The ratio utilized here appears more appropriate than the net food importing measure to identify vulnerable countries and to help evaluate the impact of trade issues in general, and not just on food (which is only a part of agricultural exports). [18]

[18] Another indicator sometimes used in measuring the burden of the food import bill is the ratio of food imports to total imports. But this indicator does not convey precisely the level of external vulnerability: it underestimates the burden of the food import bill for a country with a trade deficit, and it overestimates the burden in the case of a trade surplus country. Another possibility to measure the food import bill is to adjust the ratio utilized in this analysis by subtracting the payments of interests and principal on external

Calories per capita and protein per capita: Two separate variables are utilized as indicators of average consumption levels at the national level: calories per capita per day (CALCAP) and protein per capita per day measured in grams (PROTCAP). While national averages have limitations as indicators of household and individual food and nutrition security, Smith and Haddad (2000) show that aggregate calories (which they label food availability) is an important variable in explaining changes in malnutrition as defined by anthropometrical measures of children.[19] Yet measures based only on consumption of calories (such as the chronic malnourishment indicator utilized by the FAO), have been criticized, among other things, for ignoring protein and micronutrient consumption (Bouis 2000, Smith 1998, von Braun et al. 1992). Consistent data on micronutrients at the national level are difficult to obtain, but this analysis uses time series for both calories and proteins from FAOSTAT (1999), thus improving upon a calories-only measure. [20]

Non-agricultural population: A fifth indicator is the share of non-agricultural population share (NAGRPOP), which gives an idea of the extent to which countries may be affected by changes in trade and agricultural policies, and the possible distributive impact along the rural/urban dimension. Several developing countries have indicated their concern that further liberalization of agricultural and trade policies may create problems for their large agricultural populations, where poverty is still concentrated (WTO 2000a, and 2000b). At the same time it is also important to notice the shift in the locus of poverty, food insecurity, and malnutrition from rural to urban areas that different developing countries are experiencing, some of them for several decades now, some others as a more recent phenomenon (Ruel et al. 1998, Ruel et al. 1999, Haddad et al. 1999, and Garrett and Ruel 2000). Therefore, while for the other indicators (consumption per capita of calories and proteins, food production per capita, and total exports per unit of food import) a higher value would be associated with greater food security, the ratio of urban population may be somewhat more ambiguous in its implications.

Urbanization in developing countries is posing new questions regarding economic and social policies in general, and also in relation to the impact of trade and trade policies on food security. Trade protection for food products is equivalent to a tax on food consumption, with the proceeds of that tax transferred to food producers, while agricultural liberalization (if domestic markets operate adequately) should result in a reduction in the tax burden for food consumers. Therefore, a similar profile of trade

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debt and by adding unrequited remittances, foreign aid and other financial inflows, to give an idea of the incidence of food imports on a measure that, borrowing from accounting analysis at the level of individual firms, may be called "total national cash flow". However, because this paper focuses on the relationship between food security and trade issues, the ratio was not adjusted by the incidence of the external debt and other financial flows to avoid mixing trade with other components of the balance of payments.

[19] Aggregate calories is shown to be the second most important determinant to contribute to the decrease in child malnutrition over the period 1970 to 1996, contributing to 26 percent of the decline, while women's education, the most important factor, explained 48 percent of that decline. The impact of the first determinant, however, decreases at higher level of food availability.

[20] Bouis (2000) presents evidence showing that the animal component of food intakes is more strongly correlated with direct measures of nutrition such as weight-for-age, or blood hemoglobin, a marker of iron status. In that sense, the animal portion of proteins, instead of total proteins, could have been utilized in this exercise.

protection (or trade liberalization) will have different implications for developing countries with important contingents of urban poor affected by food insecurity (such as several Latin America countries), than for other poor countries (such as many African and Asian countries) where a majority of the population affected by poverty and food insecurity lives in rural areas and works in agricultural production.[21]

2.3. Data Sources

The data for constructing the five indicators were taken from the FAO database (FAOSTAT 1999) [22] and from the World Development Indicators of the World Bank (2000b). The last five-year average in the decade of the nineties, which for most of the countries is 1993-1997, was used for the analysis. The data set shown in Appendix II covers 167 countries for which data exist, including 133 WTO members (96 percent of total) and 24 WTO observers (75 percent of total)?[23] Those 167 countries comprise 43 LDCs (90 percent of the LDCs), and all 19 NFIDCs defined under WTO rules are also included.[24]

3. CLUSTER ANALYSIS

3.1 General Methodological Issues

Clustering methods are utilized to differentiate categories of countries based on the five measures of food security mentioned above.[25] Cluster analysis tries to maximize the homogeneity within each category or cluster, while also maximizing heterogeneity between different clusters, as reflected in the variables selected. It is a form of data dimensionality reduction, which compacts information from an entire population or sample into information about specific, smaller groups (Hair et al. 1998**,** and Cherkassky and Mulier 1998). Cluster analysis has no statistical basis and can be characterized as descriptive, atheoretical, and non-inferential. Although issues such as normality,

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[21] Of course there are also vulnerable rural groups which are net consumers of food, and for which taxes on food imports may have impacts more comparable to food-insecure urban groups, depending on the balance between possibly higher incomes and larger food costs.

[22] FAOSTAT is periodically updated, and some of the data already published may be adjusted in the process. The calculations presented here reflect data as published during the reference year (see Appendix II).

[23] The WTO members not included for lack of data are Bahrain, Cyprus, Liechtenstein, Qatar, and Singapore, and the WTO observers are Andorra, Belarus, Bhutan, Bosnia and Herzegovina, Oman, Samoa, and Tonga.

[24] The LDCs not included for lack of data are: Bhutan and Samoa (WTO observers), and Equatorial Guinea, Sao Tome Principe, and Tuvalu, which are not part of the WTO**.**

[25] The selection of the variables is crucial because the derived clusters would only reflect the structure of the data as defined by those variables. In other words, two objects that belong to the same cluster are considered similar only with respect to the variables selected, but they may well be very different in terms of other variables not considered.

linearity, and homoskedasticity have little importance in this analysis, there are other statistical aspects that must be addressed, including whether the sample data represent the population, whether multicollinearity exists, and the possible existence of outliers (Hair et al. 1998).

In our exercise, the sample is close to the whole population, so the first issue is less relevant. Regarding multicollinearity, calories per capita and proteins per capita are closely correlated, while the other variables are less so (Table 1). The impact of multicollinearity is to give additional weight in the clustering to the underlying characteristic represented by the collinear variables. In this case, the correlation of calories and proteins places a greater weight on the consumption indicators. Finally, cluster analysis is very sensitive to the presence of outliers, which may result from extreme values of some of the variables or a unique combination of them. In the application discussed below, those outliers are identified early in the analysis and treated separately.

The next issues that must be addressed are: how do we measure similarity, how do we form clusters, and how many clusters do we form? Similarity between each pair of observations is measured according to the (squared) Euclidean distance, which is the recommended distance measure for the clustering methods utilized here (Ross 1995, Romesburg 1984, and Hair et al. 1998). To avoid giving more weight to any one variable because of its unit of measure, variables are converted to z-scores (subtracting the mean and dividing by the standard deviation).

The clustering algorithms try to maximize the differences between clusters relative to the variation within the clusters. Clustering algorithms can be classified into two general categories: hierarchical and nonhierarchical. Within the hierarchical method there are also two alternatives: agglomerative and divisive methods. The first (agglomerative) method begins by assigning one object per cluster and subsequently clusters are joined together according to the smallest distance between them. The second (divisive) method starts from one cluster containing all the objects and divides them according to the longest distance between them. In both cases each sequence is nested in the previous one, and the sequence of divisions or agglomerations does not allow an object to change clusters once it has been assigned.

In nonhierarchical methods, clusters are not formed sequentially but simultaneously, and they require the previous specification of the number of clusters. Objects are allowed to change clusters during a process of iteration in which similarity within clusters is maximized.

We employ an agglomerative hierarchical method and two nonhierarchical methods (k-means and fuzzy) to generate a food security profile for the 167 countries included in this study. We define the number of clusters utilizing the hierarchical method, which also yields cluster centers for each variable. Then the k-means and fuzzy methods are applied, using as a starting point the results from the hierarchical method.[26]

[26] See Hair et al. (1998) for a discussion of the combined used of hierarchical and nonhierarchical methods as best practice in cluster analysis.

3.2. Agglomerative Hierarchical Method

Process and Results: The agglomerative hierarchical method is a stepwise process, which starts by specifying a cluster for each country. Clustering begins by combining the two countries that are the most similar (after the first step, the combination may be a country and a cluster, or two clusters). To measure the changes in similarity within clusters resulting from the agglomeration process, an agglomeration coefficient is computed using the within-cluster minimum variance, or Ward's method. The clusters are joined together as to minimize the variance at each step (see Appendix I for more details).

The cluster centers (centroids), which represent the average value of the country indicators, are shown for the levels of agglomeration 4, 10, and 15 in Tables 2 to 4.[27]

The food security profiles identified at the 4-cluster agglomeration level are shown in Figure 5. The "food insecure" group (Cluster 4-1), which includes 32 countries, is characterized by z-score values of the five indicators around one standard deviation below zero; the "food neutral" category (Cluster 4-2), which include 86 countries, is characterized by intermediate z-score values around the mean (zero) (Cluster 4-2); and the "food secure" group of 45 countries has z-score values around one standard deviation above zero (Cluster 4-3). There is also a fourth cluster of "very food secure" countries, which includes only Australia, Denmark, Ireland, and New Zealand (Cluster 4-4). In this cluster all indicators are above one positive standard deviation, particularly production per capita.

While clusters 4-1 and 4-4 are very stable under subsequent divisions, both the "food neutral" (4-2) and the "food secure" (4-3), show important differentiations with increasing number of clusters. Particularly important for the definition of the number of clusters are the subdivisions of the "food neutral" cluster 4-2, in which some countries are merged into more food insecure groups, while others remain in the intermediate category. Also, in the process of subdivisions two countries emerge as outliers: New Zealand from the "very food secure" group, and Thailand from the "food (Table 5).[28]

Defining the number of clusters. Because there is no basis in statistical inference for the clustering, there are no objective selection criteria for the "correct" number of clusters, although a number of approaches have been suggested. One of the most common

[27] Although the process of clustering proceeds from a high number of clusters (equal to the total number of countries) down to a single one, it is more convenient to describe the sequence of clusters beginning from the more aggregate levels and then move to the disaggregated ones.

[28] Thailand splits from the food secure group at the 9-cluster level, and New Zealand splits from the very food secure group at the 13-cluster level (not shown here). The existence of outliers may be due to extreme values of some variable or to the particular general profile and not the value of any single one of them. Thailand's peculiarity is the special combination of a very high ratio of total exports to food imports (very trade secure), with average to low consumption and production of food, and an important rural population. This may simply indicate a production profile tilted towards non-food agricultural export goods, which combined with the strong performance of nonagricultural exports, lead to the particular combination of values for the five variables. But there may also be some under-recording of domestic food crops and products for self-consumption in farms with exports crops. New Zealand, not surprisingly, stands out as an outlier, due to a very high production per capita.

procedures is to evaluate the changes in the similarity index during the agglomerative process: as countries and clusters are combined, the similarity within cluster decreases, so changes in those values at each successive step provide an indicator of the loss of homogeneity within clusters as the number of clusters is reduced**.** The number of clusters selected is partly a function of the desired level of similarity among members of the same cluster.

A useful device for that analysis is the dendrogram, a chart that provides a graphical view of the agglomeration process and shows the increase of the agglomeration coefficient, at each level of agglomeration. At the start, the value of the coefficient is zero and it increases as clusters are joined together. The dendrogram in Appendix III shows that the agglomeration coefficients are very small (high similarity within clusters) up to the 10-cluster level of agglomeration and start to increase in larger jumps after that, particularly from the 4-cluster level, if the number of clusters is further reduced.[29] This indicates that increasingly more non-homogeneous clusters are being formed if the agglomeration goes to less than 10 clusters.

On the other hand, specifying too many groups is not desirable. At 15 clusters, the agglomeration coefficient appears small. Some judgment has to be applied as to whether further splitting of clusters provides additional information that is policy relevant. For instance, at the 15-cluster sequence, Thailand and New Zealand have been identified as outliers and further splitting of clusters beyond the 15 clusters results mainly in increasing homogeneity among food secure groups, which are mostly comprised of developed countries, and which are not the main focus of this analysis**.**

Further examination of the 13 remaining clusters, once Thailand and New Zealand are excluded, reveals that the two most food insecure groups, 15-1 and 15-13, share a similar profile: they both have low consumption, low production, suffer from high food import bills relative to total exports (referred here as being "trade stressed"), and they are rural (Table 4). They also have the smallest proximity coefficient between them (0.883), indicating that these two clusters are more similar to each other than any other two clusters (Table 6). It seems appropriate for our purpose to combine them into one group, resulting in a final structure of 12 clusters.

The cluster centroids for the proposed structure are shown in Table 7 (h1 to h12). Both the number of clusters and the centroids are used as initial seeds for the application of the two nonhierarchical methods: the k-means clustering (a "crisp" approach), and fuzzy clustering.[30]

[29] The values of the agglomeration coefficient shown at the top of the chart are rescaled from 0 to 25, so the chart can be presented in a more compact way.

[30] When the centers for those clusters are provided beforehand, it enhances the speed with which the nonhierarchical techniques compute the distance to specified cluster centers. Nonhierarchical techniques can also be run without random seed points but using those techniques in combination with the centroids suggested by the hierarchical results maximizes the advantages of both types of procedures.

3.3. Nonhierarchical Methods

The k-means and fuzzy methods are used in combination with the hierarchical method to complete the process of the country classification into 12 food security profiles. Both methods allocate objects to clusters so as to minimize an expression that includes the sum of Euclidean distances over all objects and clusters, and they allow reclassification of countries as the cluster centers are recalculated (see Appendix I for the mathematical formulation). This is an advantage over the hierarchical method, which does not allow a country to be assigned to a cluster different from the one it is assigned in the previous step. But these nonhierarchical procedures depend on the hierarchical one to define the number of clusters and specify their corresponding clusters seeds.

In the two nonhierarchical procedures, all objects that are closest to a particular center are assigned to the corresponding cluster. In a first iteration, all countries are assigned to the 12 clusters following this process. In subsequent iterations, as new centers are recomputed, objects are reassigned, changing the cluster membership and the cluster centers. The procedure stops when successive iterations do not change the centers more than a minimum threshold. Both the k-means and the fuzzy methods converged quickly in our application.[31]

The main difference between the two nonhierarchical methods is that the k-means is deterministic in its cluster partition (i.e. the objects being classified, countries in this case, are either in a group or they are not), while the fuzzy algorithm allows degrees of membership in different groups. Fuzzy cluster analysis incorporates what is called "event ambiguity "(i.e. an event that can be deterministic in probability, but ambiguous in nature), a form of uncertainty different from well-defined, unambiguous events than can be random. Fuzzy analysis measures the degree to which an event occurs, not whether it occurs. Each cluster in our analysis can be viewed as an event category, such as a country being, for instance, "trade secure", rural, with low consumption, and low production. In turn, every country in our sample, with its specific characteristics, will be a member to a different degree (measured on a 0 to 1 range) of each and every cluster. In the fuzzy method we classify a country in the cluster in which it has a dominant degree of membership. Usually, a country has a dominant degree of membership in a particular cluster, but there are interesting cases where a country has significant degrees of membership in more than one cluster.

The k-means method also generates an indicator of membership, which measures the distance of an object from the center of the cluster to which it has been allocated. But the k-mean indicator does not show in which "direction" the object differs from the cluster center. For instance, two countries may be classified in a cluster considered "food security neutral", and both may have a k-means membership indicator that shows that they are equally distant from their cluster's centroids. Yet, the distance from the centroids in the case of one of them may result from similarities with "food insecure" clusters, while in the case of the other country it may be because it shares the profile of

[31] The k-means method was run in SPSS, and Andrea Cattaneo programmed the fuzzy method in GAMS. The General Algebraic Modeling System (GAMS) is a high-level modeling system for mathematical programming problems (Brooke et al. 1998).

more "food secure" groups. Fuzzy-cluster analysis clarifies this ambiguity by showing the degree of membership in the different clusters**.**

The counterpart to the advantage of the fuzzy process over the k-means approach in handling event ambiguity is that fuzzy clustering may not maintain the profiles identified by the initial cluster centers, while the k-means method generates a structure that is more in line with the initial partitioning of interest**.** Keeping close to the initial clustering is important in cases where the cluster profiles used to initialize the nonhierarchical methods are the result of combinations or disaggregations to highlight differences or similarities that are relevant to the policy focus.[32]

3.4. Results from all Three Methods

Table 7 gives the results from all three methods: h1 to h12 for the hierarchical, k1 to k12 for the k-means, and fz1 to fz12 for the fuzzy. Those 12 groups encompass 165 countries, excluding New Zealand and Thailand as outliers.

All three approaches identify clusters with rather similar profiles, especially for clusters 1 and 2 within the more vulnerable groups, and for clusters 7 to 12 for the "food secure" groups. There are some differences between clustering methods in the centroids for consumption levels of clusters 4 and 6; for production levels and the rural/urban variable of cluster 5; and for the consumption levels and the rural/urban variable in cluster 3 (see Figure 6).

The differences between the profiles are due to the cluster membership schedule, which varies somewhat between methodologies. Therefore, it is important to consider the extent do the three approaches agree when classifying countries to different clusters. In principle, the larger the number of countries classified similarly by all three methods, the greater the confidence in the final cluster structure. The answer is that the three methods agree to a large extent, although there are some interesting differences in the allocation of individual countries: about 78 percent of the countries (129 in total) have the same cluster membership in all three methods; another 22 percent (36 countries in total) have the same cluster membership in two out of three methods, and no country was classified differently by each of the three clustering methods. Of the 36 countries for which only two methods agreed, 21 (58 percent) were classified similarly by the hierarchical and the k-means approaches, while 15 (42 percent), were classified similarly by the fuzzy and the k-means methods. There are no cases in which the hierarchical and the fuzzy method agree while disagreeing with the k-means classification. This is the result of the k-means method following closely the centroids obtained from the hierarchical method, while at the same time, sharing with the fuzzy methodology the nonhierarchical approach that allows for reallocation of countries in clusters. Table 8 shows the 165 countries as they are allocated to each one of the 12 clusters, where at least

[32] It is always possible to increase the number of clusters in order to accommodate all the differences (but then some of the data-reduction advantages of clustering would be lost), or to do a clustering analysis only of the subset of interest (but then it would be reverting to a form of hierarchical method, instead of looking at the whole set of countries simultaneously). See the discussion in the earlier section on "defining the number of clusters".

two methods coincided in their allocation (countries in bold are those in which only two of the three cluster methods agreed, while the rest have been allocated unanimously).[33] Table 9 shows the average values of the variables (computed in their original units) for each cluster, including a column, which shows in percentages the burden of the food import bill.[34]

The next section will analyze in greater detail these 12 clusters and their composition, utilizing the results of the fuzzy cluster analysis. This method provides an indicator of the degree of membership, thus allowing a deeper understanding of the composition of clusters and the differences between countries. There are two questions that the fuzzy analysis can help clarify. First, for the 36 countries not classified unanimously by all three methods, what is their level of ambiguity in membership, and the "direction" in which they are ambiguous? Second, for the 129 countries in which the three methods agree, are there cases of ambiguity that may have implications for food security analysis?

4. TYPOLOGY OF COUNTRIES

4.1. Overview

Figures 7 to 9 show the 12 clusters combined into three groups, which we define based on the z-score values (y-axis) of the variables (x-axis). Clusters with centers falling below -0.5 (minus half a standard deviation from zero) are defined as "food insecure". Clusters 1, 2, 3, and 4 fall in that category. Clusters 5,6,7, and 8 have most of their variables in the –0.5 to +0.5 range (plus or minus half a standard deviation around zero). They are considered to be in the "food neutral" category. Finally, clusters 9, 10, 11, and 12, with most of the variables above +0.5, are considered "food secure".

Within this framework, the issue of membership ambiguity focuses on countries that may share substantial membership in various clusters across the three main categories of food insecure, food neutral, and food secure. For instance, a country may be classified by two or even all three methods in a cluster of the food neutral group, and yet the fuzzy analysis may indicate substantial degree of membership in the food insecure clusters, such as clusters 4 and 3. This type of ambiguity may lead to misclassification of some countries and have policy implications for food security. On the other hand, even if a country has not been classified unanimously and is very ambiguous, the fuzzy analysis may show that the ambiguity is between clusters that are all within the same general group of food insecure, neutral, or secure clusters. In this case, ambiguity would not lead to a misclassification of the country with significant policy implications for food security.

[33] The allocation of countries using that rule defines, in this application, cluster memberships that are identical to the k-means results.

[34] As mentioned before, the variable utilized in the clustering exercise is total exports over food imports, which helps to visualize the profiles in the charts when using z-scores. In Table 9 the inverse is also included, because that is the way this ratio is usually presented when utilizing numerical values from the data.

Figure 10 illustrates the relative position of the 12 clusters in a different diagram where the average value of the z-score variables for the combined consumption of calories and proteins, is plotted against the trade indicator showing the burden of the food bill (also in z-score values). The solid lines at the values of –0.5 across both axis of the chart divide the space into 4 main quadrants separating the food insecure clusters from the rest (the dotted lines at the +0.5 values add other quadrants differentiating among clusters that are food neutral or food secure): clusters 1 and 2 appear in the quadrant that is consumption vulnerable and trade stressed (Southwest quadrant), with the values below –0.5 on both dimensions; cluster 3 is in the quadrant, which identifies consumption vulnerability but not trade stress (Southeast quadrant); cluster 4 is in the trade stressed quadrant but is above the level of –0.5 for consumption (Northwest quadrant). The rest of the clusters appear in the intermediate or high levels of consumption and trade security (Northeast quadrant), with both dimensions above the –0.5 value.

4.2. Food Insecure Group

Cluster 1- most food insecure countries. Countries in cluster 1 have indicators that are all under the –0.5 threshold of their z-score values (Figure 7). They show the lowest levels of consumption measured in calories (1,983) and proteins (49 grams) per capita, and of food production per capita (US$82). Their food imports require over 20 percent of their total export earnings, compared to the world weighted- average of 6 percent, and they are predominantly rural (only about 23 percent of the population is urban; Table 9). This group includes 30 countries, all of them LDCs, except Kenya, a country classified as NFIDC by the WTO. They are mostly from Africa (23 out of the total 30). They include 21 WTO members and 4 WTO observers (Table 8).

