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Demand Growth in Developing Countries

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EXECUTIVE SUMMARY

This report prepared by a consultant, Dr. David Abler of Penn State University in the United States, examines structural changes in the demand for agricultural products arising from economic growth in a number of large developing and emerging economies comprising primarily the BRIIC group of countries (Brazil, Russia, India, Indonesia and China). It reviews and evaluates a number of studies made of the effects of economic growth in large developing and emerging economies on agricultural product demand and the structure of demand. In particular, the report seeks to evaluate the effects of economic growth and rising incomes on the composition of agricultural product demand across product categories (*e.g.* cereals *vs.* meat), within product categories (*e.g*. lower-quality cereals *vs.* higher-quality cereals) and on the evolution of price and income elasticities of demand for agricultural products - that is, how rapidly are they moving toward the low elasticities seen in many OECD countries. The report also utilises the results of these studies to draw out the possible implications for agricultural commodity demand, commodity prices, and possible price volatility.

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CHANGING AGRICULTURAL PRODUCT DEMAND CHARACTERISTICS IN LARGE DEVELOPING AND EMERGING ECONOMIES

I. Introduction and task description

1. The objective of this report is to summarize and critically evaluate recent studies on the effects of economic growth in large developing and emerging economies on agricultural product demand and the structure of demand, including:

- Effects on the composition of agricultural product demand across product categories (e.g. cereals *vs.* meat)
- Effects on the composition of agricultural product demand within product categories (e.g. lower-quality cereals vs. higher-quality cereals)
- Effects on price and income elasticities of demand for agricultural products - how rapidly are they moving toward the low elasticities seen in many OECD countries

2. This report also utilizes the results of these studies to:

- Draw out the implications of these effects for agricultural commodity demand, commodity prices, and possible price volatility
- Develop recommendations about how to incorporate these effects into the AGLINK-COSIMO model for complementary scenario analyses

3. This report focuses on the five largest developing and emerging economies, the so-called BRIIC: Brazil, China, India, Indonesia, and Russia. These five countries accounted for more than one-half of non-OECD global GDP in 2008. The US Department of Agriculture's projections for 2010-2019 are that China's real GDP will grow by 8.0% per year, India's by 7.5% per year, Indonesia's by 4.9% per year, Russia's by 4.6% per year, and Brazil's by 4.2% per year (US Department of Agriculture 2010a). These are rapid rates of growth and significantly greater than projected growth rates for most OECD countries. China is on track to become the world's second largest economy early in this decade, perhaps as soon as 2011. India may become the world's seventh largest economy by 2020, after the US, China, Japan, Germany, the United Kingdom, and France.

4. This report is based on studies using data collected during the last 30 years. Using studies going back three decades can be questioned given the rapid economic growth that has occurred in the countries examined here. Ideally, a report such as this one would be written based on studies using data from the last five or ten years. However, with the possible exception of China, that would leave too few studies upon which to base a report. For most developing countries one finds an irregular flow of published research of agricultural product demand, with extended periods where there is no research at all. Research depends on data, and in most developing countries surveys of household consumption patterns are conducted

intermittently. Time lags in the research and publication process also mean that some studies published recently use data from the 1990s or even 1980s.

II. Effects of economic growth on food demand

5. This section reviews recent studies for Brazil, China, India, Indonesia, and Russia that shed light on the effects of economic growth on food demand. This section focuses on studies reporting estimates of the income elasticity of demand for cereals, meat and seafood, dairy products, fruits and vegetables, sugar, and fats and oils. The income elasticity of demand is defined as the percentage change in consumption of a good in response to a 1% increase in a consumer's income. Most of these studies also report estimates of the own-price elasticity of demand, which is the percentage change in consumption of a good in response to a 1% increase its price. When these estimates are available they are also reported here. As discussed later in this report, price elasticities of demand have implications for agricultural commodity price volatility.

6. Many studies for developing countries estimate consumer demand at the level of broad product categories such as food, clothing, and housing, such that all food items are grouped together into a single good. Because this report focuses on specific agricultural products, rather than food as a whole, those studies are not included in this section.

7. Many studies view a household's decision-making process regarding food consumption as a two-stage process. In the first stage, the household decides how to allocate its spending across broad product categories such as food, clothing, and housing. In the second stage, total food expenditures are allocated among specific food items. Some studies extend this to a three-stage process, where the second stage is groups of food items (cereals, meat, dairy products, *etc.*) and the third stage allocates expenditures on each food group among the specific items within that group.