The countries selected by only two methods are Angola, Cambodia, Madagascar, Mali, Nepal, and Uganda. They are categorized by the fuzzy method as belonging predominantly to cluster fz3 followed by membership in cluster fz1 (see Appendix IV). In particular, Angola, Mali, and Nepal have substantial degrees of membership in cluster fz1 (Figure 11). Yet those two clusters are very similar and they differ basically in that cluster fz3 has a lower burden of food imports in the trade balance (i.e. they are less "trade stressed"). Therefore, the fact that those six countries have not been selected unanimously does not change their general profile: they belong to the food insecure group, with some differences in the level of trade stress.

Even some of the countries confirmed to belong to cluster fz1 by all three methods (Bangladesh, Burkina Faso, Central African Republic, Congo Democratic Republic, Gambia, Guinea, Guinea Bissau, Kenya, and Yemen), have substantial degrees of membership in cluster fz3 (see Figure 11). This result underlines the similarity between these two clusters.

Cluster 2- food insecure countries with an urban profile. Cluster 2 shows somewhat higher levels of consumption and production than cluster 1, but is still "consumption vulnerable" and is also trade stressed (see Figures 7 and 10). The main difference is that these countries are far less rural than those in other food vulnerable clusters: in fact, on

average, more than 70 percent of the population is classified as urban (Table 9). This raises the issue of urban food insecurity, which has its own special characteristics (see Garret and Ruel 2000). While countries in the previous cluster, being mostly rural, may be more concerned about food insecurity in the countryside and the impact of agricultural imports on poor agricultural producers, in countries with larger urban populations (like those in cluster 2), and where conceivably an important percentage of poor and food insecure groups may be urban dwellers, there is a clear trade-off for policies aimed at agricultural trade protection: they may maintain higher incomes for poor producers, but they may also act as a tax on poor consumers (both effects depending on other policies and the interaction of markets and institutions).[35]

Among the 14 members of this cluster, two are LDCs from Africa and five are NFIDCs (mostly from Latin America). The other seven members are basically former republics of the ex-Soviet Union and Latin American countries. Except for Tajikistan, all of the countries are either WTO members (11) or observers (2) (Table 8).

In this second cluster there is also substantial convergence between the different clustering methods. There are just three countries for which only two methods agree: Botswana, the Dominican Republic, and Mongolia. The fuzzy membership indicator shows that for Botswana the second important cluster is number 4, also food insecure, while for Mongolia, it is cluster 5, food neutral, followed by cluster 4, food insecure (Figure 11). Yet the degree of membership of Mongolia in the food insecure clusters (1 to 4) is more than 70 percent (Figure 11 and Appendix IV). Therefore, both appear adequately classified among food insecure countries. The case of the Dominican Republic is somewhat different because the second and third membership degrees are in clusters 5 and 6, which are food neutral, with more than 40 percent membership in these two clusters, against 43 percent in cluster 2 (Figure 11 and Appendix IV). In fact, the hierarchical method puts this country in a food neutral group. The reason for this ambiguity is that relative to other countries in cluster 2 the Dominican Republic is the least trade stressed, with a food bill of about 6.7 percent of total exports (close to the average for the world and for developing countries). Also, although the Dominican Republic is considered a NFIDC within WTO, some of its food imports are linked to an expanding tourism industry (which in this case would not reflect food security concerns). Yet, its fuzzy membership degree in clusters considered food insecure is 54 percent (Appendix IV), and therefore, the classification is maintained.

Of the countries selected by all three methods, only El Salvador shows some ambiguity in the dominant cluster fz2, but still the membership degree in food insecure clusters 1 to 4 adds up to almost 75 percent.

Cluster 3- food insecure countries with consumption vulnerability. This cluster has consumption below the –0.5 level, particularly proteins which are below cluster 2, but is better off than cluster 1 (consumption of calories 2,245 and 53 grams of proteins). It is also slightly below cluster 2 in production (but above cluster 1), and it is as rural as cluster 4. The main characteristic is that the burden of the food bill is at an intermediate level (close to zero in z-score value, equivalent to about 7 percent of total exports; Table

[35] As mentioned before, the case of vulnerable rural groups that are net consumers of food must also be considered separately.

9). This cluster can be characterized as consumption vulnerable but trade neutral, the mirror image of cluster 4 (Figure 10).

Cluster 3 includes 17 countries, 4 of which are LDCs and 2 are NFIDCs. All belong to the WTO as members or observers, and are developing countries in Africa, Asia, and Latin America (Table 8). Three countries from the Cairns Group appear in this group (Bolivia, Guatemala, and the Philippines).[36]

Cluster 3 has the largest number of countries classified by only two methods: Bolivia, Côte d'Ivoire, Ghana, Guatemala, India, Namibia, Papua New Guinea, the Philippines, Solomon Islands, Sri Lanka, and Viet Nam. According to their fuzzy membership degrees both Papua New Guinea and Solomon Islands appear solidly in fz3, a food insecure cluster. The k-means method also classified those countries in Cluster k3, while the hierarchical method placed them in Cluster h1, the most food insecure group (Table 5). Bolivia and Sri Lanka, classified by the fuzzy method as fz2 (also food insecure), have substantial membership degree in cluster fz3, where the other two methods place them, and overall they have more than 80 percent membership degree in food insecure clusters (Figure 11). Côte d'Ivoire, Ghana, and Guatemala, are classified by the fuzzy method as fz4 (also food insecure) and have accumulated membership of at least 70 percent in food insecure clusters 1 to 4. Therefore, for all those countries, there is no ambiguity regarding their food insecure profile.

Somewhat different is the case of India, Namibia, the Philippines, and Viet Nam, which are classified by the fuzzy method as fz6, a food neutral group. This result is mainly because the incidence of the food bill on total exports ("trade stress") is low: 4.5 percent for India, 5.3 percent for Viet Nam, and about 6 percent for Namibia and the Philippines. Except for the Philippines, these countries are all net food exporters. Some of them may also exemplify a possible policy dilemma: because they are not trade stressed they could expand food imports to improve their low levels of consumption; but at the same time, because they have large poor agricultural populations, there is concern regarding the impact of additional food imports on those rural groups.

The fuzzy membership degree for those countries helps to clarify some of the ambiguity regarding their food insecure or food neutral status. Namibia has a membership in food insecure groups of more than 50 percent and Viet Nam, more than 40 percent (Figure 11 and Appendix IV). This agrees with the classification by the hierarchical and k-means which place those countries in Cluster 3, a food insecure group. But, according to the fuzzy method, there is far less ambiguity in the cases of India and the Philippines, which are clearly in cluster fz6 and which have only between 10-20 percent membership degree in the food insecure groups (Figure 11 and Appendix IV). Yet it should be noted that these results are influenced by the fact that the fz6's profile shows a somewhat more food insecure situation than its counterparts generated by the hierarchical and k-means methods (h6 and k6 respectively). All in all, following the criterion that two of three methods classify them as food insecure (in this case the

[36] The Cairns Group is a negotiating block of agricultural exporting countries that has argued for greater liberalization in world agricultural markets. The current 18 members are Argentina, Australia, Bolivia, Brazil, Canada, Chile, Colombia, Costa Rica, Fiji, Guatemala, Indonesia, Malaysia, New Zealand, Paraguay, the Philippines, South Africa, Thailand, and Uruguay.

hierarchical and the k-means), and the fact that the cluster fz6, where the fuzzy method classifies them, has a relatively more food insecure profile than the other two methods, all four countries are retained in the food insecure cluster 3.

Of the six countries selected unanimously by all methods, Congo is the most ambiguous according to the fuzzy analysis, but in any case more than 85 percent of its membership degree is in clusters 1 to 4 (Figure 11 and Appendix IV).

Cluster 4- food insecure countries with trade vulnerability. While the previous cluster had low consumption but intermediate levels of trade burden, cluster 4 shows the opposite profile: it has intermediate levels of consumption (close to zero in z-score value, or 2,581 calories and 71 grams of proteins) but it is very trade stressed (below the –0.5 line); in fact, this group has the heaviest trade burden with a food bill of almost 21 percent of total exports (Table 9 and Figure 7). Figure 10 shows cluster 4 in the trade stressed quadrant but with an average consumption of calories and proteins above not only Clusters 1, 2, and 3, the other food insecure groups, but also the food neutral Cluster 5.

Cluster 4 has 13 members, including five LDCs and three NFIDCs. All of them except one are WTO members or observers. Although the inclusion of some bigger countries in this group (such as Pakistan, Sudan, and Senegal) conform to the notion of having intermediate consumption but being trade stressed, the classification of some small islands from the Caribbean and the Pacific in this group is less clear (Table 8). This may simply reflect lack of data regarding exports of services (like tourism) and/or the fact that the urban/rural distinction does not have the same meaning in small islands as in bigger continental countries.

Within cluster 4, the countries classified by only two methods are: Albania, Benin, Pakistan, Saint Vincent/Grenadines, and Seychelles. The fuzzy method does not show any ambiguity for Benin, Pakistan, and Saint Vincent. The discrepancy is with the hierarchical method that places them in cluster h3, also a food insecure cluster. Seychelles is more ambiguous: on the one hand, the hierarchical method places this country in a food neutral group, on the other hand the fuzzy method shows that about 75 percent of its membership degree is in food insecure groups (mainly clusters 4 and 2) (Figure 11 and Appendix IV).

Finally, Albania is clearly ambiguous, being classified in fz7 by the fuzzy method, with only about 28 percent degree of membership in food insecure clusters 1 to 4. Albania's special profile combines relatively higher levels of consumption of calories and proteins than the average for cluster 4, with a substantial level of trade stress (food imports represent about 80 percent of total exports, which is equivalent to a z-score value below –1).[37] That profile is similar to cluster 7, where higher consumption is combined with borderline trade-stress values. In fact, as discussed below, some of the countries classified in cluster 7 by at least two methods may be considered part of an expanded cluster 4, because of high levels of trade stress. All in all, Albania's high trade vulnerability justifies its classification in the food insecure cluster 4 by two out of three methods.

[37] This profile is also the opposite of the situation for countries such as Namibia, Viet Nam, India, or the Philippines, with relatively lower levels of consumption but also with little trade stress.

Of the countries classified unanimously as belonging to cluster 4, the fuzzy analysis shows greater ambiguity for Saint Lucia and Vanuatu (Figure 11 and Appendix IV). They have substantial membership in the food neutral clusters (fz5, fz6, and fz7). Still, with more than 70 percent membership degree in clusters 1 to 4, they are all food insecure. In addition to Saint Lucia and Vanuatu, there are also other small islands, such as Grenada, Kiribati, and Saint Kitts and Nevis. There are several data issues that may modify the status of these countries. Agricultural production data may not be reliable. As mentioned earlier this exercise does not include fisheries, which for some of those islands may represent an important addition to production. The tourism industry has an impact on the external food balance and the receipts from tourism services may not be properly reflected in balance of payment accounts. Finally, the distinction between rural and urban is not clear in a small island.

4.3. Food Neutral Clusters

The food neutral clusters 5, 6,7, and 8 have their indicators mostly in the –0.5 to +0.5 range, although there are some deviations mostly towards values above +0.5 (consumption and urban population in cluster 7, and trade ratios in clusters 6 and 8). The only exception is that cluster 6, which includes China, is rural, while all the other clusters in that group are urban (Figure 8). All of them show levels of consumption of calories and proteins, and of production per capita above clusters 1, 2, and 3. The range goes from 2,600 calories and 66 grams of proteins (cluster 5) to 2,976 calories and 83 grams (cluster 7). They are also clearly less trade stressed than clusters 1, 2, and 4, particularly clusters 6 and 8, which have a food bill of only five percent and 3.9 percent of total exports, respectively.

Cluster 5 is the clearest case of an intermediate cluster, with most of the z- score variables around zero (Figure 8). Clusters 6 and 8 have a similar profile in all variables, but cluster 8 has higher values than cluster 6 for all the indicators. The main characteristic of cluster 7 is the combination of high consumption (indeed, within the food secure range), with comparatively more trade stress than the other food neutral clusters. The food bill is on average 11 percent of total exports, which is less than half the levels of cluster 1, 2, and 4, but higher than in cluster 3 (Table 9).

Cluster 5 includes three NFIDCs; cluster 6, one LDC; and cluster 7, two LDCs and five NFIDCs. The membership of the clusters is mostly developing countries and transition economies from different continents, but cluster 7 also includes four countries considered high income by the World Bank: Bahamas, Brunei, Kuwait, and Macau. There are several members of the Cairns Group in cluster 5 (Brazil, Colombia, Costa Rica, Fiji, and Paraguay), in cluster 6 (Indonesia), and in cluster 8 (Chile, Malaysia, and South Africa). Thailand, which was treated as an outlier, is also a member of the Cairns Group, but would fall within the food neutral group.

Cluster 5- food neutral countries. Of the 18 countries included in this cluster, 16 are classified unanimously. The two exceptions are Ecuador, and Trinidad and Tobago (Table 8). The fuzzy method classifies Ecuador in cluster fz6, while the hierarchical

method places Trinidad and Tobago in h7, both food neutral clusters. Therefore any ambiguity remains within the food neutral group.

As indicated before, a valid question is how ambiguous are the other countries, even when classified unanimously? Do some of these countries share substantial membership characteristics to food insecure groups, even though the three methods agree that they belong in the food neutral category? The countries with largest membership degrees in food insecure groups are Kyrgyzstan, Swaziland, and Uzbekistan; but all have less than 40 percent membership degrees in the lower clusters 1 to 4 (Appendix IV). Therefore, the composition of cluster 5 appears to correctly reflect intermediate levels of food security.

Cluster 6- rural and trade- secure food neutral countries. In cluster 6, the fuzzy clustering deviates from the other two methods, especially in terms of having lower calorie and protein intakes, which leads to the inclusion in this cluster of countries (such as India, Namibia, the Philippines, and Viet Nam) that the other two methods placed in cluster 3. In the fuzzy analysis, India is firmly placed in cluster fz6 with a membership degree of 88.3 percent, highlighting similarities with China, also in this cluster with 61.6 percent membership degree. Both have large shares of rural population and low food bills relative to total exports. The center values of fz6 are lower than the corresponding clusters in the other two methods, and therefore, a country like India, is placed in a higher cluster number by the fuzzy method, although its consumption and production profiles are more in line with the food insecure cluster 3. On the other hand, China clearly has the profile of a food neutral cluster. For the small number of remaining countries (Antigua and Barbuda, China, Gabon, Indonesia, and Myanmar), there are no disagreements. Yet, Antigua has about 40 percent membership degree in food insecure clusters and China about 30 percent (mostly in cluster 4) (Appendix IV). These high degrees of membership in food insecure groups reflect higher food bills (Antigua) or larger shares of rural population, than expressed by their cluster center (China). But those values do not change their classification in the food neutral category.

Cluster 7- high-consumption and trade stressed food neutral countries. Within the food neutral group, cluster 7 requires some further analysis because its level of trade stress is the highest of all the clusters in the intermediate group. We consider first the case of the countries allocated to cluster 7 by two out of three methods: Bahamas, Dominica (Commonwealth of), Iran, Kuwait, Macau, and Maldives (Table 8). Bahamas and Macau are placed by the fuzzy method in fz5, a food neutral group, and have more than 80 percent membership degree in food neutral and food secure clusters. Dominica and Iran are classified by the fuzzy method in fz7 and also have more than 80 percent membership degree in food secure and neutral clusters. Kuwait, classified in fz7, has considerable membership degree in cluster fz9, and so is very close to being food secure. The same happens with other countries in fz7, like Estonia, Mexico, the Russian Federation, and Tunisia, which, although they have been assigned unanimously to cluster 7, have important membership degrees in fz9, a food secure cluster**.** A different situation is Maldives (an LDC), which has substantial membership degrees of more than 35 percent in food insecure clusters, mainly clusters fz2 and fz4. The main problem is a high incidence of food imports over total exports: about 83 percent.

The level of trade stress is an issue for some of the countries in this cluster. Although the food import bill for the group on average amounts to 11 percent of total exports (which, as mentioned, is only about half the average value for the trade stressed groups), there are some individual countries that have a high to very high food import bill. In addition to Maldives, other countries with high levels of trade stress include Cape Verde (also an LDC) and Lebanon, both with food import bills of more than 60 percent of total exports. But Egypt (an NFIDC), Dominica, Jordan, and Algeria all have food import bills of 18-21 percent of total exports, close to the average of cluster 4. With such levels of trade stress, the question is whether those countries should not be classified in cluster 4 (food insecure), rather than in cluster 7 (food neutral).

Figure 12 helps visualize the position of all the countries in cluster 7 relative to the mean for cluster 4, utilizing the average of consumption of calories and proteins on the vertical axis and the ratio of total exports to food imports on the horizontal axis. Although in terms of trade stress, the countries mentioned before are as vulnerable or worse than cluster 4, they also have far higher levels of consumption of calories and proteins; some of them in the food secure range. In addition, these countries are less rural (not shown in Figure 12).[38] Therefore, those trade stressed countries are nonetheless classified by the clustering algorithms in cluster 7 because the grouping depends on the structure similarity of the combined variables: clearly, if two groups of countries have similar levels of trade stress, the group with middle to lower consumption will be more vulnerable than the group with higher levels of consumption in both calories and proteins.

In any case, if the main concern is to avoid the possibility of classifying as food neutral a food insecure country, then those seven countries may be included in an expanded cluster 4.

Looking at clusters 5 to 8 without the adjustments to group 7 mentioned above, there are three LDCs and eight NFIDCs in these sets of countries considered to have intermediate levels of food security. If cluster 7 is adjusted as indicated (with the very trade stressed countries in that cluster joining an expanded cluster 4), then there is only one LDC and seven NFIDCs among the food neutral groups (Table 8).[39]

The conclusions will consider both the separation into clusters 4 and 7, as defined by the clustering methods, as well as the possibility of an expanded cluster 4, which includes those seven countries from cluster 7 suffering from high trade stress.

Cluster 8- urban and trade-secure food neutral countries. Among the food neutral clusters, cluster 8 is the most food secure, with better levels for all indicators compared to clusters 5 to 7. Also, all three methods coincide in the allocation of countries to this cluster and there are no important degrees of ambiguity. Panama is the most ambiguous country in the group, followed by Korea. But they still have about 70 percent membership degrees in the food neutral clusters, with the only difference being that while Panama has additional membership degrees of about 17 percent in food secure clusters and 12 percent in food insecure ones, and Korea has almost 30 percent membership degrees in food secure clusters.

[38] See Appendix II for individual country data.

[39] The remaining LDC is Myanmar and the NFIDCs are Barbados, Jamaica, Mauritius, Morocco, Trinidad and Tobago, Tunisia, and Venezuela.

4.4. Food Secure Group

Finally, clusters 9, 10, 11, and 12 are food secure, with most of the variables above the +0.5 value, which translates into consumption of calories and proteins well in excess of 3,200 and 97 grams, production per capita above the intermediate groups, food import bills between 3 and 6 percent of total exports (i.e. these countries are trade secure), and very urban (above 88 percent of total population is urban). The main differences among them are the levels of production per capita, which ranges between US$254 (cluster 9) and US$924 (cluster 12). These groups have levels of consumption and production as well as a trade ratio for food imports that seem to provide more than enough margin to achieve food security under any likely event, domestic or international. Those clusters are labeled as *food secure countries with intermediate production and trade indicators* (Cluster 9); *food secure countries with intermediate production* (Cluster 10); *food secure countries with intermediate trade indicators* (Cluster 11); and *very food secure countries* (Cluster 12).

All industrialized countries (considered in the category of high-income OECD countries by the World Bank) fall in food secure clusters, but they also include some developing countries and former socialist countries (which fall under the middle income label of the World Bank). All European Union (EU) members are in food secure clusters, as well as all the applicants for future membership, except for Bulgaria, Latvia, and Slovakia, which are in cluster 8, (the more food secure of the food neutral clusters) and Estonia, which is in cluster 7.[40] From the Cairns Group, in addition to the industrialized members (Australia and Canada), there are also two developing countries: Argentina and Uruguay. New Zealand, an outlier that can be characterized as very food secure, is also part of the Cairns Group. It is interesting to note that, considering cluster 12 and New Zealand, the four very food secure countries are divided equally between the Cairns Group and the European Union.

These four food secure clusters appear to be very robust in terms of similarity in membership and cluster centers across clustering methods. The only countries selected by only two of three methods are the Czech Republic in cluster 9, Hungary in cluster 10, and Canada in cluster 11 (Table 8). The Czech Republic and Canada are classified by the fuzzy method predominantly in cluster 10, while Hungary is classified by the hierarchical method in cluster 9. Those differences are only small variations in countries with membership well above 80 percent in the food secure clusters (Appendix IV).

Among the countries allocated unanimously, a case with some ambiguity regarding its membership is Japan, which has almost 60 percent membership degree in the food secure clusters and 40 percent in food neutral. Belarus, Hong Kong, Ukraine, and Uruguay, also show some ambiguity, with degrees of membership mostly in the 65-70 percent range in the food secure clusters, and about 30-35 percent in the food neutral clusters (Appendix IV).

[40] The list of EU applicants includes: Bulgaria, Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia and Slovenia. Cyprus is the only country not included in this exercise for lack of data.

5. CONCLUSIONS AND ISSUES FOR FURTHER RESEARCH

5.1. Implications for WTO Categories and Negotiations

This exercise has been an intermediate step between the analysis of aggregate categories and the study of individual country cases. By highlighting groups of countries with similarities in their food security profiles, as measured by the variables considered here, it allows a more differentiated analysis of possible situations of food (in)security. This classificatory exercise is also relevant for the grouping of countries in terms of their possible negotiating positions.

The results have implications for the two issues identified in the introduction: first, the usefulness of the categories currently utilized in the WTO to discuss food security concerns, and, second, the relationship between the definition of appropriate grouping of food (in) secure countries, and WTO current and future commitments. This paper concentrates on the first issue. The implications of the cluster analysis for the legal obligations in the WTO will de discussed in a separate paper.

Some of the categories utilized by the WTO appear inadequate to capture food security concerns. The most obvious case is the category of "developing countri Concerns about the wide variety of countries that have self-identified as developing countries, with special treatment, have existed for some time in GATT and now in the WTO. Those concerns are borne out by this analysis, where developing countries appear scattered across all levels of food (in)security, except for cluster 12, a group of very high food secure countries.[41]

The category of NFIDCs, however, is split between food insecure and food neutral groups: eleven out of the 19 countries appear in clusters 1 to 4 (including Kenya which appears in cluster 1, the most food insecure, and Botswana, Cuba, the Dominican Republic, Honduras, and Peru, in cluster 2). The remaining eight countries are classified in clusters 5 and 7, with intermediate levels of food security. If an expanded definition of group 4 is taken, then Egypt is in the trade insecure category, mainly because of being trade stressed (with a food bill of almost 20 percent of total exports). In that case, this analysis will classify as food insecure 12 out of 19 countries within the NFIDCs, or about 63 percent of the cases, while more than one third of the NFIDCs will not be in the food insecure category.

Being a net food importer appears to be only a weak indicator of food vulnerability. Some countries may be net food exporters but still have a larger percentage of their total exports allocated to buy food, and vice-versa, as the contrasting examples of Mali and Venezuela have shown. Additionally, some countries may be net food importers just because of a dominant tourist industry (like Barbados, which also has

[41] Many observers have emphasized the diversity among developing countries. For an analysis in the context of agricultural negotiations see McCalla and Valdes (1999).

the highest income per capita of the NFIDCs, about US$7,000).[42] Other NFIDCs have important levels of oil exports (such as the case of Venezuela, and Trinidad and Tobago) and therefore imports of food only reflect the comparative advantages of their production structure. In any case, the seven NFIDCs considered here in the food neutral group (excluding Egypt), have food imports that represent about nine percent of total exports, while for the food insecure NFIDCs (including Egypt), the average is about 16 percent.

The category of LDCs, on the other hand, does correspond broadly to countries suffering from food insecurity, even though this issue was not explicit in their definition. Only three out of the 43 LDCs covered in this study are not among the vulnerable countries in clusters 1 to 4 (namely, Cape Verde, Maldives, and Myanmar). According to UNCTAD data, the first two have incomes per capita of US$990 and 1,255 (1997), respectively, which represents four to five times the LDCs' average of US$235. For Myanmar, UNCTAD reported an income per capita of US$3,657 (1997).[43]

If an expanded view of cluster 4 is taken, as suggested in the previous section, then Cape Verde and Maldives, also fall in the food insecure category, leaving only Myanmar in the food neutral group. Of the LDCs considered in this study, 42 out of 43 are food insecure according to the typology presented here.

But, at the same time, there are some countries that have a food security profile similar to the more vulnerable LDCs that are not included in this category, like Kenya. And there are others with only somewhat better profiles, but still in the food insecure categories, that are neither LDCs nor NFIDCs, such as El Salvador, Georgia, Mongolia, and Nicaragua (all WTO members).

In terms of the WTO negotiations, the analysis presented here suggests that to define specific rights and obligations in the WTO using the category of LDCs appears an appropriate starting point, even though food security issues have not been part of the criteria for the definition of LDC, but may not be enough. Some food insecure countries appear to be excluded because they have been defined neither as LDCs nor as NFIDCs.[44]

A possible approach would be to consider for special treatment both LDCs as defined by the United Nations plus all those countries classified here as food insecure. A more limited approach would be to combine the consumption of calories and proteins per capita as indicators of consumption vulnerability, and the food import bill as percentage of all exports (merchandise and services) as indicator of trade stress. The values utilized, as it has been done here, may be those below –0.5 in the z-score transformation of the raw data, based, for instance, on the average of the last three or five years. Currently, the equivalent cut-off values would be 2,380 calories and 62 grams of proteins per day per capita for consumption, and about 13 percent as the burden of the food import bill over

[42] Another example is offered in an interesting paper prepared by Mauritius officials for consultations within UNCTAD, which indicates that increases in food import flows "have been brought about by changes in consumer pattern and more particularly, the significant increase in tourist population" (Mauritius 2000).
[43] UNCTAD, as one of the main UN agencies working on LDCs issues, maintains a database for the individual countries in that category. Comparable figures from the World Bank Development Indicators for 1998 are: Cape Verde, US$1,200 of income per capita, Maldives, US$1,130; and the average for all LDCs, US$270. There is no information for Myanmar in the World Bank database on income per capita, but considering other indicators, the figure reported by UNCTAD seems high.
[44] It should be remembered, however, that only 43 out of the total 48 LDCs have been included in this exercise because of the lack of data for the last five countries.

total exports. Countries may move in and out of the food insecure category so defined, depending on their performance.

Those food insecure countries would receive a treatment similar to LDCs for rights and obligations related to domestic support and their own market access. Also, they will be considered for the food aid, financial support, and technical assistance envisaged in the Ministerial Decision on possible negative effects of the agricultural reform program on LDCs and NFIDCs. The issue of special access to other countries' markets for LDCs, and the additional benefits conferred upon LDCs because of reasons other than food security, would still be limited only to the countries specified by the United Nations. The quantitative limits suggested would help differentiate developing countries that may need special treatment in terms of food security from those that do not.

A special issue is the current definition and composition of the category of NFIDCs. This classification, negotiated during the Uruguay Round, has some implications as defined in the Ministerial Decision, and constitute an acquired right. The implementation of that Decision, as discussed in the meetings of the Committee on Agriculture of the WTO, appears to have been limited mostly to exchanges of information among multilateral organizations and bilateral donors about programs already under execution. In particular, there was no special action taken during the 1995-1996 increases in agricultural prices, because the agencies providing food aid (and financial and technical assistance) considered that the rise was not related to the implementation of the Uruguay Round agricultural agreements.[45] For that reason, many LDCs and NFIDCs have been calling for objective criteria to "operationalize" the Ministerial Decision (UNCTAD 2000).

The classification presented here of food insecure countries would help accomplish such operationalization, defining more precisely the group of countries that appear vulnerable to food security problems. It can be argued that the perception that the category of NFIDCs is not adequate (because it leaves vulnerable countries out, while including countries that are relatively better off) may have contributed to the lack of implementation of the Decision.

In any case, the current category of NFIDCs does not have to be changed, and the WTO members already included may remain in it. But the operationalization of the Ministerial Decision using specific indicators, as suggested here, implies that the application of the Decision will have effects only on part of the current members that fit the criteria, while it should also include other countries not currently considered within the NFIDCs.

It is also relevant to ask about the food security situation of the developed countries. Several developed countries have advanced the notion of food security as part of the "multifunctionality" of agriculture, or, more generally, among non-trade concerns. Our typology, however, shows that developed countries are unanimously concentrated in the food secure groups, according to the variables utilized here. There appears to be a very different meaning of the term "food security" in developed and developing countries. In terms of policy implications and the agricultural negotiations, maintaining the same label for two altogether different situations only obscures the issues being

[45] See also the discussion above on the burden of the food bill in section "*Food Security Indicators at the National Level*"

negotiated. The discussion of food security should be limited to the vulnerability of developing countries, using a different terminology for developed countries.

In terms of coalitions for the negotiations, there appears to be a large core constituency among the food insecure countries that could adhere to a common negotiating strategy, at least considering the variables utilized to identify food (in)security situations. There is less homogeneity among the food neutral groups, for which a majority of countries could have multiple allegiances across clusters.

Among the food secure countries, which include mostly developed economies, the indicators do not show significant dispersion. Some of these countries, however, have expounded very different positions for the agricultural framework, both in the Uruguay Round as well as in the current negotiations. For instance, Norway and the USA, which are together in cluster 10, or the mix of Cairns Group and European Union members in clusters 11 and 12, all have very different positions in the negotiations. A high degree of food security certainly does not imply commonality in agricultural interests.

The only case of an industrialized country with some substantial membership outside food secure clusters is Japan, which has about 40 percent membership degree in food neutral groups. Also, the Cairns Group has members across different clusters, with diverse situations of food (in)security.

5.2. Issues for Further Research

Our analysis raises several issues that may require additional research. First, the calculations presented here used level variables as an average of the last five years. It may be important to include indicators of time trends and variations over time, to have a better idea of types of food vulnerability (Valdes and Konandreas 1981). A related matter is the possibility and actual occurrence of extreme events that disrupt agricultural production in a country and that compromise its food security, such as weather events or wars. Famines and droughts already have special treatment under different international and bilateral arrangements, but a possible question is whether they may also require special provisions for domestic and trade policies under the WTO agreement

Second, and following Bouis (2000), the cluster analysis can be recalculated with animal proteins instead of total proteins, to try to focus more precisely on malnutrition issues. A related aspect is that the definitions of food production and trade utilized here could be expanded to include fisheries. This may be important for several developing countries, in particular small-island economies, and countries like Peru which is a net food importer under the definition utilized here, but is a net food exporter if fisheries are included (Quirós, 2000).

Finally, after classifying countries in different types of food (in)secure groups, the relevant issue is why they ended up where they are. Different statistical techniques can be applied to analyze other characteristics and determinants for the clustering patterns. It seems important to identify countries that have been changing, either moving to more secure or more insecure clusters, and then analyze the reasons for those transitions, considering both policy variables and exogenous events.

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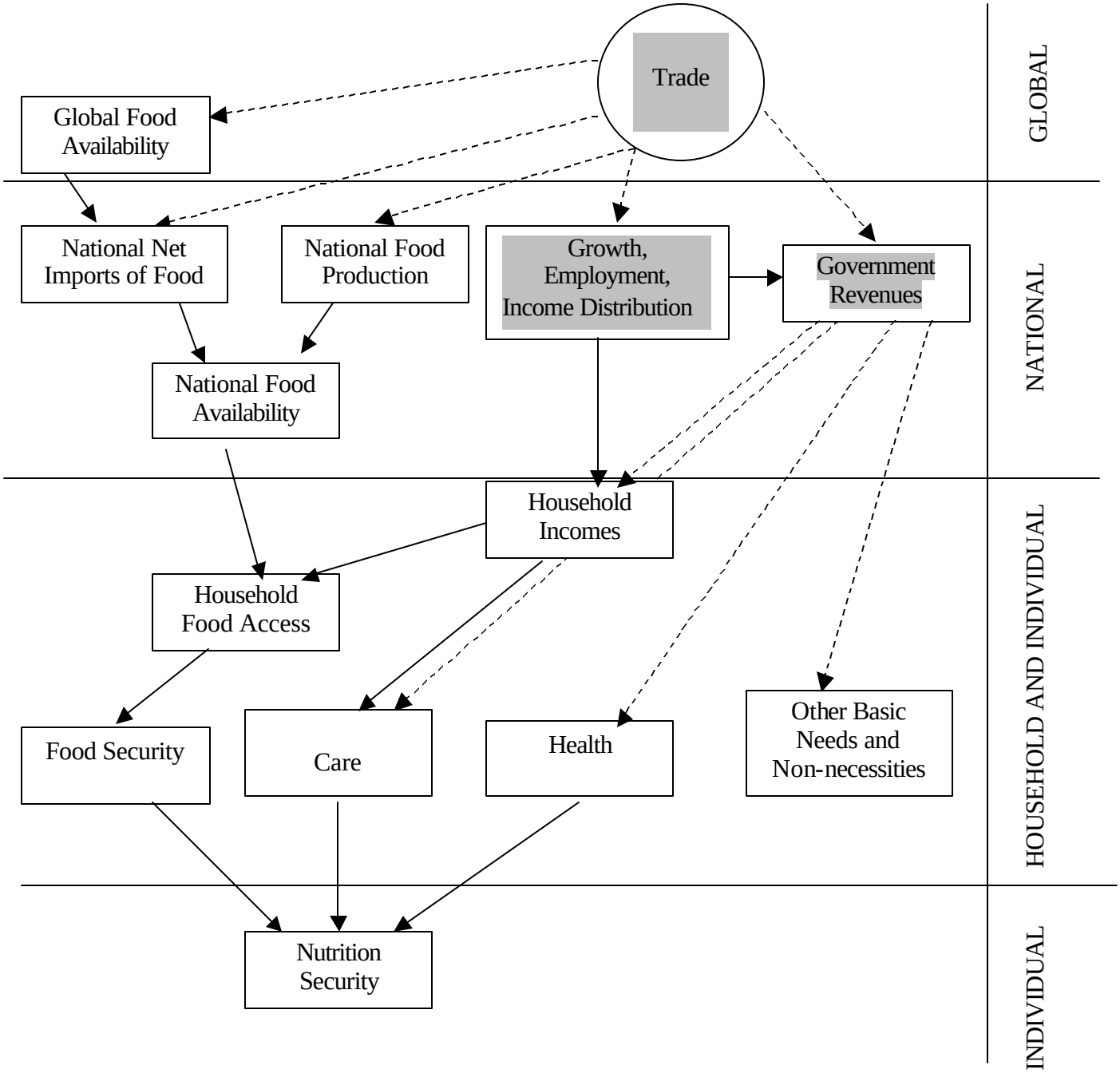
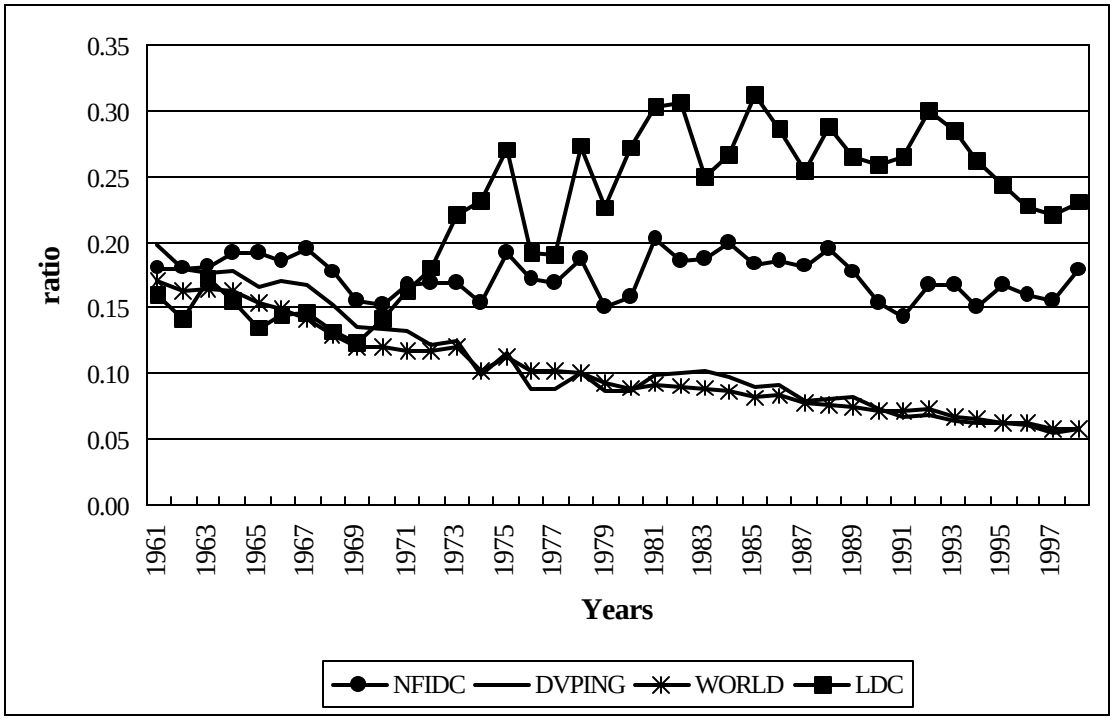
Figure 1--Conceptual framework for food security



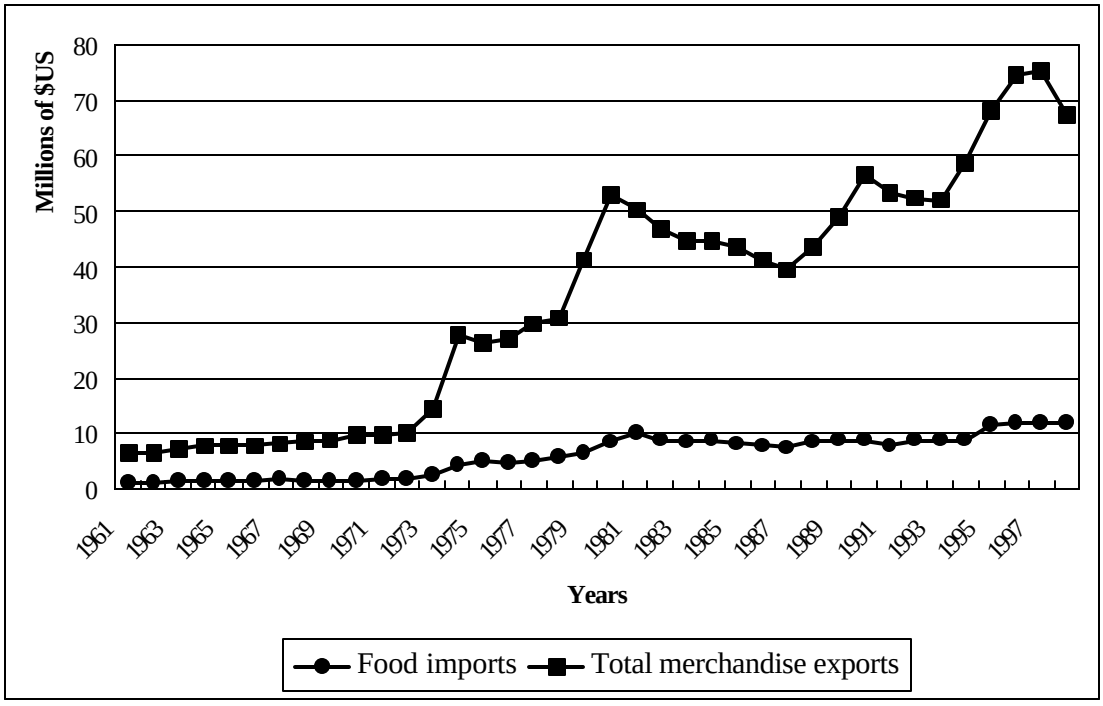
Source: Adapted from Smith (1998).

Figure 2--Ratio of food import value to total merchandise export value



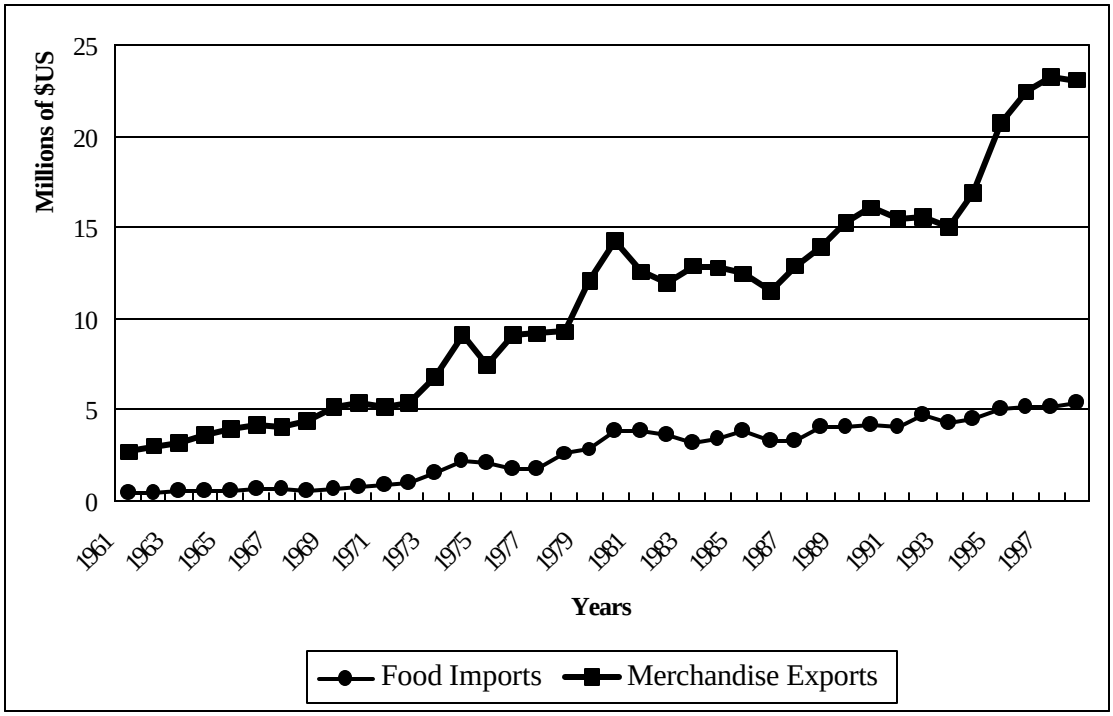
Source: Computed from FAOSTAT (1999) data.

Figure 3--Least Developed Countries (LDCs)



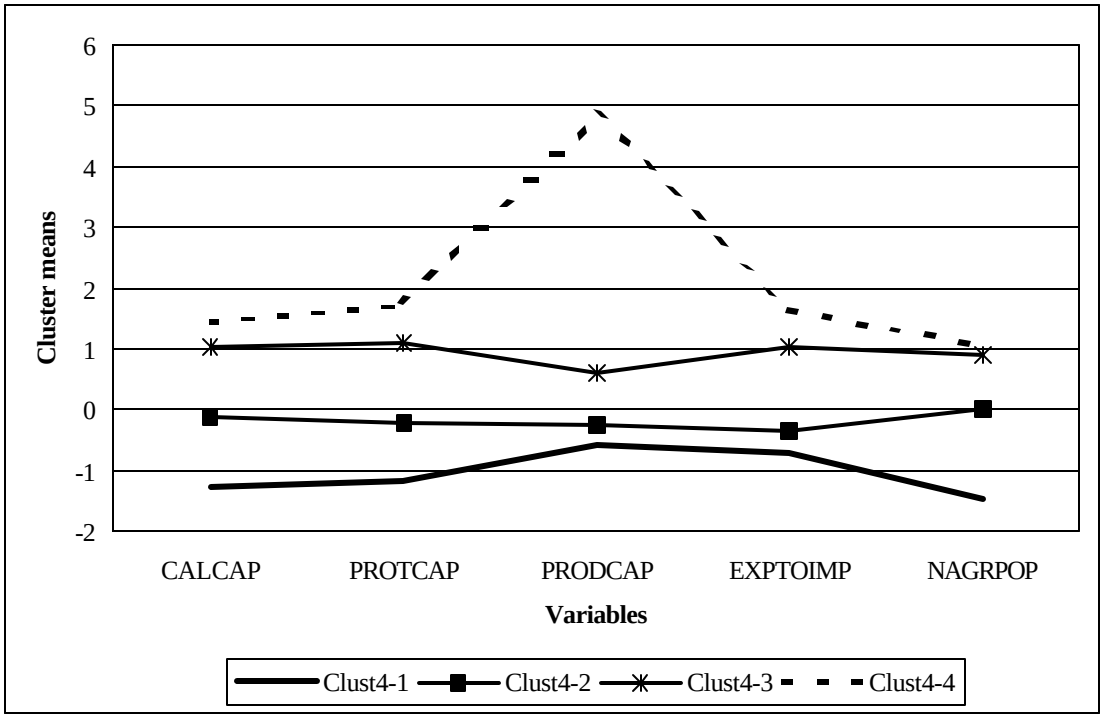
Source: Computed from FAOSTAT (1999) data.