8. Some of the studies that view household decision-making as a two-stage process estimate the determinants of consumption at both stages, while others only estimate the determinants of consumption at the second stage (specific food items). In these studies, consumption of each food item is assumed to be a function of total food expenditures and prices of food items. To obtain income elasticities of demand for food items from these studies, auxiliary information is needed on the impact of income on total food expenditures (Thompson 2004). In general, the income elasticity of demand for a food item is not the same the elasticity of demand for that item with respect to total food expenditures. Instead it is the elasticity of demand for the item with respect to total food expenditures multiplied by the elasticity of total food expenditures with respect to income (Edgerton 1997). The elasticity of total food expenditures with respect to income is typically less than one, implying that income elasticities of demand are smaller in absolute value than elasticities with respect to total food expenditure. Price elasticities of demand obtained from these "second stage only" studies, which hold total food expenditures constant as food prices change, are also generally different from the price elasticities that would emerge from a study in which changes in food prices altered total food expenditures (Edgerton 1997). For these reasons, this report only uses two-stage studies if both stages are estimated.[1]

1 In the case of Chatterjee *et al.* (2007) and Meenakshi and Ray (1999), the first stage (total food expenditures) was not estimated. However, due to the small number of studies for India, this report took first-stage results from other studies for India in order to be able to use the findings of these two studies. Pan *et al*. (2008) estimated that the elasticity of total food expenditures with respect to income for India is 0.57, while Mittal (2006) obtained an estimate of 0.63. This report uses an average (0.60) of these two elasticity estimates.

a) Cereals

9. Estimated demand elasticities for cereals from recent studies for the five BRIIC countries are shown in Tables 1-5. Some of the elasticity estimates are for cereals as a whole, some are for specific cereals, while others are for cereal products such as bread. In general, how a study categorizes and aggregates products depends on research decisions by the study's authors and, for studies using secondary data, the way products are classified in the dataset analyzed. There are 16 studies for China listed in Table 5 but only a small number of studies (two to four) for each of the other four countries.

10. Demand elasticity estimates in each country for the same or similar products often differ significantly from one study to another. For example, for China, the estimated income elasticity of demand for rice ranges from 0.31 (Fan *et al.* 1994) to 1.16 (Gould and Villarreal 2006). The range of income elasticity estimates for cereals as a whole for China is even greater, from -0.09 (urban areas; Gale and Huang 2007) to 0.97 (rural areas; Yan and Chern 2005). For Brazil, the estimated income elasticity of demand for rice ranges from 0.09 (rice and beans; Menezes *et al.* 2008) to 1.26 (Coelho and de Aguiar 2007).

11. The number of studies, even for China, is too small to permit a statistically rigorous meta-analysis of the differences in demand elasticity estimates. However, several factors may play a role. One factor is whether the study analyzed data from rural areas, urban areas, or both. For China, seven studies estimate the income elasticity of demand for cereals in rural areas, and a simple average of their estimates is 0.54. Five studies estimate the income elasticity of demand for cereals in urban areas, with a simple average of their estimates being 0.26. For Brazil, the lowest estimated income elasticity of demand for rice is from a study using urban data (Menezes *et al*. 2008), the highest is from a study using rural data (Gould and Villarreal, 2006), and a middle estimate is from a study using both rural and urban data (Pintos-Payeras, 2009). For Russia, the estimated income elasticity of demand for bread is 0.13 from Shiptsova *et al.* (2004), who used urban data, and 0.51 from Elsner (1999), who used both rural and urban data. These two studies for Russia make an interesting comparison because they are otherwise similar methodologically.

12. This tendency for income elasticities to be lower in urban areas than rural areas is based on a small number of studies and is not universal. For rice in China, the average estimated income elasticity across three studies for urban areas is 0.86; the average across two studies for rural areas is 0.41. Nonetheless, this tendency makes sense insofar as we believe that income elasticities of demand for cereals decline as income increases, because average incomes are lower in rural areas than urban areas of most developing countries.

13. Another factor may be the time period for the data analyzed in a study. For Indonesia, the lowest estimated income elasticity of demand is from Fabiosa and Jensen (2003), who used 1996 data. The highest estimated income elasticities are from Teklu and Johnson (1988) and Deaton (1990), who used data from 1980 and 1981, respectively. If we look at the seven studies estimating the income elasticity of demand for cereals in rural areas of China, six of them used data from the 1980s or first half of the 1990s, and the average estimated income elasticity across these six studies was 0.62. One study (Gale and Huang 2007) used data since 2000 and obtained an estimate of 0.06. On the other hand, if we look at the five studies estimating the income elasticity of demand for cereals in urban areas of China, the average for studies using data from the 1990s (0.17) is less than the average for studies using data since 2000 (0.42). Income elasticities of demand for cereals should be lower for more recent years insofar as we believe that they decline as income increases.

14. A third factor may be whether a study used a single-stage demand system model versus the alternatives: a two- or three-stage demand system model, or no demand system at all. Studies not using a

demand system specify either a demand equation for a single product or demand equations for multiple products that are not linked in any way across these products. They are referred to here as "unlinked" models.