Figure 4--Net Food Importing Developing Countries (NFIDCs)



Source: Computed from FAOSTAT (1999) data.

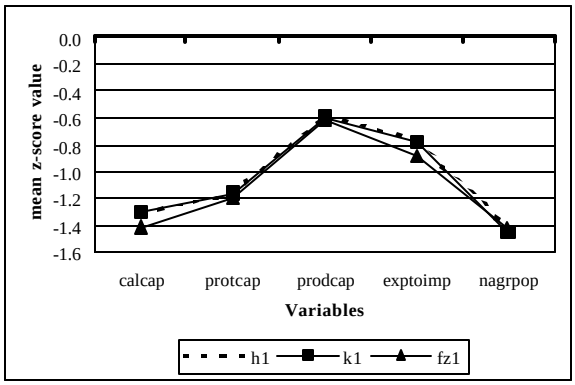
Figure 5--Food security profile in the hierarchical 4-cluster sequence



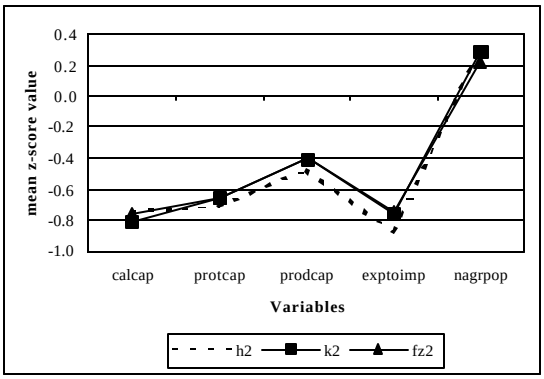
Note: Cluster 4-1 refers to cluster 1 in the 4-cluster sequence**.**

Figure 6--Comparison of cluster means between the hierarchical (h), the k-means (k), and the fuzzy (fz).

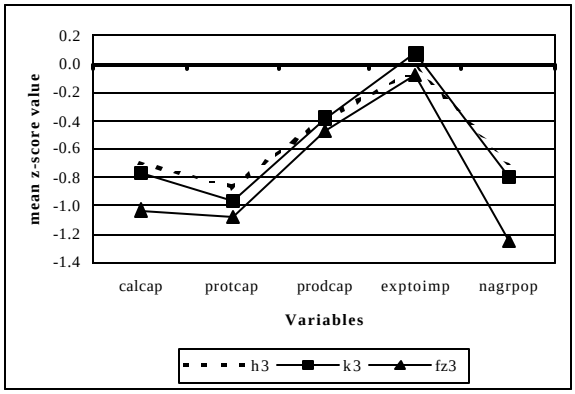
Cluster 1



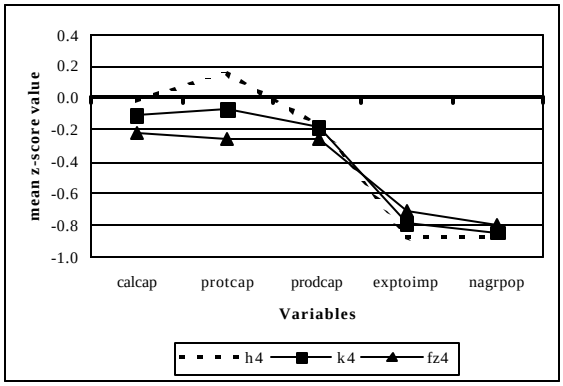
Cluster 2



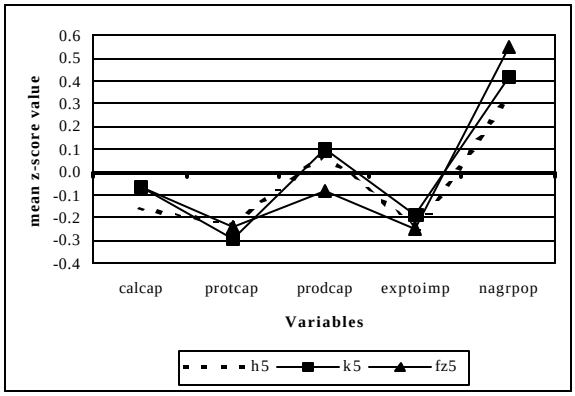
Cluster 3



Cluster 4



Cluster 5



Cluster 6

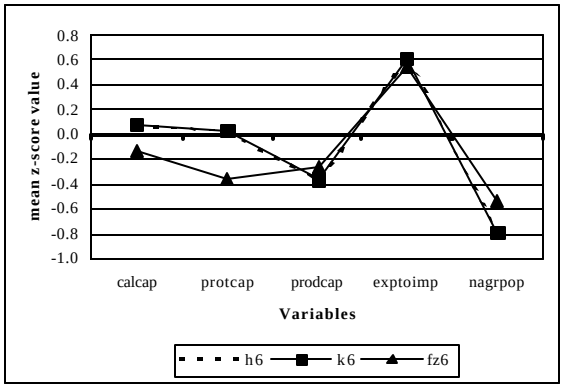
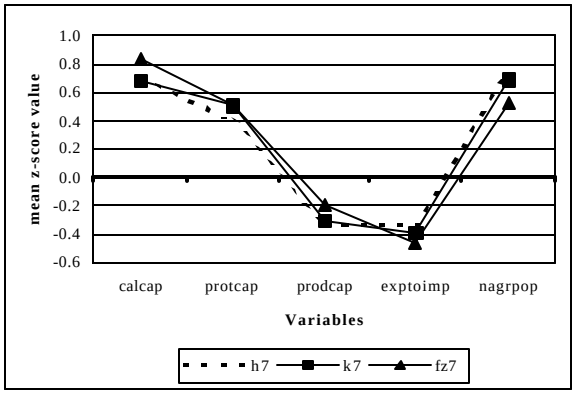
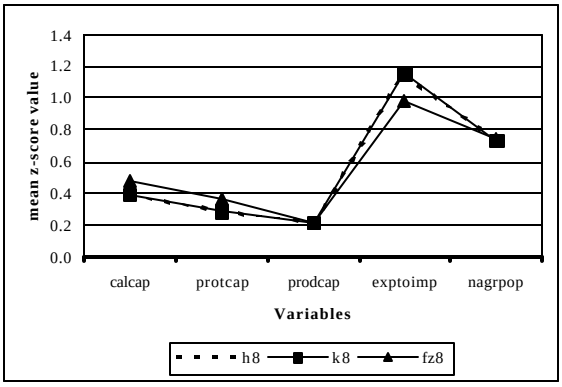


Figure 6—Continued

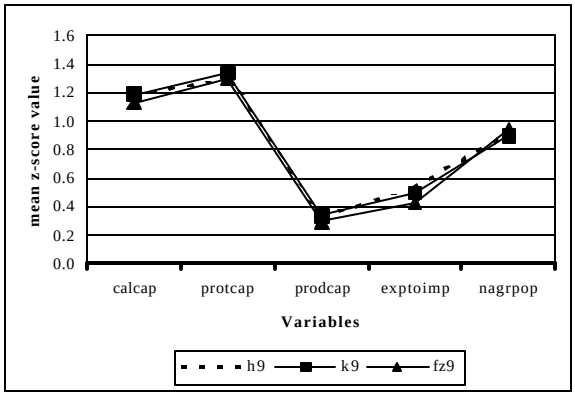
Cluster 7



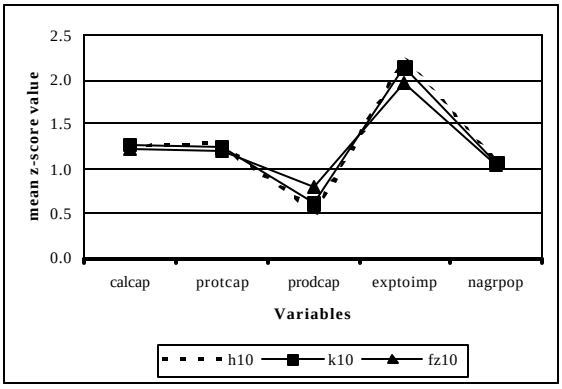
Cluster 8



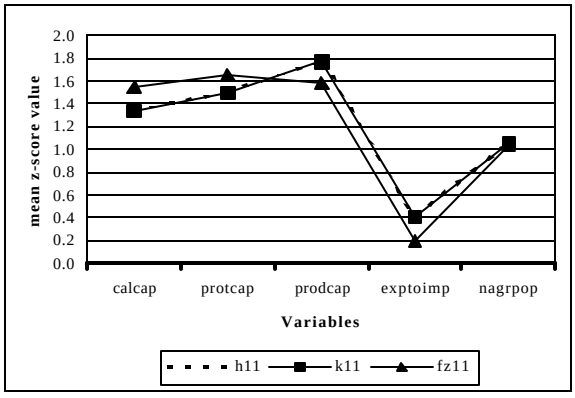
Cluster 9



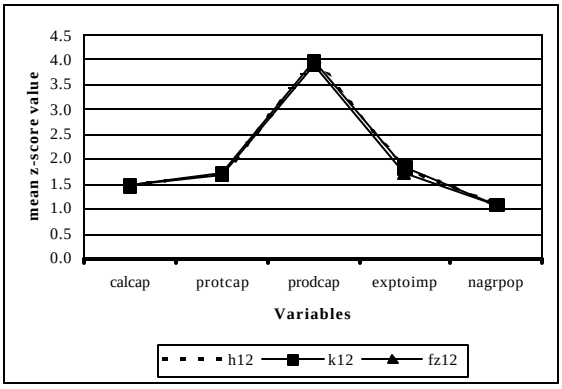
Cluster 10



Cluster 11

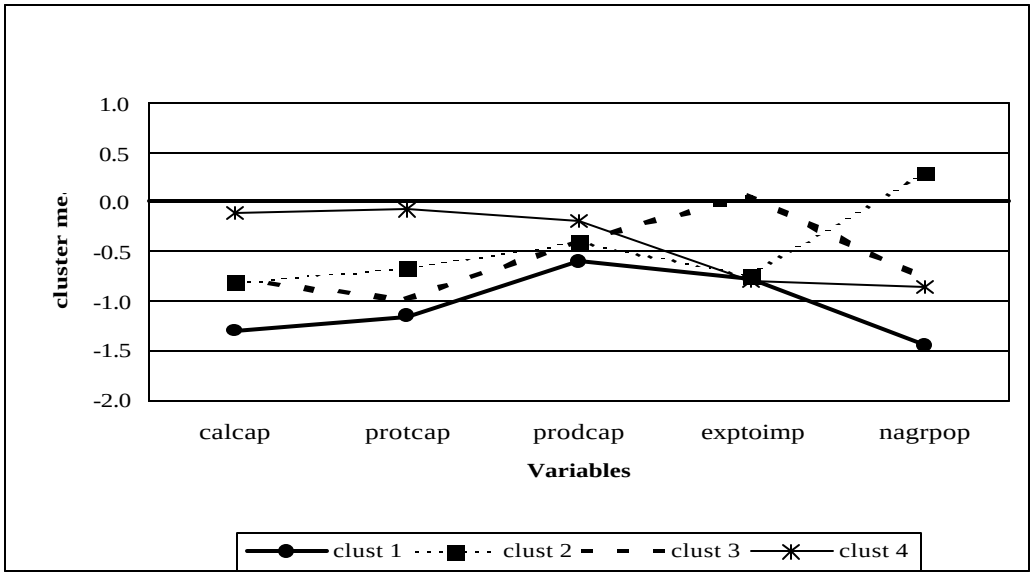


Cluster 12



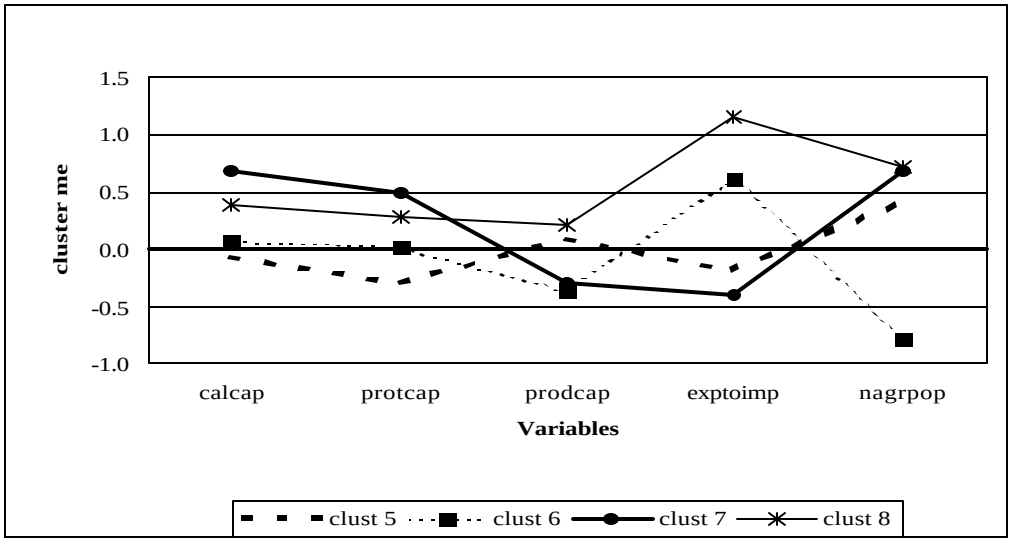
Note: h1 to h12 refers to hierarchical method clusters, k1 to k12 to k-means clusters, and fz1 to fz12 to fuzzy clusters.

Figure 7--Food Insecure Groups



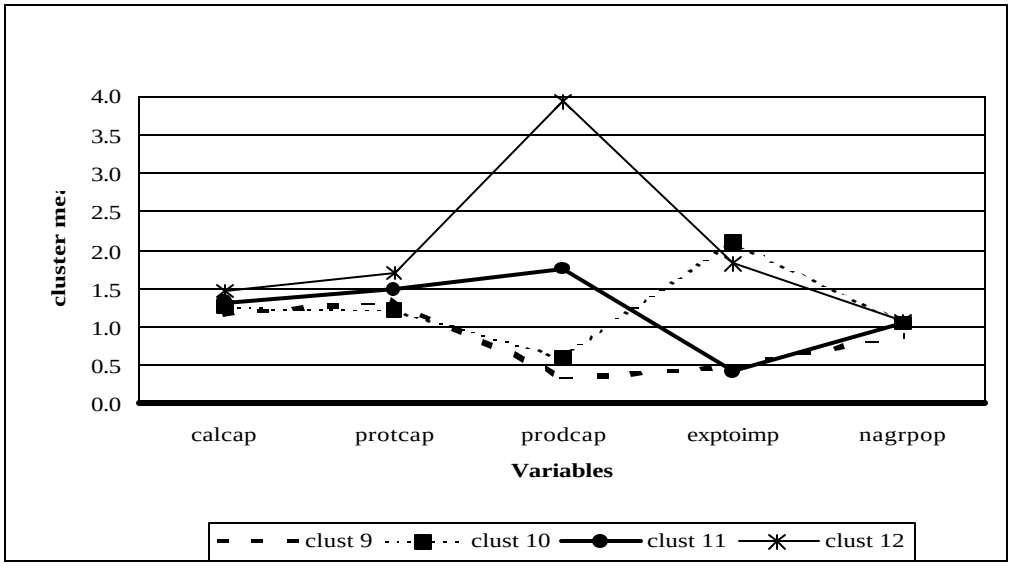
Note: Food insecure groups indicators have z-score values below -0.5 (minus half a standard deviation from zero). Clusters 1 to 4 fall in that category.

Figure 8--Food Neutral Groups



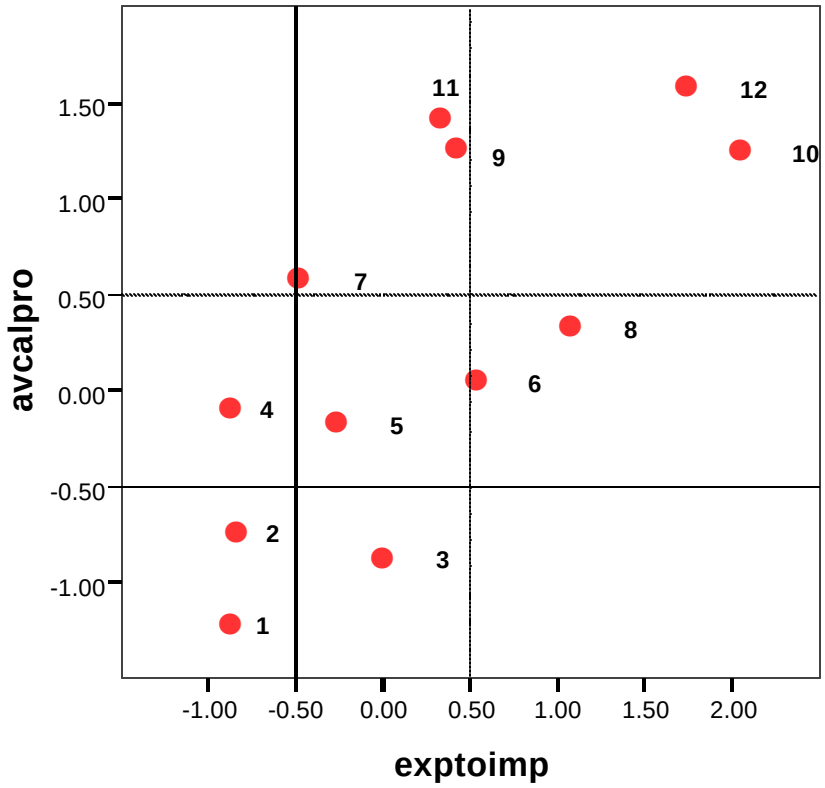
Note: Food neutral groups indicators have z-score values in the –0.5 to +0.5 range (plus or minus half a standard deviation around zero). Clusters 5 to 8 fall in that category.

Figure 9--Food Secure Groups



Note: Food secure groups indicators have z-score values above +0.5 (plus half a standard deviation from zero). Clusters 9 to 12 fall in that category

Figure 10--Scatter plot of consumption per capita versus trade indicator



Note: In the above diagram the average value of the z-score variables for the consumption of calories and proteins, is plotted against the trade indicator showing the burden of the food bill (also in z-score values). The solid lines at the values of –0.5 across both axis of the chart divide the space into 4 main quadrants separating the food insecure clusters from the rest (the dotted lines at the +0.5 values add other quadrants differentiating among clusters that are food neutral or food secure).

Figure 11--Membership composition for all clusters with dominant membership below 0.8

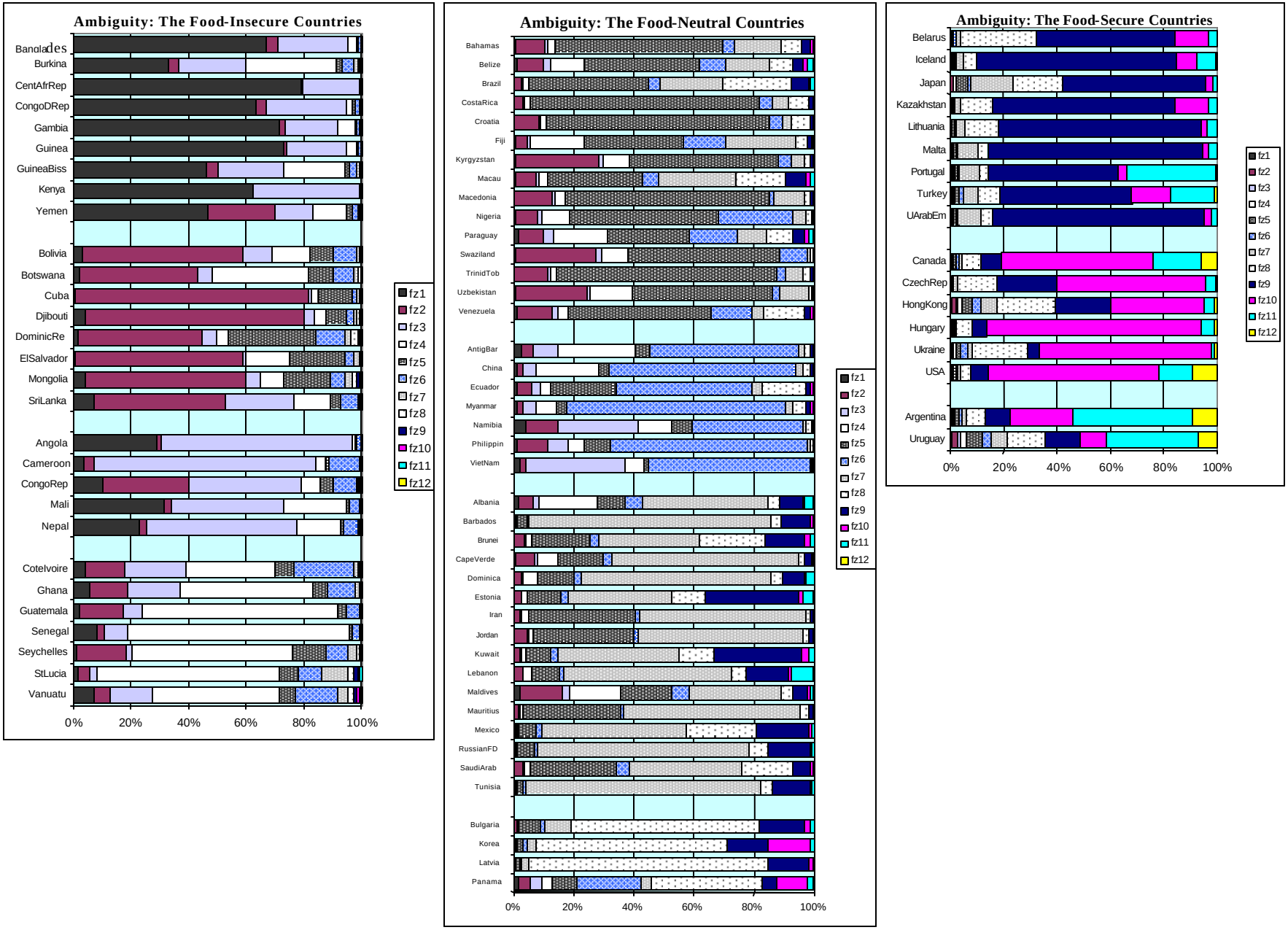
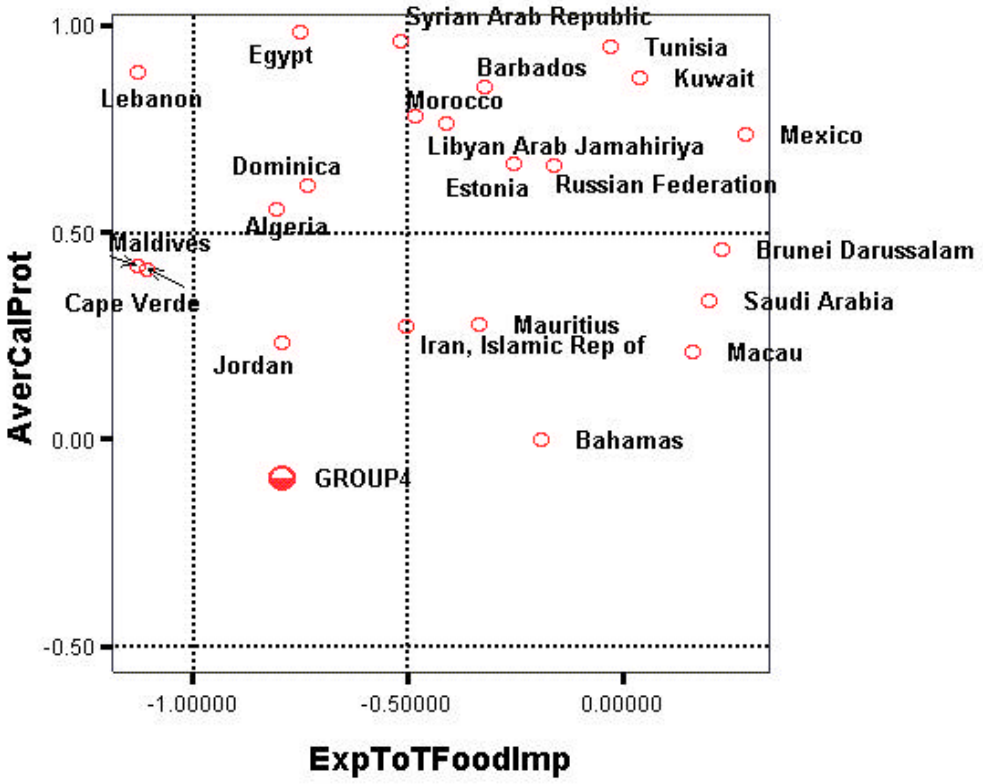


Figure 12--Scatter plot of consumption per capita versus trade indicator for countries in cluster-7



Note: The above figure indicates the position of countries in cluster 7 relative to the mean for cluster 4, utilizing the average of consumption of calories and proteins on the vertical axis and the ratio of total exports to food imports on the horizontal axis.

Table 1--Pearson correlations

	CALCAP	PROTCAP	PRODCAP	EXPTOIMP	NAGRPOP
CALCAP	1.000	0.892	0.603	0.532	0.724
PROTCAP	0.892	1.000	0.621	0.527	0.717
PRODCAP	0.603	0.621	1.000	0.455	0.433
EXPTOIMP	0.532	0.527	0.455	1.000	0.511
NAGRPOP	0.724	0.717	0.433	0.511	1.000

Table 2--Cluster means for the 4-cluster sequence

Clusters	CALCAP (calories)	PROTCAP (grams)	PRODCAP (US$)	EXPTOIMP ratio	NAGRPOP ratio
4-1:					
Food insecure	1,995	48.6	85.3	5.4	0.2
4-2:					
Food neutral	2,573	67.8	148.9	9.7	0.6
4-3:					
Food secure	3,148	94.7	307.0	24.2	0.9
4-4:					
Very food secure	3,373	108.0	1,090.2	31.0	0.9

Source: Authors' calculations based on FAOSTAT (1999) and WDI (2000).

Table 3--Centers for the 10-cluster sequence

Clusters	CALCAP (calories)	PROTCAP (grams)	PRODCAP (US$)	EXPTOIMP ratio	NAGRPOP ratio
10-1	1,995	48.6	85.3	5.4	0.23
Thailand	2,331	53.5	191.9	64.4	0.48
10-4	2,371	58.5	121.8	14.3	0.43
10-6	2,461	64.5	174.9	8.4	0.72
10-2	2,629	75.7	159.4	3.9	0.39
10-3	2,990	80.7	129.9	9.6	0.84
10-9	3,093	92.2	245.4	21.2	0.87
10-8	3,261	98.8	288.7	36.7	0.94
10-5	3,304	103.3	520.6	17.7	0.93
10-7	3,373	108.0	1090.2	31.0	0.93

Source: Authors' calculations based on FAOSTAT (1999) and WDI (2000).

Table 4--Centers for the 15-cluster sequence

Clusters	CALCAP (calories)	PROTCAP (grams)	PRODCAP (US$)	EXPTOIMP ratio	NAGRPOP ratio
15-1	1,828	44.5	66.3	3.7	0.29
15-13	2,124	51.8	100.2	6.8	0.18
15-6	2,260	57.7	105.1	3.9	0.72
15-11	2,287	54.5	121.1	12.8	0.44
Thailand	2,331	53.5	191.9	64.4	0.48
15-10	2,556	67.7	208.2	10.6	0.72
15-2	2,629	75.7	159.4	3.9	0.39
15-4	2,673	72.8	124.1	19.8	0.41
15-12	2,828	78.4	233.3	25.6	0.83
15-3	2,990	80.7	129.9	9.6	0.84
15-9	3,225	99.1	251.5	19.0	0.89
15-8	3,261	98.8	288.7	36.7	0.94
15-5	3,304	103.3	520.6	17.7	0.93
New Zealand	3,371	109.5	1589.1	26.1	0.91
15-7	3,374	107.5	923.9	32.7	0.93

Source: Authors' calculations based on FAOSTAT (1999) and WDI (2000).

Table 5--Cluster classification in the 4, 10 and 15 sequences

4-cluster	10-cluster	15-cluster
4-1: Afghanistan, Angola, Bangladesh, Burkina Faso, Burundi, Cambodia, Central African Rep., Chad, Comoros, Dem. Republic of Congo, Eritrea, Ethiopia, Gambia, Guinea, Guinea-Bissau, Haiti, Kenya, Liberia, Madagascar, Malawi, Mali, Mozambique, Nepal, Niger, Papua New Guinea, Rwanda, Sierra Leone, Solomon Islands, Somalia, United Rep. of Tanzania, Uganda, Yemen	**10-1:** Afghanistan, Angola, Bangladesh, Burkina Faso, Burundi, Cambodia, Central African Republic, Chad, Comoros, Dem. Republic of Congo, Eritrea, Ethiopia, Gambia, Guinea, Guinea-Bissau, Haiti, Kenya, Liberia, Madagascar, Malawi, Mali, Mozambique, Nepal, Niger, Papua New Guinea, Rwanda, Sierra Leone, Solomon Islands, Somalia, United Rep. of Tanzania, Uganda, Yemen	**15-1:** Afghanistan, Angola, Bangladesh, Burundi, Comoros, Dem. Republic of Congo, Eritrea, Ethiopia, Haiti, Liberia, Mozambique, Sierra Leone, Somalia, Yemen
		15-13: Burkina Faso, Cambodia, Central African Rep., Chad, Gambia, Guinea, Guinea-Bissau, Kenya, Madagascar, Malawi, Mali, Nepal, Niger, Papua New Guinea, Rwanda, Solomon Islands, United Rep. of Tanzania, Uganda
4-2: Albania, Algeria, Antigua and Barbuda, Armenia, Azerbaijan, Bahamas, Barbados, Belize, Benin, Bolivia, Botswana, Brazil, Brunei Darussalam, Cameroon, Cape Verde, China, Colombia, Republic of Congo, Costa Rica, Côte d'Ivoire, Croatia, Cuba, Djibouti, Dominica, Dominican Republic, Ecuador, Egypt, El Salvador, Estonia, Fiji Islands, Gabon, Georgia, Ghana, Grenada Guatemala, Guyana, Honduras, India, Indonesia, Islamic Rep. of Iran, Jamaica, Jordan, Kiribati, Kyrgyzstan, Laos, Lebanon, Lesotho, Libyan Arab Jamahiri, Macau, Macedonia, Maldives, Mauritania, Mauritius, Mexico, Mongolia, Morocco, Myanmar, Namibia, Nicaragua, Nigeria, Pakistan, Paraguay, Peru, Philippines, Russian Federation, Saint Kitts and Nevis, Saint Lucia, Saint Vincent/Grenadines, Saudi Arabia, Senegal, Seychelles, Sri Lanka, Sudan, Suriname, Swaziland, Syrian Arab Republic, Tajikistan, Togo, Trinidad and Tobago, Tunisia, Uzbekistan, Vanuatu, Venezuela, Viet Nam, Zambia, Zimbabwe	**10-2:** Albania, Grenada, Kiribati, Maldives, Mauritania, Saint Kitts and Nevis, Saint Lucia, Senegal, Sudan, Vanuatu	**15-2:** Albania, Grenada, Kiribati, Maldives, Mauritania, Saint Kitts and Nevis, Saint Lucia, Senegal, Sudan, Vanuatu
	10-3: Algeria, Bahamas, Barbados, Brunei Darussalam, Cape Verde, Egypt, Estonia, Jordan, Lebanon, Libyan Arab Jamahiri, Macau, Mauritius, Mexico, Morocco, Russian Federation, Saudi Arabia, Syrian Arab Republic, Trinidad and Tobago, Tunisia	**15-3:** Algeria, Bahamas, Barbados, Brunei Darussalam, Cape Verde, Egypt, Estonia, Jordan, Lebanon, Libyan Arab Jamahiri, Macau, Mauritius, Mexico, Morocco, Russian Federation, Saudi Arabia, Syrian Arab Republic, Trinidad and Tobago, Tunisia
	10-4: Antigua and Barbuda, Benin, Bolivia, Cameroon, China, Republic of Congo, Côte d'Ivoire, Gabon, Ghana, Guatemala, India, Indonesia, Laos, Myanmar, Namibia, Pakistan, Philippines, Saint Vincent/Grenadines, Sri Lanka, Togo, Viet Nam, Zambia, Zimbabwe	**15-4:** Antigua and Barbuda, China, Gabon, Indonesia, Myanmar
		15-11: Benin, Bolivia, Cameroon, Republic of Congo, Côte d'Ivoire, Ghana, Guatemala, India, Laos, Namibia, Pakistan, Philippines, Saint Vincent/Grenadines, Sri Lanka, Togo, Viet Nam, Zambia, Zimbabwe

Table 5–Continued

4-cluster	10-cluster	15-cluster
	10-6: Armenia, Azerbaijan, Belize, Botswana, Brazil, Colombia, Costa Rica, Croatia, Cuba, Djibouti, Dominica, Dominican Republic, Ecuador, El Salvador, Fiji Islands, Georgia, Guyana, Honduras, Islamic Rep of Iran, Jamaica, Kyrgyzstan, Lesotho, Macedonia, Mongolia, Nicaragua, Nigeria, Paraguay, Peru, Seychelles, Suriname, Swaziland, Tajikistan, Uzbekistan, Venezuela	**15-6:** Armenia, Azerbaijan, Cuba, Djibouti, El Salvador, Georgia, Honduras, Lesotho, Nicaragua, Peru, Tajikistan
		15-10: Belize, Botswana, Brazil, Colombia, Costa Rica, Croatia, Dominica, Dominican Republic, Ecuador, Fiji Islands, Guyana, Islamic Rep of Iran, Jamaica, Kyrgyzstan, Macedonia, Mongolia, Nigeria, Paraguay, Seychelles, Suriname, Swaziland, Uzbekistan, Venezuela
4-3: Argentina, Austria, Belarus, Belgium-Luxembourg, Bulgaria, Canada, Chile, China-Hong Kong SAR, Czech Republic, Finland, France, Germany, Greece, Hungary, Iceland, Israel, Italy, Japan, Kazakhstan, Republic of Korea, Kuwait, Latvia, Lithuania, Malaysia, Malta, Republic of Moldova, Netherlands, Norway, Panama, Poland, Portugal, Romania, Slovakia, Slovenia, South Africa, Spain, Sweden, Switzerland, Thailand, Turkey, Ukraine, United Arab Emirates, United Kingdom, USA, Uruguay	**10-5:** Argentina, Belgium-Luxembourg, Canada, France, Greece, Italy, Netherlands, Spain, Uruguay	**15-5:** Argentina, Belgium-Luxembourg, Canada, France, Greece, Italy, Netherlands, Spain, Uruguay
	10-8: Austria, China-Hong Kong SAR, Finland, Norway, Sweden, Switzerland, Ukraine, USA	**15-8:** Austria, China-Hong Kong SAR, Finland, Norway, Sweden, Switzerland, Ukraine, USA
	10-9: Belarus, Bulgaria, Chile, Czech Republic, Germany, Hungary, Iceland, Israel, Japan, Kazakhstan, Republic of Korea, Kuwait, Latvia, Lithuania, Malaysia, Malta, Republic of Moldova, Panama, Poland, Portugal, Romania, Slovakia, Slovenia, South Africa, Turkey, United Arab Emirates, United Kingdom	**15-9:** Belarus, Czech Republic, Germany, Hungary, Iceland, Israel, Japan, Kazakhstan, Kuwait, Lithuania, Malta, Poland, Portugal, Romania, Slovenia, Turkey, United Arab Emirates, United Kingdom
		15-12: Bulgaria, Chile, Republic of Korea, Latvia, Malaysia, Republic of Moldova, Panama, Slovakia, South Africa
	10-10: Thailand	**15-15:** Thailand
4-4: Australia, Denmark, Ireland, New Zealand	**10-7:** Australia, Denmark, Ireland, New Zealand	**15-7:** Australia, Denmark, Ireland
		15-14: New Zealand

Table 6--Proximity Matrix: Distances between cluster centers

Clusters	1	2	3	4	5	6	7	8	9	10	11	12	13
1		2.231	3.564	2.681	5.442	1.906	7.255	5.55	4.747	2.703	1.481	3.927	0.882
2	2.231		1.786	1.442	3.539	1.636	5.654	3.961	2.832	1.46	1.403	2.571	1.653
3	3.564	1.786		1.948	2.559	1.983	5.024	2.861	1.494	1.206	2.361	1.681	3.185
4	2.681	1.442	1.948		3.436	2.122	5.323	3.089	2.523	1.560	1.342	1.764	2.035
5	5.442	3.539	2.559	3.436		4.012	2.602	2.088	1.464	2.953	4.171	2.333	4.956
6	1.906	1.636	1.983	2.122	4.012		6.097	4.240	3.265	1.152	1.229	2.584	1.972
7	7.255	5.654	5.024	5.323	2.602	6.097		3.396	3.877	5.059	6.038	4.199	6.763
8	5.550	3.961	2.861	3.089	2.088	4.240	3.396		1.657	3.173	4.093	1.69	5.040
9	4.747	2.832	1.494	2.523	1.464	3.265	3.877	1.657		2.234	3.397	1.495	4.252
10	2.703	1.460	1.206	1.560	2.953	1.152	5.059	3.173	2.234		1.444	1.563	2.422
11	1.481	1.403	2.361	1.342	4.171	1.229	6.038	4.093	3.397	1.444		2.478	1.144
12	3.927	2.571	1.681	1.764	2.333	2.584	4.199	1.690	1.495	1.563	2.478		3.512
13	0.882	1.653	3.185	2.035	4.956	1.972	6.763	5.040	4.252	2.422	1.144	3.512	

Note: Thailand and New Zealand have been excluded.

Table 7--Centroids for the 12-cluster classification

Hierarchical method

	CALCAP	PROTCAP	PRODCAP	EXPTOIMP	NAGRPOP
h1	-1.313	-1.180	-0.589	-0.756	-1.424
h2	-0.746	-0.717	-0.471	-0.880	0.314
h3	-0.694	-0.874	-0.384	-0.049	-0.695
h4	-0.013	0.160	-0.178	-0.875	-0.876
h5	-0.157	-0.228	0.086	-0.252	0.321
h6	0.075	0.019	-0.368	0.611	-0.793
h7	0.706	0.399	-0.337	-0.345	0.739
h8	0.384	0.288	0.221	1.157	0.724
h9	1.175	1.295	0.319	0.531	0.918
h10	1.248	1.284	0.520	2.194	1.090
h11	1.332	1.502	1.771	0.412	1.055
h12	1.472	1.704	3.946	1.818	1.070

K-means method

	CALCAP	PROTCAP	PRODCAP	EXPTOIMP	NAGRPOP
k1	-1.299	-1.158	-0.596	-0.785	-1.448
k2	-0.808	-0.664	-0.403	-0.752	0.291
k3	-0.778	-0.967	-0.388	0.073	-0.797
k4	-0.107	-0.077	-0.190	-0.794	-0.851
k5	-0.065	-0.289	0.097	-0.186	0.419
k6	0.075	0.019	-0.368	0.611	-0.793
k7	0.679	0.499	-0.309	-0.396	0.684
k8	0.384	0.288	0.221	1.157	0.724
k9	1.188	1.343	0.334	0.499	0.901
k10	1.268	1.229	0.604	2.120	1.061
k11	1.332	1.502	1.771	0.412	1.055
k12	1.472	1.704	3.946	1.818	1.070

Table 7–Continued

Fuzzy method

	CALCAP	PROTCAP	PRODCAP	EXPTOIMP	NAGRPOP
fz1	-1.42	-1.2	-0.62	-0.89	-1.43
fz2	-0.76	-0.66	-0.4	-0.75	0.22
fz3	-1.03	-1.09	-0.47	-0.08	-1.25
fz4	-0.22	-0.25	-0.26	-0.71	-0.8
fz5	-0.07	-0.24	-0.08	-0.24	0.55
fz6	-0.14	-0.35	-0.28	0.54	-0.54
fz7	0.82	0.51	-0.2	-0.45	0.53
fz8	0.47	0.37	0.22	0.99	0.74
fz9	1.12	1.3	0.29	0.42	0.95
fz10	1.21	1.2	0.79	1.95	1.04
fz11	1.55	1.65	1.58	0.21	1.04
fz12	1.48	1.68	3.9	1.69	1.07

Source: Authors' calculations based on FAOSTAT (1999) and WDI (2000).

Table 8--Country Profile Summary

		LDC	NFIDC	Others
1. Food Insecure	**WTO members**	**Angola**, Bangladesh, Burkina Faso, Burundi, Central African Republic, Chad, Dem Republic of Congo, The Gambia, Guinea, Guinea-Bissau, Haiti, **Madagascar**, Malawi, **Mali**, Mozambique, Niger, Rwanda, Sierra Leone, United Rep of Tanzania, **Uganda**	Kenya	
	WTO observers	**Cambodia**[1], Ethiopia, **Nepal** [1], Yemen		
	Others	Afghanistan, Comoros, Eritrea, Liberia, Somalia		
2. Food Insecure	**WTO members**	Djibouti, Lesotho	**Botswana**, Cuba, **Dominican Republic**, Honduras, Peru	El Salvador, Georgia, **Mongolia**, Nicaragua
	WTO observers			Armenia, Azerbaijan
	Others			Tajikistan
3. Food Insecure	**WTO members**	**Solomon Islands**, Togo, Zambia	**Côte d'Ivoire**, **Sri Lanka**	**Bolivia**, Cameroon, Republic of Congo, **Ghana**, **Guatemala**, **India**, **Namibia**, **Papua New Guinea**, **Philippines**, Zimbabwe
	WTO observers	Laos[1]		**Viet Nam**
	Others			
4. Food Insecure	**WTO members**	**Benin**, Mauritania	**Pakistan**, Saint Lucia, Senegal	**Albania**, Grenada, Saint Kitts and Nevis, **Saint Vincent/Grenadines**
	WTO observers	Sudan[1], Vanuatu[1]		**Seychelles**
	Others	Kiribati		

Table 8--Continued

		LDC	NFIDC	Others
5. Food Neutral	**WTO members**		Jamaica, **Trinidad and Tobago**, Venezuela	Belize, Brazil, Colombia, Costa Rica, Croatia, **Ecuador**, Fiji Islands, Guyana, Kyrgyzstan, Nigeria, Paraguay, Suriname, Swaziland
	WTO observers			Macedonia (The Former Yug. Rep.), Uzbekistan
	Others			
6. Food Neutral	**WTO members**	Myanmar		Antigua and Barbuda, Gabon, Indonesia
	WTO observers			China
	Others			
7. Food Neutral	**WTO members**	**Maldives**	Barbados, Egypt, Mauritius, Morocco, Tunisia	Brunei Darussalam, **Dominica**, Estonia, Jordan, **Kuwait**, **Macau**, Mexico
	WTO observers	Cape Verde		Algeria, Lebanon, Russian Federation, Saudi Arabia
	Others			**Bahamas**, **Islamic Rep of Iran**, Libyan Arab Jamahiriya, Syrian Arab Republic
8. Food Neutral	**WTO members**			Bulgaria, Chile, Republic of Korea, Latvia, Malaysia, Panama, Slovakia, South Africa
	WTO observers			Republic of Moldova
	Others			
9. Food Secure	**WTO members**			**Czech Republic**, Germany, Iceland, Israel, Japan, Malta, Poland, Portugal, Romania, Slovenia, Turkey, United Arab Emirates, United Kingdom
	WTO observers			Belarus, Kazakhstan, Lithuania
	Others			

Table 8--Continued

		LDC	NFIDC	OTHERS
10. Food Secure	**WTO members**			Austria, China--Hong Kong SAR, Finland, **Hungary**, Norway, Sweden, Switzerland, United States of America
	WTO observers			Ukraine
	Others			
11. Food Secure	**WTO members**			Argentina, Belgium-Luxembourg, **Canada**, France, Greece, Italy, Netherlands, Spain, Uruguay
	WTO observers			
	Others			
12. Food Secure	**WTO members**			Australia, Denmark, Ireland
	WTO observers			
	Others			
Outliers	**WTO [1]**			New Zealand, Thailand

Notes: WTO members not included because of data unavailability: Bahrain, Cyprus, Liechtenstein, Oman, Qatar, and Singapore.
WTO observers not included because of data unavailability: Andorra, Bahamas, Bhutan (LDC), Bosnia and Herzegovina, Samoa (LDC), Chinese Taipei, and Tonga. Other LDCs not included because of data unavailability: Equatorial Guinea, Sao Tome Principe, and Tuvalu.
NFIDC: Net Food Importing Developing Countries.
The majority of countries have been classified in the same group by all three clustering methods; the countries in bold have been classified in the same group by two out the three clustering methods.
[1] Countries in the process of accession to the WTO.