15. The single-stage model estimates tend to be greater than those from multi-stage demand models or unlinked models. If we look at the seven studies estimating the income elasticity of demand for cereals in rural areas of China, four of them used a single-stage model, and the average estimated income elasticity across these four studies was 0.86. The other three used a multi-stage or unlinked model, and their average estimated income elasticity was 0.28. Looking at the five studies that estimated the income elasticity of demand for cereals in urban areas of China, two used a single-stage model and their average estimated income elasticity was 0.68. The other three used a multi-stage or unlinked model, and their average estimated income elasticity was 0.08. Looking at the five studies estimating the income elasticity of demand for rice in China, three used a single-stage model and their average estimated income elasticity was 0.81. The other two used a multi-stage or unlinked model, and their average estimated income elasticity was 0.47.

16. It is not clear why a single-stage demand system model should cause estimated income elasticities to be greater than other types of models, if this is more than a coincidence. This issue has not been addressed in the literature. The literature does include some tests of separability such as Moschini *et al.* (1994), who find for the US that food is weakly separable from non-food items, and that meat products are separable from other types of food. This suggests that a multi-stage model is an appropriate way of analyzing food consumption. Moschini *et al.* (1994) also find that income and cross-price elasticities are often smaller in absolute value in a multi-stage model than in a single-stage model.

17. It is very difficult to reconcile any of the high estimated income elasticities of demand for China with recent trends in Chinese cereal consumption.[2] *Per capita* domestic consumption of rice has fallen by about 0.5% annually since 2000, while *per capita* domestic consumption of wheat, net of feed use, has fallen by about 1.4% annually since 2000. During this time real *per capita* GDP has risen at more than 9% annually. Leaving aside other variables affecting consumption, this would suggest negative income elasticities of demand for wheat and rice in China. Among the studies listed in Table 5, the one that comes closest to being consistent with these trends is Gale and Huang (2007), who estimated an income elasticity of demand for cereals of 0.06 in rural areas and -0.09 in urban areas. Of course, other variables such as prices have also been affecting consumption, but the gap between actual consumption trends and the income effects implied by some studies for China is too large to reconcile by appeal to other variables.

18. The same difficulty in reconciliation is evident for the other four BRIIC countries. In Brazil, *per capita* domestic consumption of rice and wheat, net of feed use, has essentially been flat since 2000, while real *per capita* GDP has risen by about 1.7% annually. The study in Table 1 that comes closest to being consistent with these trends is Menezes *et al.* (2008), who estimated an income elasticity of demand in urban areas for wheat of 0.24 and for rice and beans of 0.09. In Russia, *per capita* domestic consumption of wheat, net of feed use, has basically been flat since 2000, while real *per capita* GDP has risen by about 5.5% annually. The Shiptsova *et al*. (2004) study in Table 2 comes closest to being consistent with these trends, with its low estimated income elasticities for bread, flour, and pasta. In India, *per capita* domestic consumption of rice and wheat, net of feed use, has been almost completely flat since 2000, even as real *per capita* GDP has risen by about 5.5% annually. Only the study by Mittal (2006) in Table 3 estimates a relatively low income elasticity, of 0.17 for cereals. In Indonesia, *per capita* domestic consumption of rice has fallen by about 0.8% annually since 2000, while *per capita* domestic consumption of wheat, net of feed

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2 Consumption statistics in this report are drawn from the US Department of Agriculture's PSD database (US Department of Agriculture 2010b). Population and real GDP statistics are drawn from the US Department of Agriculture's long-term projections database (US Department of Agriculture 2010a).

use, increased by about 1.6% annually during this time. Real *per capita* GDP has risen at about 3.1% annually since 2000. The study in Table 4 reporting the lowest income elasticity is Fabiosa and Jensen (2003), whose estimate for cereals is 0.02. The predominant cereal in Indonesia is rice.

b) Meat and seafood

19. Estimated demand elasticities for meat and seafood from recent studies for the five BRIIC countries are shown in Tables 6-10. Some of the elasticity estimates are for meat as a whole, some are for specific meats and types of seafood, while others are for meat products such as processed meats and sausages. There are 19 studies for China listed in Table 10 but only a small number of studies (two to five) for each of the other four countries.

20. As with cereals, demand elasticity estimates in each country for the same or similar products often differ significantly from one study to another. For example, for China, the estimated income elasticity of demand for pork in urban areas ranges from 0.13 (Gale and Huang 2007) to 1.28 (Dong and Gould 2007). For rural areas of China, the range of estimates for pork is from 0.24 (Gale and Huang 2007) to 1.24 (Katchova and Chern 2004). In Indonesia, income elasticity estimates for fish range from 0.24 (Fabiosa and Jensen 2003) to 1.46 (Dey *et al.* 2008).

21. Like cereals, there does not seem to be a single explanation for these differences in demand elasticity estimates, but instead several factors that may play a role. One factor may be whether the study analyzed data from rural areas, urban areas, or both. For China, seven studies estimate the income elasticity of demand for pork in urban areas, and the average estimated elasticity is 0.63. Five studies estimate this elasticity for rural areas and the average there is 0.90. For beef, seven studies estimate the income elasticity of demand for urban China and the average is 0.62. Three studies estimate this elasticity for rural areas and the average is 0.74. These comparisons are based on a small number of studies and this tendency is not universal. For poultry the average estimated income elasticity across studies for China is about the same for rural and urban areas: 0.89 for urban areas (seven studies) and 0.85 for rural areas (four studies). For studies of Chinese seafood/fish consumption, the average is also about the same for rural and urban areas: 0.92 for urban areas (eight studies) and 0.95 for rural areas (four studies).

22. The time period for the data analyzed in a study may also be important, but in contrast to cereals, income elasticities of demand for meat and seafood may have risen over time, at least in urban China. For urban areas of China, the average estimated income elasticity for pork across four studies with data prior to 2000 is 0.44; for three studies with data since 2000 the average is 0.87. The average estimated income elasticity for beef in urban areas of China across four studies with data prior to 2000 is 0.46; for three studies with data since 2000 the average is 0.84. The average estimated income elasticity for seafood/fish in urban areas of China across three studies with data prior to 2000 is 0.56; for five studies with data since 2000 the average is 1.13. The number of studies upon which these comparisons are based is small in each case but it is interesting that the same tendency holds for all three products. There are not enough studies for rural China or for the other BRIIC countries to permit any comparison over time.

23. With respect to model specification, the same tendency found for cereals, where the single-stage model estimates tend to be greater than those from multi-stage demand models or unlinked models, is also evident for meat and seafood in urban China. Of the seven studies estimating an income elasticity for pork in urban China, three used a one-stage model and their average is 1.10; four used a multi-stage or unlinked model and their average is 0.27. Of the seven studies estimating an income elasticity for beef in urban China, three used a one-stage model and their average is 1.06; four used a multi-stage or unlinked model and their average is 0.30. Of the seven studies estimating an income elasticity for poultry in urban China, four used a one-stage model and their average is 1.36; three used a multi-stage or unlinked model and their average is 0.28. Of the eight studies estimating an income elasticity for seafood/fish in urban China, five

used a one-stage model and their average is 1.26; three used a multi-stage or unlinked model and their average is 0.33. There are not enough studies for rural China or for the other BRIIC countries to permit this type of comparison.

24. The estimated income elasticities of demand for meat in Brazil appear plausible when compared to recent trends in consumption. *Per capita* domestic consumption of beef and veal has risen about 0.9% annually since 2000; for pork and chicken the figures are 2.1% and 3.6%, respectively. Real *per capita* GDP has risen about 1.7% annually during this period. Leaving aside other variables affecting consumption, these statistics would suggest an income elasticity of demand of less than one for beef and veal, somewhat greater than one for pork, and greater than two for chicken. The estimated income elasticities for Brazil in Table 6 are not unreasonable when compared with these statistics. For beef, the study most consistent with these trends is Pintos-Payeras (2009); for pork and chicken, it is Coelho and de Aguiar (2007).

25. In the case of Russia, *per capita* domestic consumption has risen by about 6.2% annually for pork and 8.6% for chicken since 2000, while for beef and veal it has fallen by about 0.9% annually. Real *per capita* GDP increased about 5.5% annually during this period. Leaving aside other variables affecting consumption, these statistics would suggest an income elasticity of demand of a little greater than one for pork, about 1.5 for chicken, and a negative income elasticity for beef and veal. Compared to these statistics, the estimated income elasticities for Russia in Table 7 for pork and chicken may be too small, while the estimated income elasticities for beef and veal may be too large. For India *per capita* domestic consumption has risen by about 8.4% annually for chicken and 2.7% for beef and veal since 2000. Real *per capita* GDP increased about 5.5% annually during this period. The two estimated income elasticities for meat in Table 8 are for meat as a whole combined with fish and eggs, but they seem reasonable relative to these statistics for India. For Indonesia *per capita* chicken consumption has risen by about 6.1% annually since 2000, while real *per capita* GDP rose about 3.1% annually during this period. Among the studies in Table 9, the results in Deaton (1990) appear most consistent with these trends.

26. For China, *per capita* consumption of beef and veal has increased about 0.7% annually; for pork and chicken the figures are 1.6% and 2.4%, respectively. Compared to China's real *per capita* GDP growth of 9.1% annually during this period, and leaving aside other variables affecting consumption, these statistics suggest income elasticities of demand for meat in the 0.1-0.3 range. Some studies listed in Table 10 such as Gale and Huang (2007), Gould (2002), and Zhang and Wang (2003) are consistent with these statistics. Other studies showing significantly higher estimated income elasticities are difficult to reconcile with these statistics.

c) Dairy products

27. Estimated demand elasticities for dairy products from recent studies for the five BRIIC countries are shown in Tables 11-15. Some of the elasticity estimates are for dairy products as a whole while some are for products such as fluid milk or cheese. There are ten studies for China listed in Table 15 but only a small number of studies (one to three) for each of the other four countries.