Table 9--Final cluster means

	CALCAP (calories)	PROTCAP (grams)	PRODCAP (US$)	EXPTOIMP ratio	IMPEXPOT (percent)	NAGRPOP ratio
Cluster-1	1,982.9	48.6	81.8	4.9	20.4	0.23
Cluster-2	2,229.2	58.8	117.6	5.3	19.0	0.71
Cluster-3	2,244.6	52.6	120.3	14.1	7.1	0.41
Cluster-4	2,581.5	70.8	157.2	4.8	20.8	0.39
Cluster-5	2,602.3	66.5	210.4	11.3	8.8	0.75
Cluster-6	2,672.9	72.8	124.1	19.8	5.0	0.41
Cluster-7	2,976.1	82.7	135.1	9.1	11.0	0.82
Cluster-8	2,827.7	78.4	233.3	25.6	3.9	0.83
Cluster-9	3,231.3	100.1	254.2	18.6	5.4	0.88
Cluster-10	3,271.8	97.7	304.2	35.9	2.8	0.93
Cluster-11	3,303.7	103.3	520.6	17.7	5.7	0.93
Cluster-12	3,374.1	107.5	923.9	32.7	3.1	0.93

Source: Authors' calculations based on FAOSTAT (1999) and WDI (2000).

APPENDIX I—Clustering techniques: theory, formulas, and algorithms

1. INTRODUCTION

This study focuses on identifying a formal classification of countries according to their food security status. This can be done using a number of techniques generally grouped under the broad class of vector quantization and dimensionality reduction methods. Cluster analysis is an example of these methods. The objective is to find a mapping from an n-dimensional input (sample or universe) space R^n to some c-dimensional output space R^c, where **c** is number of clusters, n is number of objects to be classified, and
$1 \leq c \leq n$.

$$G(x): \quad R^n \longrightarrow R^c$$

The obviously uninteresting cases are c=1, which places all objects in the same cluster, and c = n, which allows each object to be its own cluster. The mapping G should act as a low-dimensional encoder of the original data, such that there exists an inverse mapping F(z) producing the decoded value of the original input $\boldsymbol{x}$. To implement this approach, one must specify a class of approximating functions

$$f(x,\boldsymbol{w}) = F(G(x))$$

parametized by a vector of parameters w to be estimated by minimizing a loss function.

Different methods can generate the reduction in data dimensionality. We present here the methods utilized in our analysis: hierarchical and nonhierarchical methods.

2. HIERARCHICAL: AGGLOMERATIVE TECHNIQUE (Romesburg 1987)

The hierarchical agglomerative technique follows a series of clustering steps, starting with a number of clusters equal to the number of objects to classify. In subsequent steps clusters are merged to yield the smallest increase in the value of a dissimilarity index computed following Ward's method.[46] One important constraint of the hierarchical method is that once objects have been merged together in a cluster, they cannot be unmerged.

The notation is as follows:
c, number of clusters (i).
n, number of objects to be classified (countries: k=1, 2…167).

[46] In SPSS, this index is referred to as the agglomeration coefficient.

m, number of attributes characterizing each object (food security indicators: j=1, 2, …5).
x_{kj}, value of the jth attribute of the kth object (i.e. consumption of calories per capita (jth) in Madagascar (kth)).
$\boldsymbol{n}_{ij}$, value of the ith cluster mean corresponding to the jth attribute. It is the mean average for an attribute across all the objects in a given cluster (i.e. average of food production per capita (jth) for cluster 12 (ith)).

2.1. Distance measure: within-cluster sum of squares

$$d_{ik}^2 = \sum_{j=1}^{m} (x_{kj} - n_{ij})^2$$

2.2. Dissimilarity index: Ward variance

$$\mathrm{E} = \sum_{i=1}^{c} \sum_{k=1}^{n} d_{ik}^2$$

E is computed as follows:

- First, the mean $\boldsymbol{n}_{ij}$ is computed for each cluster.
- Second, the distance d_{ik} between each object and its cluster mean is computed and squared.
- Finally, the squared distances are summed over all clusters to yield the dissimilarity index.

2.3. Algorithm

- Begin with a number of clusters equal to the number of objects to be classified: At the start c = n and the value of the dissimilarity index, E, is therefore 0.
- Step1: Compute the dissimilarity index corresponding to joining any two objects into one cluster. Select among all possibilities, $\binom{n}{2}$, the clustering schedule yielding the smallest increase in the value of the dissimilarity index.
- Repeat the process until all objects are merged into one single cluster.
- Comment: The numbers of clusters goes from the total universe (or sample) of objects being classified (167 in this case), to 1, when all objects are joined together. As clusters merge, the dissimilarity index increases. The evolution of this index can be utilized to define the final number of clusters to be considered.

3. **Nonhierarchical** (Ross 1995)

The nonhierarchical methods are a mapping of n-dimensional Euclidean space R^n into a finite subset $\boldsymbol{V_c}$ of R^n, where, as before, **c** is the number of clusters (), **n** is the number of objects (k) to be classified, and 1<c< *n*. Thus

$$Q: \quad R^n \longrightarrow V \qquad \text{Where } V = \{\boldsymbol{n}_1, \boldsymbol{n}_2, \ldots, \boldsymbol{n}_c\} \text{ with } \boldsymbol{n}_i \in R^n \quad \forall i$$

Here the partition is defined in advance. For the k-means method (a "crisp" method), the *i*th point quantizer in R^n is associated with a partition such that the regions defining it are non-overlapping and their union is the universe of discourse (in our case a subset of R^n). In the case of fuzzy clustering analysis, the regions are allowed to overlap so that sample points can belong to more than one cluster. The methods aim at minimizing a well-defined approximation (quantization) error when the number of clusters or prototypes *i* is fixed *a priori*.

3.1. K-means[47]

The central task is to select, among all the possible *c*-partitions for *n* data points, the most reasonable *c*-partition among all the possible combinations for the partition space (given $c=12$ and $n=167$). To this end, an objective function (or classification criterion) is introduced to cluster the data. The objective function that is commonly used is the within-class sum of squared errors using a Euclidean norm to represent the distance.

3.1.1. Distance measure

Euclidean distance between the *i*th cluster center (a vector of m elements) and the *k*th data point (a vector of *m* elements)

$$d_{ik} = \left[\sum_{j=1}^{m} (x_{kj} - \boldsymbol{n}_{ij})^2 \right]^{\frac{1}{2}}$$

The cluster center measure is the arithmetic means of the feature values of all data points in this center

[47] This method is also referred as Hard c-Means (HCM) in Ross (1995)

$$\nu_{ij} = \frac{\sum_{k=1}^{n} c_{ij} \cdot x_{kj}}{\sum_{k=1}^{n} c_{ij}}$$

Where c_{ik} (sometimes called the characteristic function) takes the value 1 if the kth data point is in the ith cluster, 0 otherwise.
All the c_{ik} define a matrix **U** with c rows (the number of clusters) and n columns (the number of objects to be classified). This is the partition matrix, which indicates the way objects are allocated to the different clusters. For example, if there are 2 clusters and 4 objects

$$\mathrm{U} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 1 & 1 \end{bmatrix}$$

The partition matrix U indicates that object 1 is in cluster 1, while objects 2, 3, and 4 are in cluster 2. The number of possible partition matrices is

$$h_{M_c} = \left(\frac{1}{c!}\right)\left[\sum_{i=1}^{c}\binom{c}{i}(-1)^{c-i} \cdot i^{n}\right]$$

The objective is to find an optimum partition U*.

3.1.2. Objective function

$$J(\mathrm{U},\nu) = \sum_{k=1}^{n}\sum_{i=1}^{c} c_{ik}(d_{ik})^2$$

An optimum partition U*, corresponding to cluster centers v*, produces the minimum value for the J function.

$$J(\mathrm{U}^*,\nu^*) = \min J(\mathrm{U},\nu)$$

For U* belonging to the set of all possible U partitions.

3.1.3. Algorithm

a) Begin with the predetermined number of clusters and centroids.[48] Calculate the distance d_{ik} for every object k.
b) In this initial calculation v_{ij} is given and not calculated according to the formula above; let us call v^0, the c by k matrix of initial centers. Allocate objects to the cluster for which d_{ik} is smaller. This defines a c times n elements c_{ik} of membership value (0 or 1) for each data point in a particular cluster, and an initial partition matrix U^0.
c) Calculate $J(U^0, v^0)$, and call it J^0.
d) Calculate the new cluster centers v_{ij} given by the partition U^0, and call it v^1.
e) Recalculate the distances from each data points to each cluster center and place the data point in the cluster to which it has the smallest distance. This defines a new partition U^1.
f) Calculate $J^1(U^1, v^1)$.
g) Repeat steps c), d), and e) until the changes in the J^{h+1} compared to J^h are below the tolerance level. The partition matrix corresponding to J^h is U*.

3.2.Fuzzy

Using the same notation as in the previous section, one can develop a framework where degrees membership to a fuzzy cluster are assigned to the various data points, thus extending the crisp classification into a fuzzy classification notion. First we define a family of fuzzy sets $\{A_i, i = 1,2,\ldots, c\}$ as a fuzzy c-partition on a universe of data points, X. It is useful to introduce the notation for the membership value of the *k*th data point has in the *i*th cluster:

$$m_{ik} = m_{A_i}(x_k) \in [0,1]$$

With the restriction that the sum of all membership values for a single data point in all the classes has to be unity and also there must be no empty clusters, which requires:

$$\sum_{i=1}^{c} m_{ik} = 1 \qquad \text{For all } k = 1,2\ldots n$$

$$0 < \sum_{k=1}^{n} m_{ik} < n \qquad \text{For all } i = 1,2\ldots c$$

We can thus define a family of fuzzy partition matrices, M_{fc}, for the classification involving *c* clusters and *n* data points,

[48] When the centroids are not provided, the algorithm picks randomly a number of objects equal to the number of clusters and starts the iterations from that point.

$$M_{fc} = \left\{ Uf \;\middle|\; m_{ik} \in [0,1] \;;\; \sum_{i=1}^{c} m_{ik} = 1 \;;\; 0 < \sum_{k=1}^{n} m_{ik} < n \right\}$$

Where any $Uf \in M_{fc}$ is a fuzzy *c*-partition. It is a c by n matrix as U in the k-means method, but instead of having only 1 and 0 elements, now the value of the cells in the matrix *Uf* is between 1 and 0. The columns must add up to one (i.e. the sum of the membership degree in each cluster for every object classified is equal to one).

As before, the objective is to find an optimal partition *Uf*.

3.2.1. *Distance measure*

$$d_{ik} = \left[\sum_{j=1}^{m} (x_{kj} - n_{ij})^2 \right]^{\frac{1}{2}}$$

Although the formula appears similar to the k-means, the definition of distance in the fuzzy method differs on two accounts:

- First, a new parameter $m' \in [1,\infty]$ is introduced, called a weighting parameter to control the amount of fuzziness in the classification process.[49]
- Second, centroids for each cluster now have to consider the fact that objects belong in different degrees to different clusters. While in the k-means the centroids were a direct average, in the fuzzy they have to be weighted by the degree of membership. Therefore, the *j*th coordinate of the *i*th cluster center is calculated as

$$v_{ij} = \frac{\sum_{k=1}^{n} m_{ik}^{m'} \cdot x_{kj}}{\sum_{k=1}^{n} m_{ik}^{m'}}$$

3.2.2. Objective function

$$J_m(Uf, \boldsymbol{n}) = \sum_{k=1}^{n} \sum_{i=1}^{c} (m_{ik})^{m'} (d_{ik})^2$$

[49] For $m' = 1$, the FCM algorithm approaches a hard *c*-means algorithm (only 0's and 1's emerge as solutions). Conversely, for $m' \to \infty$ the value of the objective $J_m \to 0$ and the fuzzier are the membership assignments of the clustering. The bulk of the literature reports values in the range 1.25 to 2. For this analysis we adopted a value of 1.5 after having performed sensitivity analysis in the above range.

An optimum partition *Uf**, corresponding to cluster centers v*, produces the minimum value for the J_m function

$$J_m(Uf^*, v^*) = \min J_m(Uf, v)$$

3.2.3. Algorithm

a) Fix c $(2 \le c < n)$ and select a value for parameter m′. Initialize the partition matrix, U^0. Each step in this algorithm will be labeled r, where r = 0, 1, 2, …

b) Calculate the c centers $\{v_i^{(r)}\}$ for each step.

c) Update the partition matrix for the rth step, $U^{(r)}$ as follows

$$m_{ik}^{(r+1)} = \left[\sum_{j=1}^{c} \left(\frac{d_{ik}^{(r)}}{d_{jk}^{(r)}} \right)^{2/(m'-1)} \right]^{-1} \quad \text{for } I_k = \varnothing$$

$$m_{ik}^{(r+1)} = 0 \qquad \text{for all classes } i \text{ where } i \in \tilde{I}_k$$

$$I_k = \{ i \mid 2 \le c < n;\ d_{ik}^{(r)} = 0 \} \quad \text{and}$$

$$\text{Where } \tilde{I}_k = \{1,2,...,c\} - I_k \quad \text{and}$$

$$\sum_{i \in I_k} m_{ik}^{(r+1)} = 1$$

d) If $\left\| \underset{\sim}{U}^{(r+1)} - \underset{\sim}{U}^{(r+1)} \right\| \le \varepsilon_L$, stop; otherwise set r = r+1 and return to step b).

APPENDIX II--Table of countries and indicator values

	CALCAP	PROTCAP	PRODCAP	EXPTOIMP	NAGRPOP
Afghanistan	1,706	47.8	75.0	1.8	0.3
Albania	2,924	97.1	177.7	1.2	0.5
Algeria	2,972	81.6	90.3	4.7	0.8
Angola	1,857	38.3	60.5	13.0	0.3
Antigua and Barbuda	2,379	79.3	86.1	15.4	0.4
Argentina	3,111	96.7	586.3	25.7	0.9
Armenia	2,095	59.8	111.1	2.5	0.9
Australia	3,222	109.1	850.4	48.4	1.0
Austria	3,515	104.4	389.5	33.8	0.9
Azerbaijan	2,181	64.5	113.3	3.9	0.7
Bahamas	2,514	77.6	66.2	11.3	1.0
Bangladesh	2,047	43.9	67.1	5.1	0.4
Barbados	3,121	87.6	115.6	9.9	1.0
Belarus	3,140	92.1	301.6	23.8	0.8
Belgium-Luxembourg	3,599	103.7	448.4	15.6	1.0
Belize	2,828	64.1	384.2	8.1	0.7
Benin	2,435	58.4	120.8	5.0	0.4
Bolivia	2,187	57.1	192.6	10.1	0.6
Botswana	2,208	70.6	112.7	8.5	0.6
Brazil	2,879	72.5	299.1	13.7	0.8
Brunei Darussalam	2,846	82.8	45.9	15.7	1.0
Bulgaria	2,819	83.6	292.0	17.1	0.9
Burkina Faso	2,276	67.7	81.9	3.6	0.1
Burundi	1,719	53.1	106.9	2.8	0.1
Cambodia	2,017	46.7	95.7	9.4	0.3
Cameroon	2,146	49.8	105.2	17.4	0.4
Canada	3,083	97.1	545.2	30.4	1.0
Cape Verde	3,080	71.2	57.1	1.5	0.7
Central African Republic	1,961	42.7	124.9	7.4	0.2
Chad	1,892	54.5	88.5	7.3	0.2
Chile	2,761	77.5	268.9	23.2	0.8
China	2,782	72.6	176.6	15.9	0.3
China, Hong Kong SAR	3,202	100.3	5.4	34.6	1.0
Colombia	2,542	60.8	165.7	12.3	0.8
Comoros	1,835	42.8	60.4	2.0	0.3
Congo, Dem. Rep. of	1,885	30.7	64.2	7.1	0.4
Congo, Republic of	2,131	44.4	61.7	12.0	0.6
Costa Rica	2,683	67.7	292.2	13.4	0.8
Côte d'Ivoire	2,529	50.0	153.8	10.7	0.5
Croatia	2,414	63.2	188.6	16.3	0.9
Cuba	2,424	52.0	139.1	2.7	0.8
Czech Republic	3,150	93.6	336.5	26.3	0.9
Denmark	3,332	103.8	913.9	27.3	1.0
Djibouti	2,056	44.2	50.9	3.3	0.8
Dominica	2,991	83.2	311.3	5.5	0.7
Dominican Republic	2,279	49.5	143.1	14.8	0.8
Ecuador	2,638	55.3	223.3	21.8	0.7
Egypt	3,254	87.6	145.0	5.3	0.6

APPENDIX II --Continued

	CALCAP	PROTCAP	PRODCAP	EXPTOIMP	NAGRPOP
El Salvador	2,544	62.2	92.3	6.4	0.6
Eritrea	1,628	52.0	39.8	3.4	0.2
Estonia	2,721	96.3	254.5	10.6	0.9
Ethiopia	1,762	51.4	71.0	3.6	0.2
Fiji Islands	2,825	73.8	211.3	10.5	0.6
Finland	3,063	97.4	315.0	35.4	0.9
France	3,524	113.2	543.6	18.0	1.0
Gabon	2,508	74.6	109.5	23.3	0.6
Gambia	2,287	48.7	60.3	2.6	0.2
Georgia	2,323	64.8	142.4	3.4	0.8
Germany	3,371	95.5	307.4	16.7	1.0
Ghana	2,572	49.4	115.4	7.7	0.4
Greece	3,605	113.9	493.3	6.4	0.9
Grenada	2,715	67.7	154.6	3.9	0.4
Guatemala	2,354	60.3	129.8	8.1	0.5
Guinea	2,245	47.7	82.1	4.1	0.2
Guinea-Bissau	2,440	48.8	113.3	1.1	0.2
Guyana	2,458	66.9	226.1	12.2	0.8
Haiti	1,803	41.7	67.9	0.8	0.4
Honduras	2,351	55.7	128.7	7.2	0.6
Hungary	3,355	88.8	428.4	29.6	0.9
Iceland	3,076	115.7	238.2	21.4	0.9
India	2,400	57.4	112.5	22.1	0.4
Indonesia	2,859	66.4	112.7	20.5	0.5
Iran, Islamic Rep. of	2,842	75.3	191.1	7.9	0.7
Ireland	3,568	109.5	1007.4	22.3	0.9
Israel	3,227	107.4	232.7	18.9	1.0
Italy	3,484	108.0	375.8	16.0	0.9
Jamaica	2,634	66.5	148.3	8.4	0.8
Japan	2,913	96.0	114.3	17.6	1.0
Jordan	2,843	73.7	117.3	4.8	0.9
Kazakhstan	3,177	98.4	278.0	24.0	0.8
Kenya	1,933	51.1	89.3	8.7	0.2
Kiribati	2,727	68.6	163.1	2.4	0.4
Korea, Rep. of	3,133	85.7	145.6	28.7	0.9
Kuwait	2,996	93.8	32.4	13.7	1.0
Kyrgyzstan	2,307	77.4	184.2	7.2	0.7
Laos	2,041	50.6	98.3	16.9	0.2
Latvia	2,815	90.1	245.6	20.8	0.9
Lebanon	3,263	83.2	288.7	1.3	1.0
Lesotho	2,216	62.3	53.1	1.5	0.6
Liberia	2,005	36.8	49.1	5.2	0.3
Libyan Arab Jamahiriya	3,251	78.8	90.0	8.9	0.9
Lithuania	3,005	94.7	321.6	18.5	0.8

APPENDIX II --Continued

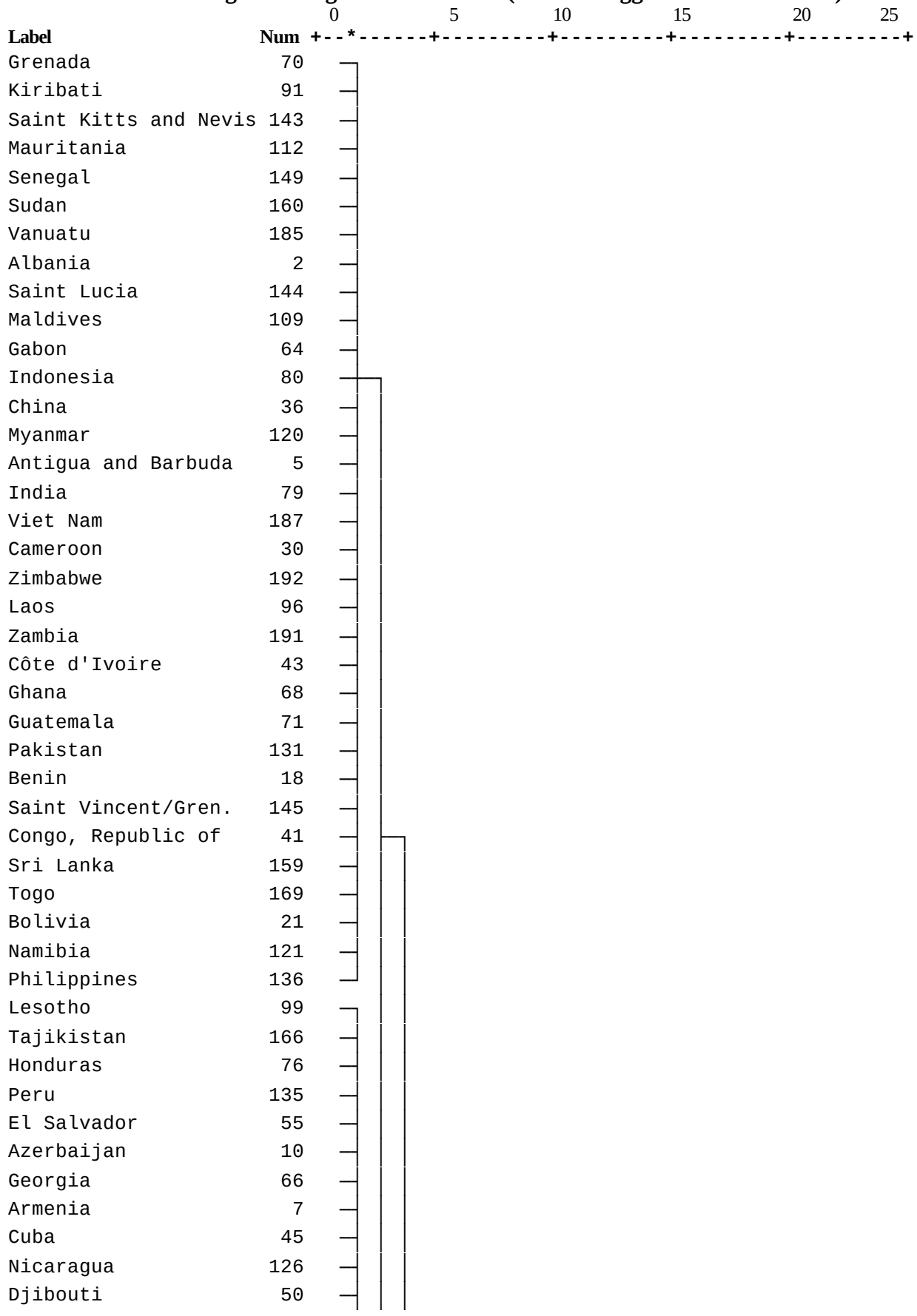
	CALCAP	PROTCAP	PRODCAP	EXPTOIMP	NAGRPOP
Macau	2,788	75.0	4.3	15.0	1.0
Macedonia, The Fmr. Yug. Rep.	2,582	71.5	226.2	3.3	0.8
Madagascar	2,027	47.4	120.9	11.0	0.2
Malawi	2,034	54.2	67.3	3.8	0.2
Malaysia	2,891	73.7	194.9	27.9	0.8
Maldives	2,498	95.3	42.8	1.2	0.7
Mali	2,184	63.9	110.8	6.7	0.2
Malta	3,340	105.4	126.7	14.9	1.0
Mauritania	2,598	76.8	117.2	3.7	0.5
Mauritius	2,925	72.2	126.5	9.7	0.9
Mexico	3,125	82.7	195.1	16.3	0.7
Moldova, Republic of	2,709	72.9	305.6	23.5	0.7
Mongolia	1,859	68.3	233.7	7.5	0.7
Morocco	3,140	83.9	144.5	8.1	0.6
Mozambique	1,727	33.1	49.5	2.2	0.2
Myanmar	2,837	71.3	135.5	24.0	0.3
Namibia	2,138	59.1	237.6	16.5	0.5
Nepal	2,311	59.7	104.1	9.4	0.1
Netherlands	3,243	103.4	642.0	13.2	1.0
New Zealand	3,371	109.5	1589.1	26.1	0.9
Nicaragua	2,180	51.0	114.2	2.8	0.8
Niger	2,029	56.2	89.1	4.0	0.1
Nigeria	2,747	61.4	133.4	12.6	0.6
Norway	3,308	102.5	252.9	46.4	0.9
Pakistan	2,452	60.9	120.0	7.1	0.5
Panama	2,447	64.8	194.0	38.3	0.8
Papua New Guinea	2,229	47.0	140.3	12.7	0.2
Paraguay	2,538	75.7	374.3	11.4	0.6
Peru	2,300	58.0	120.6	6.1	0.7
Philippines	2,367	56.4	131.3	16.6	0.6
Poland	3,343	99.0	317.6	16.0	0.8
Portugal	3,633	111.6	270.6	11.7	0.8
Romania	3,209	96.3	280.8	14.3	0.8
Russian Federation	2,912	88.4	203.7	11.6	0.9
Rwanda	2,038	47.8	89.1	0.9	0.1
Saint Kitts and Nevis	2,667	68.4	139.7	6.6	0.3
Saint Lucia	2,731	84.1	215.3	6.0	0.4
Saint Vincent/Grenadines	2,454	64.9	168.8	4.6	0.5
Saudi Arabia	2,841	78.0	66.6	15.4	0.9
Senegal	2,380	65.3	102.0	3.6	0.3
Seychelles	2,430	75.0	82.3	7.7	0.6
Sierra Leone	2,016	43.5	58.4	1.4	0.4
Slovakia	2,949	80.7	282.3	23.2	0.9
Slovenia	3,063	99.0	291.0	18.4	1.0
Solomon Islands	2,108	50.3	134.8	13.3	0.3
Somalia	1,575	52.7	114.9	1.8	0.3
South Africa	2,926	76.2	170.6	28.1	0.8

APPENDIX II --Continued

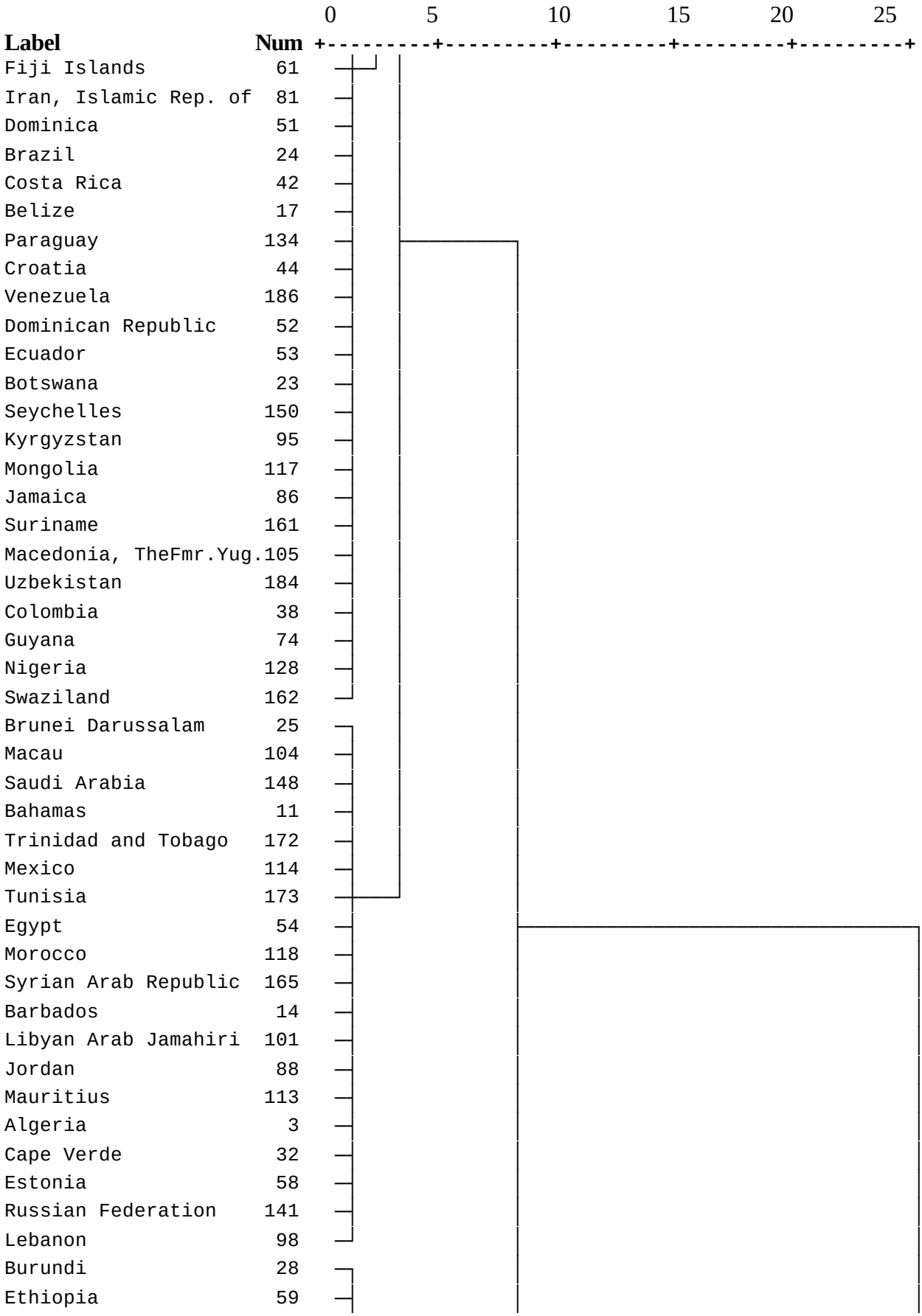
	CALCAP	PROTCAP	PRODCAP	EXPTOIMP	NAGRPOP
Spain	3,296	106.8	446.9	15.9	0.9
Sri Lanka	2,264	50.4	73.0	8.8	0.5
Sudan	2,339	73.8	149.3	2.9	0.4
Suriname	2,668	66.0	177.3	7.0	0.8
Swaziland	2,494	60.2	178.7	10.6	0.6
Sweden	3,164	100.9	275.0	32.9	1.0
Switzerland	3,262	91.1	282.6	31.9	0.9
Syrian Arab Republic	3,297	85.1	201.7	7.8	0.7
Tajikistan	2,195	60.1	90.7	3.1	0.6
Tanzania, United Rep of	2,013	48.8	91.9	5.6	0.2
Thailand	2,331	53.5	191.9	64.4	0.5
Togo	2,223	53.1	84.3	9.4	0.4
Trinidad and Tobago	2,651	60.7	72.3	11.6	0.9
Tunisia	3,256	86.1	182.3	13.0	0.7
Turkey	3,522	100.5	303.0	22.1	0.7
Uganda	2,206	50.1	118.8	10.4	0.2
Ukraine	2,931	82.6	284.9	40.6	0.8
United Arab Emirates	3,317	102.6	103.3	16.5	0.9
United Kingdom	3,217	93.2	243.9	16.7	1.0
United States of America	3,647	111.4	504.5	38.1	1.0
Uruguay	2,790	87.0	604.6	17.9	0.9
Uzbekistan	2,556	73.4	159.8	3.3	0.7
Vanuatu	2,708	60.0	332.6	8.1	0.2
Venezuela	2,399	59.9	142.1	19.9	0.9
Viet Nam	2,427	56.2	124.0	18.7	0.3
Yemen	2,030	55.4	42.9	1.5	0.5
Zambia	1,964	51.3	67.3	19.8	0.3
Zimbabwe	2,078	50.6	84.0	18.3	0.4

Source: FAOSTAT (1999) and WDI (2000).

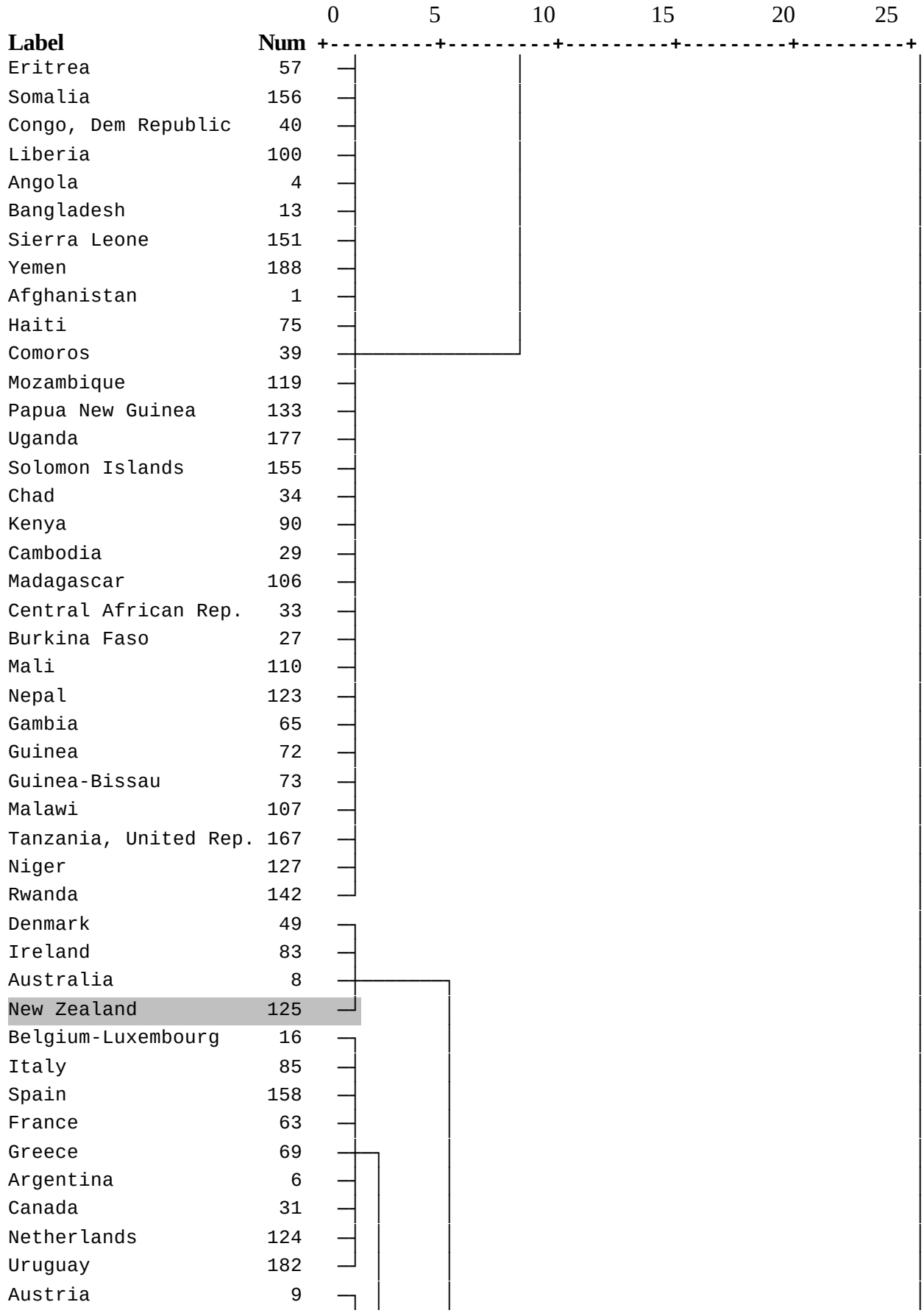
APPENDIX III--Dendrogram using Ward's Method (Rescaled agglomerative distance)



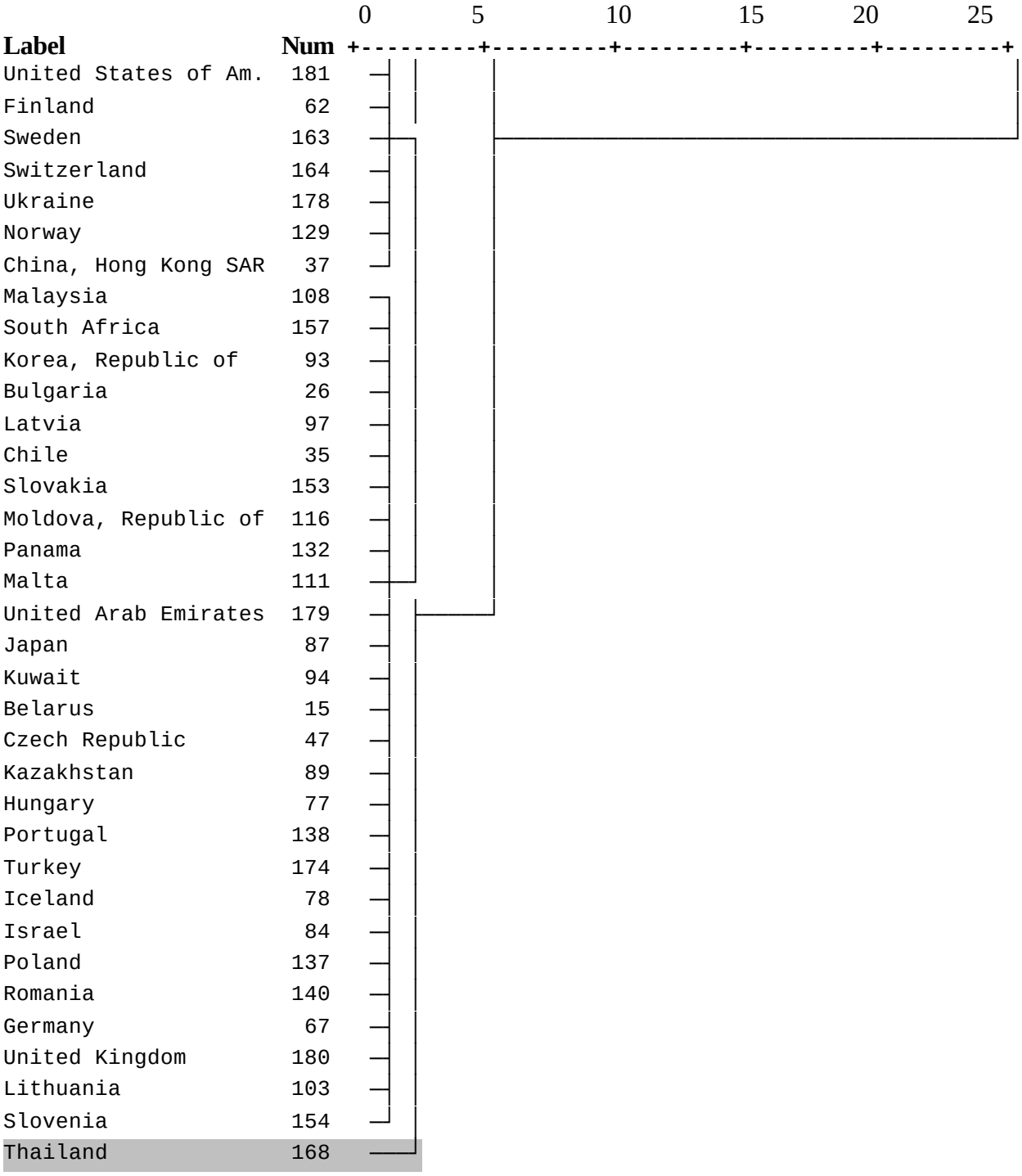
APPENDIX III--Continued



APPENDIX III--Continued



APPENDIX III--Continued



APPENDIX IV--Degree of membership in fuzzy clustering by country

Countries	fz1	fz2	fz3	fz4	fz5	fz6	fz7	fz8	fz9	fz10	fz11	fz12
Afghanistan	**0.9512**	0.0306	0.0075	0.0060	0.0014	0.0020	0.0005	0.0003	0.0002	0.0001	0.0001	0.0000
Albania	0.0151	0.0195	0.0503	0.1940	0.0946	0.0545	**0.4190**	0.0387	0.0737	0.0106	0.0277	0.0024
Algeria	0.0007	0.0010	0.0066	0.0085	0.0301	0.0042	**0.9362**	0.0047	0.0063	0.0006	0.0011	0.0001
Angola	0.2885	**0.6626**	0.0140	0.0134	0.0045	0.0127	0.0015	0.0014	0.0006	0.0004	0.0003	0.0001
Antigua and Barbuda	0.0237	0.0824	0.0428	0.2581	0.0455	**0.4928**	0.0229	0.0184	0.0075	0.0030	0.0023	0.0005
Argentina	0.0018	0.0030	0.0052	0.0060	0.0146	0.0105	0.0196	0.0701	0.0936	0.2343	**0.4495**	0.0919
Armenia	0.0077	0.0082	**0.8805**	0.0183	0.0613	0.0085	0.0082	0.0038	0.0019	0.0006	0.0007	0.0002
Australia	0.0020	0.0030	0.0036	0.0040	0.0065	0.0066	0.0071	0.0179	0.0177	0.0680	0.0352	**0.8285**
Austria	0.0002	0.0003	0.0005	0.0006	0.0014	0.0012	0.0025	0.0102	0.0207	**0.9371**	0.0218	0.0035
Azerbaijan	0.0009	0.0011	**0.9826**	0.0045	0.0082	0.0012	0.0008	0.0003	0.0002	0.0000	0.0001	0.0000
Bahamas	0.0049	0.0082	0.0999	0.0267	**0.5587**	0.0354	0.1560	0.0678	0.0305	0.0060	0.0052	0.0007
Bangladesh	**0.6648**	0.2422	0.0454	0.0282	0.0062	0.0094	0.0017	0.0011	0.0005	0.0002	0.0002	0.0001
Barbados	0.0008	0.0012	0.0058	0.0051	0.0334	0.0057	**0.8055**	0.0292	0.1018	0.0043	0.0069	0.0004
Belarus	0.0004	0.0008	0.0017	0.0021	0.0080	0.0052	0.0188	0.2847	**0.5221**	0.1266	0.0285	0.0011
Belgium-Luxembourg	0.0001	0.0001	0.0002	0.0002	0.0005	0.0003	0.0016	0.0017	0.0132	0.0033	**0.9781**	0.0007
Belize	0.0123	0.0223	0.0885	0.1122	**0.3822**	0.0842	0.1495	0.0768	0.0370	0.0108	0.0213	0.0029
Benin	0.0147	0.0290	0.0420	**0.8892**	0.0086	0.0126	0.0022	0.0009	0.0004	0.0001	0.0002	0.0000
Bolivia	0.0297	0.1016	**0.5582**	0.1316	0.0812	0.0801	0.0076	0.0061	0.0019	0.0008	0.0008	0.0002
Botswana	0.0215	0.0472	**0.4096**	0.3368	0.0856	0.0750	0.0132	0.0066	0.0027	0.0009	0.0009	0.0002
Brazil	0.0023	0.0047	0.0226	0.0202	**0.3998**	0.0368	0.2072	0.2290	0.0548	0.0092	0.0124	0.0010
Brunei Darussalam	0.0036	0.0063	0.0320	0.0186	0.1899	0.0352	**0.3338**	0.2171	0.1329	0.0180	0.0116	0.0011
Bulgaria	0.0010	0.0019	0.0076	0.0063	0.0747	0.0134	0.0847	**0.6274**	0.1510	0.0154	0.0157	0.0009
Burkina Faso	**0.3277**	0.2321	0.0383	0.3133	0.0176	0.0470	0.0109	0.0056	0.0035	0.0016	0.0018	0.0005
Burundi	**0.9044**	0.0660	0.0072	0.0129	0.0023	0.0045	0.0010	0.0007	0.0004	0.0002	0.0002	0.0001
Cambodia	0.1507	**0.8410**	0.0023	0.0033	0.0006	0.0017	0.0002	0.0001	0.0001	0.0000	0.0000	0.0000
Cameroon	0.0347	**0.7751**	0.0333	0.0299	0.0138	0.1044	0.0029	0.0037	0.0011	0.0006	0.0004	0.0001
Canada	0.0014	0.0023	0.0040	0.0042	0.0111	0.0083	0.0139	0.0697	0.0756	**0.5734**	0.1752	0.0609
Cape Verde	0.0068	0.0093	0.0615	0.0715	0.1505	0.0279	**0.6203**	0.0204	0.0218	0.0036	0.0058	0.0006
Central African Republic	**0.7918**	0.1957	0.0036	0.0050	0.0009	0.0022	0.0003	0.0002	0.0001	0.0001	0.0001	0.0000
Chad	**0.8460**	0.1398	0.0034	0.0067	0.0009	0.0024	0.0003	0.0002	0.0001	0.0001	0.0001	0.0000
Chile	0.0001	0.0001	0.0003	0.0003	0.0027	0.0014	0.0014	**0.9899**	0.0022	0.0011	0.0003	0.0000
China	0.0114	0.0403	0.0203	0.2102	0.0369	**0.6164**	0.0276	0.0212	0.0086	0.0036	0.0029	0.0006
China, Hong Kong SAR	0.0047	0.0083	0.0141	0.0140	0.0363	0.0352	0.0605	0.2171	0.2121	**0.3535**	0.0376	0.0066
Colombia	0.0005	0.0013	0.0275	0.0047	**0.9479**	0.0095	0.0042	0.0032	0.0007	0.0002	0.0002	0.0000
Comoros	**0.9899**	0.0074	0.0010	0.0010	0.0002	0.0004	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000