28. In contrast to cereals and meat/seafood, income elasticity of demand estimates in each country for the same or similar products tend to be reasonably close to each other. For Brazil, the two estimates in Table 11 of the income elasticity of demand for fluid milk from Coelho and de Aguiar (2007) and Menezes *et al.* (2008) are nearly identical. Similarly, the estimates of the income elasticity of demand for dairy products in Table 13 from Chatterjee *et al.* (2007) and Meenakshi and Ray (1999) are nearly the same, and not too far from the estimate for fluid milk in Mittal (2006). For Indonesia, the estimates in Table 14 from Fabiosa and Jensen (2003) for milk/eggs and Jensen and Manrique (1998) for fluid milk are close to each other.

29. Greater differences among studies are seen for China in Table 15, but those may be explained by in part by differences in model specification. Like cereals and meat/seafood, single-stage model estimates tend to be greater than those from multi-stage demand models or unlinked models. For fluid milk in urban China, there are two studies that used a single-stage model, and their average elasticity estimate is 1.34. There are four studies that used a multi-stage model or unlinked model, and their average elasticity estimate is 0.66. For dairy products as a whole in urban China, two studies used a single-stage model and their average elasticity estimate is 1.09. Two other studies used a multi-stage or unlinked model, and their average elasticity estimate is 0.46.

30. *Per capita* domestic consumption of dairy products in Brazil, net of feed use, has increased 1.5% annually since 2000. Real *per capita* income increased at an annual rate of 1.7% during this period. Leaving aside other variables influencing dairy products consumption, this suggests an income elasticity of demand for dairy products of about one, which is close to the estimates in Table 11. In Russia, *per capita* domestic consumption of dairy products, net of feed use, has increased 0.9% annually since 2000. Real *per capita* GDP increased about 5.5% annually during this period. This would suggest an income elasticity of about 0.1 or 0.2, which is significantly less than the estimated elasticities reported in Table 12. In India, there is a similar finding: *per capita* domestic consumption of dairy products, net of feed use, has increased about 2.0% annually since 2000, compared with an increase of real *per capita* GDP of about 5.5% annually during this period. This would suggest an income elasticity of about 0.3 or 0.4, which is significantly less than the estimated elasticities in Table 13.

31. In China, *per capita* domestic consumption of dairy products, net of feed use, has increased by nearly 14% annually since 2000, compared with an increase of real *per capita* GDP of 9.1% annually during this period. Leaving aside other variables influencing dairy products consumption, this suggests an income elasticity of demand for dairy products of more than one, which is consistent with some of the estimates in Table 15 but not others.

d) Fruits and vegetables

32. Estimated demand elasticities for fruits and vegetables from recent studies for the five BRIIC countries are shown in Tables 16-20. Some of the elasticity estimates are for fruits and vegetables as a whole while some are for specific fruits or vegetables. There are 17 studies for China listed in Table 20 but only a small number of studies (one to four) for each of the other four countries.

33. Like dairy products, many of the income elasticity of demand estimates in each country for the same or similar products tend to be reasonably close to each other. For Brazil, the estimate in Table 16 for fruits and vegetables as a whole in Pintos-Payeras (2009) lies between the separate estimates for fruits and vegetables in Menezes *et al.* (2008), and the estimates in Coelho and de Aguiar (2007) are also in the same range. Similarly for India, the results of Chatterjee *et al*. (2007) and Mittal (2006) are close to each other.

34. Greater differences among studies are seen for Indonesia and China in Tables 19-20, but those may be explained by in part by differences in the time period analyzed (Indonesia) and model specification (China). For Indonesia, the two studies using the oldest data (Deaton 1990, Teklu and Johnson 1988) have greater income elasticity estimates than the two studies using somewhat more recent data (Fabiosa and Jensen 2003, Jensen and Manrique 1998). All of the studies for Indonesia use a single-stage model.

35. For China, single-stage model estimates tend to be greater than those from multi-stage demand models or unlinked models. For vegetables in urban China, there are four studies that used a single-stage model, and their average elasticity estimate is 0.87. There are three studies that used a multi-stage model or unlinked model, and their average elasticity estimate is 0.26. For vegetables in rural China, five studies used a single-stage model and their average elasticity estimate is 1.06. Two studies used a multi-stage or

unlinked model, and their average elasticity estimate is 0.75. For fruits in urban China, there are four studies that used a single-stage model, and their average elasticity estimate is 0.81. There are three studies that used a multi-stage model or unlinked model, and their average elasticity estimate is 0.29. For fruits in rural China, three studies used a single-stage model and their average elasticity estimate is 1.17. Two studies used a multi-stage or unlinked model, and their average elasticity estimate is 0.48.

36. These comparisons also indicate that estimated income elasticities for China using rural data tend to be greater than the corresponding estimates using urban data, within a given model specification category. This tendency makes sense insofar as we believe that income elasticities of demand for fruits and vegetables decline as income increases, because average incomes are lower in rural areas than urban areas of most developing countries. The time period analyzed does not appear to be an important factor for China in explaining differences in study results for fruits and vegetables.

37. Statistics on fruit and vegetable consumption over time are scarcer than statistics for other products analyzed in this report, so it is difficult to compare estimated income elasticities with recent trends in consumption. In China *per capita* domestic consumption of fresh oranges has risen about 8.9% annually since 2000, approximately the same as the increase in real *per capita* GDP over this period. *Per capita* domestic consumption of fresh tangerines has risen 10.8% annually since 2000, while *per capita* domestic consumption of grapefruit has increased 8.6% annually. Leaving aside other variables affecting consumption, these statistics suggest an income elasticity of demand for these products of about one, which is consistent with the results from Shono *et al.* (2000) for citrus fruits in Table 20. *Per capita* domestic consumption of fresh pears in China has risen about 4.5% annually since 2000, which when compared with the increase in real *per capita* GDP over this period would suggest an income elasticity of about 0.5. This is somewhat smaller than the estimate in Shono *et al.* (2000).

e) Sugar

38. Estimated demand elasticities for sugar or sugar products (sweets) from recent studies for four of the five BRIIC countries are shown in Tables 21-24. There are no studies for Indonesia, only one study for Russia, and only two studies for each of the other three countries. The International Sugar Organization (2004) estimates income elasticities of demand for sugar by region of the world as part of its world sugar demand outlook. Their most recent elasticities (2006/07) for the regions in which the BRIIC countries reside are 0.23 for Latin America, 0.31 for Eastern Europe, 0.35 for the Indian Subcontinent, and 0.49 for the Far East and Oceania (Bichara Rocha 2010). The elasticities are broadly consistent with the estimates in Tables 21-24.

39. For the countries with two studies each, the estimated income elasticities of demand are quite similar between the two studies in the cases of Brazil and China. In Brazil *per capita* human domestic consumption of sugar has increased 1.5% annually since 2000, while real *per capita* GDP has increased 1.7% annually. Leaving aside other variables affecting consumption, this would suggest an income elasticity of demand for sugar of about one. The estimates in Table 21 are lower. In China *per capita* human domestic consumption of sugar has increased 5.8% annually since 2000, while real *per capita* GDP has increased 9.1% annually. The estimated income elasticities in Table 24 are consistent with these trends. In India *per capita* human domestic consumption of sugar has increased 2.2% annually since 2000, while real *per capita* GDP has increased 5.5% annually. The estimated income elasticity in Chatterjee *et al.* (2007) in Table 23 is consistent with these trends, while the estimate in Mittal (2006) appears somewhat high given these trends.

f) Fats and oils

40. Estimated demand elasticities for fats and oils from recent studies for the five BRIIC countries are shown in Tables 25-29. Some of the elasticity estimates are for fats and oils as a whole while some are for specific oils such as rapeseed oil. There are nine studies for China listed in Table 29 but only a small number of studies (one to three) for each of the other four countries.

41. The income elasticity of demand estimates in the three studies for India in Table 27 is reasonably similar. Greater differences among studies are found for China in Table 29, but once again those may be explained partly by differences in model specification. For fats and oils/edible oils in urban China, there are four studies that used a single-stage model, and their average elasticity estimate is 1.08. There are three studies that used a multi-stage model or unlinked model, and their average elasticity estimate is 0.14.

42. In India, *per capita* domestic food use of palm oil has increased 3.6% annually since 2000, while real *per capita* GDP has increased 5.5% annually during this period. Leaving aside other variables influencing consumption, this suggests an income elasticity of demand of somewhat more than 0.5. The estimate of 0.25 in Pan *et al.* (2008) is somewhat lower. Similarly, the estimate in Pan *et al.* (2008) for the income elasticity of demand for rapeseed oil of 0.06 is lower than that suggested by *per capita* domestic food use, which has also increased 3.6% annually since 2000.

43. In China, *per capita* domestic food use of soy oil has increased 12% annually since 2000, while real *per capita* GDP has increased 9.1% annually during this period. Leaving aside other variables influencing consumption, this suggests an income elasticity of demand somewhat greater than one. The estimate of 0.17 in Fang and Beghin (2002) is lower than this. On the other hand, the estimate of 0.10 for rapeseed oil in Fang and Beghin (2002) is consistent with its 1.5% annual increase in *per capita* domestic food use since 2000, and the estimate of 0.17 for peanut oil is in reasonable agreement with its *per capita* domestic food use, which has declined somewhat since 2000.

III. Effects of economic growth on demand for food attributes

a) Demand for food quality

44. Household surveys of consumption typically ask respondents to report their consumption quantities and expenditures for groups of items rather than specific individual items. In some surveys there are a small number of broadly defined groups (e.g. “meat”); in other surveys there are a larger number of more narrowly defined groups (e.g. “beef,” “pork,” “poultry,” etc.). Even when groups are narrowly defined in the survey, statistical authorities may limit the public release of data to more broadly defined groups. Whether broad or narrow, the survey data present goods assigned to pre-defined groups and typically do not provide data on prices of specific items within each group. Instead, there are often only unit values for each group (obtained by dividing expenditures by the quantity consumed) to use as “prices” in an econometric study of demand.