APPENDIX IV--Continued

Countries	fz1	fz2	fz3	fz4	fz5	fz6	fz7	fz8	fz9	fz10	fz11	fz12
Congo, Dem Rep. of	**0.6339**	0.2758	0.0357	0.0234	0.0088	0.0148	0.0028	0.0023	0.0010	0.0006	0.0005	0.0002
Congo, Republic of	0.1022	**0.3892**	0.2962	0.0666	0.0470	0.0790	0.0079	0.0071	0.0024	0.0012	0.0009	0.0003
Costa Rica	0.0022	0.0048	0.0300	0.0205	**0.7619**	0.0409	0.0523	0.0681	0.0122	0.0032	0.0035	0.0004
Côte d'Ivoire	0.0389	0.2101	0.1381	**0.3087**	0.0663	0.2130	0.0119	0.0079	0.0026	0.0012	0.0010	0.0003
Croatia	0.0036	0.0081	0.0805	0.0161	**0.7394**	0.0481	0.0260	0.0632	0.0087	0.0035	0.0023	0.0004
Cuba	0.0066	0.0084	**0.8090**	0.0252	0.1195	0.0110	0.0122	0.0044	0.0021	0.0007	0.0008	0.0002
Czech Republic	0.0004	0.0007	0.0015	0.0016	0.0060	0.0040	0.0112	0.1510	0.2254	**0.5584**	0.0380	0.0018
Denmark	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001	0.0001	0.0002	0.0003	0.0008	**0.9983**
Djibouti	0.0404	0.0392	**0.7569**	0.0395	0.0721	0.0235	0.0133	0.0080	0.0036	0.0016	0.0016	0.0004
Dominica	0.0036	0.0057	0.0239	0.0452	0.1216	0.0246	**0.6313**	0.0420	0.0677	0.0069	0.0261	0.0014
Dominican Republic	0.0173	0.0455	**0.4310**	0.0431	0.3006	0.1040	0.0198	0.0270	0.0060	0.0030	0.0021	0.0005
Ecuador	0.0080	0.0278	0.0513	0.0365	0.2170	**0.4526**	0.0312	0.1478	0.0136	0.0089	0.0042	0.0010
Egypt	0.0025	0.0038	0.0110	0.0306	0.0359	0.0164	**0.8251**	0.0184	0.0423	0.0041	0.0094	0.0006
El Salvador	0.0059	0.0114	**0.5807**	0.1500	0.1959	0.0312	0.0177	0.0043	0.0018	0.0005	0.0005	0.0001
Eritrea	**0.9263**	0.0503	0.0075	0.0085	0.0019	0.0034	0.0008	0.0006	0.0003	0.0002	0.0002	0.0001
Estonia	0.0027	0.0043	0.0203	0.0191	0.1122	0.0202	**0.3460**	0.1126	0.3075	0.0154	0.0381	0.0017
Ethiopia	**0.9731**	0.0203	0.0018	0.0028	0.0005	0.0010	0.0002	0.0001	0.0001	0.0000	0.0000	0.0000
Fiji Islands	0.0047	0.0108	0.0413	0.1777	**0.3326**	0.1347	0.2348	0.0389	0.0169	0.0032	0.0041	0.0004
Finland	0.0000	0.0001	0.0001	0.0001	0.0003	0.0003	0.0004	0.0047	0.0029	**0.9899**	0.0010	0.0002
France	0.0001	0.0001	0.0002	0.0003	0.0006	0.0004	0.0014	0.0019	0.0087	0.0055	**0.9776**	0.0032
Gabon	0.0035	0.0127	0.0142	0.0205	0.0406	**0.8275**	0.0141	0.0542	0.0071	0.0038	0.0015	0.0003
Gambia	**0.7156**	0.1815	0.0179	0.0641	0.0051	0.0110	0.0023	0.0012	0.0007	0.0003	0.0003	0.0001
Georgia	0.0019	0.0025	**0.8948**	0.0132	0.0752	0.0041	0.0054	0.0016	0.0008	0.0002	0.0003	0.0000
Germany	0.0002	0.0003	0.0008	0.0009	0.0034	0.0013	0.0157	0.0177	**0.8815**	0.0128	0.0648	0.0006
Ghana	0.0570	0.1885	0.1283	**0.4603**	0.0457	0.0984	0.0117	0.0057	0.0023	0.0010	0.0010	0.0002
Greece	0.0010	0.0014	0.0029	0.0040	0.0068	0.0037	0.0210	0.0113	0.0600	0.0134	**0.8663**	0.0083
Grenada	0.0028	0.0047	0.0067	**0.9676**	0.0053	0.0076	0.0035	0.0008	0.0005	0.0002	0.0002	0.0000
Guatemala	0.0182	0.0633	0.1544	**0.6822**	0.0268	0.0472	0.0043	0.0021	0.0008	0.0003	0.0003	0.0001
Guinea	**0.7281**	0.2072	0.0107	0.0382	0.0035	0.0087	0.0016	0.0009	0.0005	0.0003	0.0003	0.0001
Guinea-Bissau	**0.4606**	0.2294	0.0401	0.2102	0.0147	0.0293	0.0075	0.0036	0.0021	0.0010	0.0011	0.0003
Guyana	0.0005	0.0012	0.0201	0.0044	**0.9528**	0.0072	0.0059	0.0058	0.0012	0.0003	0.0003	0.0001
Haiti	**0.9245**	0.0440	0.0142	0.0094	0.0025	0.0032	0.0009	0.0006	0.0003	0.0002	0.0002	0.0001
Honduras	0.0039	0.0088	**0.9179**	0.0332	0.0236	0.0092	0.0019	0.0009	0.0003	0.0001	0.0001	0.0000
Hungary	0.0005	0.0010	0.0016	0.0019	0.0052	0.0045	0.0083	0.0579	0.0562	**0.8037**	0.0531	0.0061
Iceland	0.0008	0.0013	0.0028	0.0034	0.0089	0.0055	0.0265	0.0484	**0.7545**	0.0756	0.0699	0.0024
India	0.0063	0.0564	0.0113	0.0184	0.0124	**0.8830**	0.0032	0.0061	0.0013	0.0009	0.0004	0.0001
Indonesia	0.0024	0.0087	0.0098	0.0223	0.0360	**0.8612**	0.0181	0.0322	0.0055	0.0024	0.0012	0.0002

APPENDIX IV--Continued

Countries	fz1	fz2	fz3	fz4	fz5	fz6	fz7	fz8	fz9	fz10	fz11	fz12
Iran, Islamic Rep. of	0.0013	0.0024	0.0194	0.0286	0.3503	0.0169	**0.5543**	0.0146	0.0090	0.0012	0.0018	0.0002
Ireland	0.0004	0.0006	0.0008	0.0010	0.0015	0.0012	0.0019	0.0028	0.0040	0.0057	0.0177	**0.9623**
Israel	0.0001	0.0002	0.0004	0.0004	0.0015	0.0007	0.0060	0.0082	**0.9605**	0.0085	0.0133	0.0003
Italy	0.0002	0.0002	0.0005	0.0007	0.0016	0.0008	0.0061	0.0058	0.1122	0.0105	**0.8603**	0.0011
Jamaica	0.0001	0.0002	0.0073	0.0017	**0.9849**	0.0013	0.0035	0.0007	0.0002	0.0001	0.0001	0.0000
Japan	0.0014	0.0024	0.0084	0.0074	0.0426	0.0138	0.1590	0.1867	**0.5387**	0.0233	0.0153	0.0009
Jordan	0.0021	0.0032	0.0422	0.0203	0.3320	0.0123	**0.5524**	0.0165	0.0139	0.0019	0.0029	0.0003
Kazakhstan	0.0004	0.0008	0.0016	0.0023	0.0067	0.0054	0.0190	0.1226	**0.6862**	0.1223	0.0314	0.0012
Kenya	**0.6199**	0.3679	0.0030	0.0054	0.0008	0.0023	0.0003	0.0002	0.0001	0.0001	0.0000	0.0000
Kiribati	0.0052	0.0076	0.0120	**0.9441**	0.0095	0.0111	0.0071	0.0015	0.0010	0.0003	0.0004	0.0001
Korea, Republic of	0.0010	0.0021	0.0042	0.0043	0.0175	0.0154	0.0291	**0.6397**	0.1328	0.1419	0.0109	0.0012
Kuwait	0.0030	0.0048	0.0196	0.0156	0.0805	0.0221	**0.4057**	0.1167	0.2901	0.0214	0.0190	0.0014
Kyrgyzstan	0.0072	0.0119	0.2787	0.0885	**0.4959**	0.0388	0.0491	0.0172	0.0081	0.0019	0.0024	0.0003
Laos	0.0217	**0.9582**	0.0030	0.0056	0.0013	0.0088	0.0005	0.0005	0.0002	0.0001	0.0001	0.0000
Latvia	0.0004	0.0008	0.0024	0.0023	0.0159	0.0063	0.0245	**0.7944**	0.1329	0.0136	0.0062	0.0004
Lebanon	0.0041	0.0055	0.0252	0.0245	0.0916	0.0165	**0.5592**	0.0464	0.1382	0.0132	0.0726	0.0031
Lesotho	0.0158	0.0141	**0.8647**	0.0642	0.0239	0.0088	0.0051	0.0017	0.0009	0.0003	0.0003	0.0001
Liberia	**0.8292**	0.1386	0.0118	0.0108	0.0027	0.0048	0.0009	0.0006	0.0003	0.0002	0.0002	0.0001
Libyan Arab Jamahiriya	0.0012	0.0019	0.0091	0.0081	0.0488	0.0087	**0.8308**	0.0286	0.0515	0.0044	0.0063	0.0004
Lithuania	0.0004	0.0008	0.0021	0.0026	0.0110	0.0049	0.0323	0.1256	**0.7612**	0.0223	0.0360	0.0009
Macau	0.0061	0.0108	0.0652	0.0285	**0.3163**	0.0536	0.2599	0.1621	0.0712	0.0153	0.0097	0.0012
Macedonia (Fmr. Yug Rep.)	0.0038	0.0053	0.1280	0.0365	**0.6755**	0.0155	0.1048	0.0152	0.0099	0.0018	0.0033	0.0004
Madagascar	0.0322	**0.9641**	0.0008	0.0015	0.0003	0.0009	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000
Malawi	**0.9558**	0.0342	0.0021	0.0057	0.0005	0.0012	0.0002	0.0001	0.0001	0.0000	0.0000	0.0000
Malaysia	0.0004	0.0011	0.0019	0.0019	0.0100	0.0135	0.0068	**0.9418**	0.0101	0.0106	0.0016	0.0003
Maldives	0.0213	0.0247	0.1394	0.1677	0.1743	0.0562	**0.3035**	0.0392	0.0500	0.0084	0.0136	0.0016
Mali	0.3130	**0.3887**	0.0260	0.2188	0.0099	0.0332	0.0045	0.0027	0.0014	0.0007	0.0007	0.0002
Malta	0.0008	0.0012	0.0034	0.0038	0.0118	0.0050	0.0773	0.0341	**0.8096**	0.0201	0.0318	0.0011
Mauritania	0.0049	0.0073	0.0267	**0.8986**	0.0230	0.0170	0.0169	0.0027	0.0019	0.0004	0.0006	0.0001
Mauritius	0.0011	0.0019	0.0170	0.0101	0.3254	0.0117	**0.5888**	0.0256	0.0142	0.0018	0.0021	0.0002
Mexico	0.0011	0.0022	0.0063	0.0098	0.0524	0.0223	**0.4832**	0.2280	0.1741	0.0104	0.0096	0.0005
Moldova, Republic of	0.0015	0.0039	0.0080	0.0083	0.0511	0.0542	0.0192	**0.8142**	0.0201	0.0136	0.0051	0.0008
Mongolia	0.0370	0.0499	**0.5630**	0.0828	0.1574	0.0516	0.0229	0.0194	0.0081	0.0033	0.0036	0.0009
Morocco	0.0016	0.0027	0.0082	0.0260	0.0348	0.0166	**0.8640**	0.0156	0.0235	0.0024	0.0042	0.0003
Mozambique	**0.8812**	0.0800	0.0136	0.0120	0.0037	0.0057	0.0015	0.0011	0.0006	0.0003	0.0003	0.0001

APPENDIX IV--Continued

Countries	fz1	fz2	fz3	fz4	fz5	fz6	fz7	fz8	fz9	fz10	fz11	fz12
Myanmar	0.0122	0.0457	0.0178	0.0664	0.0329	**0.7270**	0.0255	0.0437	0.0138	0.0093	0.0046	0.0011
Namibia	0.0412	0.2681	0.1044	0.1102	0.0697	**0.3686**	0.0113	0.0172	0.0044	0.0025	0.0019	0.0006
Nepal	0.2315	**0.5219**	0.0214	0.1497	0.0109	0.0504	0.0058	0.0039	0.0021	0.0011	0.0010	0.0003
Netherlands	0.0008	0.0011	0.0023	0.0027	0.0058	0.0030	0.0100	0.0122	0.0322	0.0172	**0.8847**	0.0281
Nicaragua	0.0048	0.0051	**0.9574**	0.0094	0.0160	0.0035	0.0020	0.0010	0.0004	0.0002	0.0002	0.0000
Niger	**0.8502**	0.1101	0.0067	0.0230	0.0022	0.0053	0.0010	0.0006	0.0004	0.0002	0.0002	0.0001
Nigeria	0.0047	0.0141	0.0740	0.0923	**0.4956**	0.2452	0.0454	0.0204	0.0051	0.0015	0.0013	0.0002
Norway	0.0015	0.0027	0.0035	0.0038	0.0080	0.0096	0.0106	0.0510	0.0414	**0.8358**	0.0219	0.0100
Pakistan	0.0064	0.0177	0.0567	**0.8819**	0.0135	0.0195	0.0026	0.0010	0.0004	0.0001	0.0002	0.0000
Panama	0.0152	0.0406	0.0391	0.0325	0.0831	0.2101	0.0383	**0.3663**	0.0473	0.1037	0.0169	0.0070
Papua New Guinea	0.0210	**0.9646**	0.0020	0.0059	0.0009	0.0047	0.0003	0.0003	0.0001	0.0001	0.0001	0.0000
Paraguay	0.0157	0.0331	0.0847	0.1772	**0.2728**	0.1618	0.0965	0.0891	0.0364	0.0116	0.0182	0.0028
Peru	0.0000	0.0000	**0.9993**	0.0002	0.0003	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Philippines	0.0112	0.0666	0.1009	0.0551	0.0914	**0.6497**	0.0087	0.0118	0.0024	0.0012	0.0008	0.0002
Poland	0.0003	0.0005	0.0012	0.0019	0.0050	0.0027	0.0285	0.0225	**0.8247**	0.0140	0.0977	0.0009
Portugal	0.0015	0.0021	0.0047	0.0068	0.0134	0.0074	0.0752	0.0307	**0.4858**	0.0333	0.3347	0.0044
Romania	0.0002	0.0003	0.0008	0.0012	0.0041	0.0016	0.0356	0.0159	**0.9169**	0.0044	0.0188	0.0003
Russian Federation	0.0007	0.0012	0.0061	0.0056	0.0574	0.0070	**0.7082**	0.0587	0.1425	0.0044	0.0078	0.0004
Rwanda	**0.9260**	0.0500	0.0050	0.0124	0.0016	0.0032	0.0008	0.0005	0.0003	0.0001	0.0002	0.0001
Saint Kitts and Nevis	0.0018	0.0040	0.0036	**0.9771**	0.0029	0.0078	0.0017	0.0005	0.0003	0.0001	0.0001	0.0000
Saint Lucia	0.0149	0.0251	0.0404	**0.6321**	0.0656	0.0842	0.0895	0.0197	0.0169	0.0040	0.0067	0.0009
Saint Vincent/Grenadines	0.0026	0.0047	0.0330	**0.9406**	0.0097	0.0062	0.0020	0.0006	0.0003	0.0001	0.0001	0.0000
Saudi Arabia	0.0026	0.0051	0.0282	0.0185	0.2888	0.0431	**0.3728**	0.1721	0.0552	0.0079	0.0052	0.0005
Senegal	0.0788	0.0836	0.0263	**0.7708**	0.0096	0.0220	0.0048	0.0019	0.0011	0.0004	0.0005	0.0001
Seychelles	0.0110	0.0217	0.1704	**0.5571**	0.1180	0.0753	0.0317	0.0083	0.0041	0.0011	0.0011	0.0002
Sierra Leone	**0.9074**	0.0551	0.0164	0.0133	0.0026	0.0034	0.0009	0.0005	0.0003	0.0001	0.0001	0.0000
Slovakia	0.0001	0.0001	0.0004	0.0004	0.0027	0.0012	0.0029	**0.9754**	0.0112	0.0044	0.0012	0.0001
Slovenia	0.0001	0.0002	0.0004	0.0004	0.0020	0.0008	0.0066	0.0168	**0.9527**	0.0072	0.0125	0.0002
Solomon Islands	0.0017	**0.9972**	0.0002	0.0004	0.0001	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Somalia	**0.8759**	0.0729	0.0187	0.0176	0.0044	0.0063	0.0017	0.0012	0.0006	0.0003	0.0004	0.0001
South Africa	0.0004	0.0009	0.0018	0.0017	0.0091	0.0098	0.0075	**0.9394**	0.0136	0.0138	0.0018	0.0003
Spain	0.0000	0.0000	0.0000	0.0001	0.0002	0.0001	0.0004	0.0005	0.0053	0.0008	**0.9924**	0.0001
Sri Lanka	0.0703	0.2356	**0.4579**	0.1245	0.0402	0.0584	0.0064	0.0040	0.0015	0.0006	0.0006	0.0001
Sudan	0.0153	0.0177	0.0239	**0.9128**	0.0096	0.0127	0.0046	0.0015	0.0010	0.0003	0.0004	0.0001
Suriname	0.0004	0.0007	0.0186	0.0047	**0.9568**	0.0029	0.0127	0.0020	0.0008	0.0002	0.0002	0.0000
Swaziland	0.0052	0.0153	0.2694	0.0927	**0.5008**	0.0912	0.0137	0.0079	0.0021	0.0007	0.0007	0.0001

APPENDIX IV--Continued

Countries	fz1	fz2	fz3	fz4	fz5	fz6	fz7	fz8	fz9	fz10	fz11	fz12
Sweden	0.0001	0.0001	0.0002	0.0002	0.0005	0.0005	0.0009	0.0076	0.0094	**0.9781**	0.0023	0.0003
Switzerland	0.0001	0.0001	0.0002	0.0003	0.0008	0.0007	0.0014	0.0181	0.0126	**0.9625**	0.0028	0.0003
Syrian Arab Republic	0.0007	0.0012	0.0038	0.0075	0.0183	0.0060	**0.9000**	0.0133	0.0395	0.0025	0.0068	0.0003
Tajikistan	0.0021	0.0023	**0.9796**	0.0085	0.0048	0.0015	0.0007	0.0003	0.0001	0.0000	0.0000	0.0000
Tanzania, Un. Rep of	**0.9751**	0.0227	0.0005	0.0011	0.0001	0.0003	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
Togo	0.0655	**0.8281**	0.0263	0.0542	0.0052	0.0179	0.0013	0.0008	0.0003	0.0002	0.0001	0.0000
Trinidad and Tobago	0.0037	0.0070	0.1109	0.0199	**0.7307**	0.0314	0.0556	0.0280	0.0082	0.0023	0.0019	0.0003
Tunisia	0.0006	0.0011	0.0034	0.0058	0.0207	0.0080	**0.7822**	0.0381	0.1270	0.0048	0.0078	0.0003
Turkey	0.0016	0.0029	0.0046	0.0080	0.0150	0.0145	0.0540	0.0865	**0.4939**	0.1461	0.1674	0.0055
Uganda	0.0513	**0.9321**	0.0023	0.0086	0.0009	0.0040	0.0003	0.0002	0.0001	0.0001	0.0001	0.0000
Ukraine	0.0024	0.0050	0.0062	0.0065	0.0167	0.0258	0.0151	0.2099	0.0445	**0.6443**	0.0170	0.0065
United Arab Emirates	0.0008	0.0013	0.0035	0.0040	0.0128	0.0059	0.0860	0.0435	**0.7978**	0.0212	0.0222	0.0009
United Kingdom	0.0001	0.0001	0.0004	0.0004	0.0021	0.0007	0.0112	0.0131	**0.9619**	0.0037	0.0062	0.0001
United States of Am.	0.0015	0.0024	0.0034	0.0040	0.0079	0.0073	0.0125	0.0363	0.0621	**0.6484**	0.1250	0.0892
Uruguay	0.0061	0.0100	0.0214	0.0218	0.0612	0.0314	0.0580	0.1467	0.1312	0.0997	**0.3474**	0.0650
Uzbekistan	0.0057	0.0083	0.2411	0.1430	**0.4631**	0.0245	0.0946	0.0100	0.0064	0.0012	0.0019	0.0002
Vanuatu	0.0702	0.1446	0.0562	**0.4430**	0.0555	0.1494	0.0335	0.0211	0.0116	0.0056	0.0073	0.0020
Venezuela	0.0085	0.0214	0.1184	0.0292	**0.4808**	0.1315	0.0398	0.1399	0.0167	0.0087	0.0043	0.0009
Viet Nam	0.0215	0.3339	0.0177	0.0600	0.0144	**0.5384**	0.0047	0.0058	0.0017	0.0010	0.0007	0.0002
Yemen	**0.4670**	0.1375	0.2288	0.1168	0.0195	0.0192	0.0056	0.0027	0.0014	0.0006	0.0006	0.0002
Zambia	0.0592	**0.8406**	0.0154	0.0204	0.0074	0.0490	0.0024	0.0031	0.0011	0.0008	0.0005	0.0002
Zimbabwe	0.0279	**0.8959**	0.0116	0.0143	0.0052	0.0408	0.0014	0.0017	0.0006	0.0004	0.0002	0.0001

Note: Each country is classified in the cluster for which it has a dominant degree of membership (in bold).

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