45. A common point in most of the food demand studies reviewed in this report is that the price data are not actual prices but unit values. Relying on unit values can bias empirical analyses because they are not exogenous market prices; they instead reflect household food quality choices within each food product category (Deaton 1988, Nelson 1991). For example, within the category of “meat” there is considerable scope for household choice with respect to the type of meat, cut, appearance, texture, tenderness, flavour, nutrient content, freshness, and ease of preparation.

46. Regressions of quantities demanded on unit values and income may produce biased estimates of income and price elasticities of demand. Gale and Huang (2007) analyzed the impact of changes in income on the demand for food quality for several food groups in China using the Prais and Houthakker (1971)

methodology and found significant impacts in several cases. This methodology starts with the identity: $g \equiv vq$, where g represents expenditures on some food group, q is the physical quantity demanded of that food group and v is the unit value, which is an indicator of quality. Since $v = g/q$, the effect of income on the demand for food quality can be measured by the difference between the elasticity of g with respect to income and the elasticity of q with respect to income. For urban Chinese households at a median level of income, Gale and Huang (2007) find that the elasticity of demand for food quality with respect to income is significant in several cases, including 0.23 for cereals, 0.32 for cakes, 0.40 for aquatic products, 0.26 for fresh vegetables, 0.30 for fresh fruit, and 0.35 for fresh melon.

47. Yu and Abler (2009) developed a framework for assessing the magnitude of bias in estimates of income and price elasticities of demand from studies using unit values that do not account for household food quality choices and for correcting these biases. Their framework indicates that the income elasticity of demand will be biased upward, while the absolute value of the own-price elasticity of demand will be biased upward for a normal good (positive income elasticity of demand) and downward for an inferior good (negative income elasticity of demand). The degree of bias depends on the income elasticity of demand for food quality: the greater this elasticity, the greater the bias in estimated price and income elasticities of demand for food quantity. The income elasticity of demand for food quality is defined in this framework as the percentage change in the unit value paid by a consumer in response to a 1% increase in the consumer's income.

48. Yu and Abler (2009) applied their framework to panel data from rural China. They found that the estimated elasticity of demand for food quality with respect to *per capita* income was statistically significant for five food groups: cereals (estimated elasticity of 0.31), fats and oils (0.19), seafood (0.17), vegetables (0.35), and dairy products (0.18). The estimated income elasticities of demand for quality for the two of these products generally viewed as necessities - cereals and vegetables - are larger than those for fats and oils, seafood, and dairy products, which are often viewed as closer to luxuries in the case of rural China. As incomes increase, it appears that consumers in rural China make greater adjustments regarding the quality of necessities they consume than to the quality of luxuries.

49. Estimates of own-price and income elasticities of demand from the literature for rural China that do not correct for quality can be used with the results in Yu and Abler (2009) to obtain estimates of quality-corrected price and income elasticities of demand. For example, consider the five studies of demand for cereals as a whole in rural China in Table 5 for which both income and own-price elasticity estimates are available. The average estimated elasticities across these five studies are 0.70 (income) and -0.63 (price). Applying the Yu and Abler (2009) framework, these elasticities when corrected for quality become 0.56 (income) and -0.47 (price). There are three studies of demand for fish/aquatic products in rural China in Table 10 for which both income and own-price elasticity estimates are available. The average estimated elasticities across these three studies are 0.96 (income) and -0.63 (price). These elasticities when corrected for quality become 0.86 (income) and -0.56 (price). There are six studies of demand for vegetables as a whole in rural China in Table 20 for which both income and own-price elasticity estimates are available. The average estimated elasticities across these six studies are 1.00 (income) and -0.53 (price). These elasticities when corrected for quality become 0.85 (income) and -0.43 (price).

50. The implication is that the elasticities of demand discussed in Section II of this report generally overstate the responsiveness of consumption to changes in incomes and prices. This is true for both the studies using single-stage demand models and the studies using multi-stage demand models or unlinked models.

b) Demand for food variety

51. As income increases, the demand for a more diverse diet increases (Thiele and Weiss 2003). Studies of developed countries indicate that households with higher incomes consume a greater number of distinct food products. This issue has generally not been examined for developing or emerging economies, an exception being Moon *et al*. (2002), who analyzed data from Bulgaria. Moon *et al.* (2002) found that household income has a positive and statistically significant impact on the degree of variety in a household's food consumption basket measured over a day, a week, and a month.

52. Behrman and Deolalikar (1989) used cross-country data to examine how the curvature of consumers' indifference curves among nine major food groups changes as incomes increase. For the poorest subsample of countries they investigate, their estimated elasticity of substitution across the nine different food groups is 1.25, which is greater than the Cobb-Douglas case (1). Within this subsample, consumers quite readily substitute among different food groups as food prices change. For the next-poorest subsample of countries, their estimated elasticity of substitution is only 0.28, which is close to Leontief (0). They concluded that as food budgets increase from very low levels, the demand for food variety increases rapidly, with food indifference curves changing from relatively flat to nearly L-shaped (different food groups consumed in fixed proportions). This would imply that differences among food groups in income and price elasticities of demand become smaller as *per capita* income increases.

53. One implication of the demand for food variety concerns how nutrient intakes change as income changes. A common finding of studies in this area is that household nutrient intakes are less responsive than household food expenditures to changes to household income. In the case of India, Subramanian and Deaton (1996) found that the elasticity of caloric intake with respect to income is about one-half the income elasticity of total food consumption, due largely to consumer shifts toward more expensive food groups (such as meat) as income increases. For Mexico, Skoufias *et al.* (2009) find that the elasticity of caloric intake with respect to household income is essentially zero, even for households near the bottom of the income distribution. On the other hand, for some nutrients (fats, vitamins A and C, iron, and calcium), Skoufias *et al.* (2009) obtain large and statistically significant income elasticities. These are also the nutrients for which they find the largest deficiencies among the poorest households in their sample.

IV. Effects of economic growth on price and income elasticities of demand for agricultural products

54. It is well-known that income and price elasticities of demand in OECD countries for most agricultural products are low. By contrast, many of the elasticities estimated by the studies reviewed in Section II of this report are relatively large, especially for meat, seafood, and dairy products. This raises the question of rapidly price and income elasticities of demand for agricultural products in large developing and emerging economies are moving toward the low elasticities seen in OECD countries.

a) Why many existing studies cannot answer this question

55. All studies estimating price and income elasticities of demand for food and agricultural products make assumptions about the way in which prices and income influence demand. The results of each study depend on its assumptions and the data analyzed. There is no way to avoid assumptions; without them there would no strategy for analyzing the data and no framework for interpreting the econometric results. However, many existing studies make assumptions that call into question their ability to project the effects of economic growth on price and income elasticities of demand for agricultural products.

56. In recent years one popular demand system for modeling food and agricultural product consumption has been Deaton and Muellbauer's (1980) Almost Ideal Demand System (AIDS). Within this

category many studies have estimated the linear approximation of the AIDS model (LA/AIDS) (Asche and Wessells 1997). Others have used the AIDS model as the second stage of a two-stage demand system in which expenditures among broad groups of goods (food, housing, etc.) are determined at the first stage according to a system such as the linear expenditure system (LES), and then the allocation of food expenditures among specific food products is determined at the second stage according to the AIDS model. Several of the studies reviewed in Section II of this report use the AIDS or LA/AIDS models.

Consider a consumer with an expenditure function defined by

$$\ln x = a(\boldsymbol{p}) + ub(\boldsymbol{p}), \quad (1)$$

where x is the consumer's income, $a(\boldsymbol{p})$ and $b(\boldsymbol{p})$ are functions of prices for n goods facing the consumer, and u is the consumer's utility. In the AIDS model,

$$a(\boldsymbol{p}) = \alpha_0 + \sum_k \alpha_k \ln p_k + \tfrac{1}{2}\sum_k \sum_l \gamma_{kl} \ln p_k \ln p_l , \quad (2)$$

$$b(\boldsymbol{p}) = \beta_0 \prod_k p_k^{\beta_k} , \quad (3)$$

where the α 's, β 's, and γ 's are parameters satisfying

$$\sum_k \alpha_k = 1,\ \gamma_{kl} = \gamma_{lk},\ \sum_k \beta_k = \sum_k \gamma_{kl} = \sum_l \gamma_{kl} = 0 . \quad (4)$$

It can be shown that the AIDS model yields budget shares (s_i), Marshallian price elasticities of demand (e_{ij}), and income elasticities of demand (e_i) of the form

$$s_i = \alpha_i + \sum_k \gamma_{ik} \ln p_k + \beta_i \ln\left(x/a(\boldsymbol{p})\right), \quad (5)$$

$$e_{ij} = \frac{\gamma_{ij} - \beta_i\left[s_j - \beta_j \ln\left(x/a(\boldsymbol{p})\right)\right]}{s_i} - \delta_{ij}, \quad (6)$$

$$e_i = 1 + \frac{\beta_i}{s_i}, \quad (7)$$

where δ_{ij} in equation (6) is the Kronecker delta with $\delta_{ij} = 1$ if $i = j$ and $\delta_{ij} = 0$ if $i \neq j$.

57. One advantage of the AIDS model is that it is a flexible functional form, meaning that it has enough parameters to estimate all of the price and income elasticities for a given set of goods. When applied to data from a given point in time, this means that the AIDS model has the potential to perform well in estimating price and income elasticities of demand at that time. When applied to data over a given time interval, the AIDS model has the potential to perform well in estimating elasticities, on average, over that interval.

58. However, the AIDS model is likely to perform poorly in characterizing how price and income elasticities of demand change over time as income changes. The income elasticity of demand for every good in the AIDS model becomes smaller as income increases:

$$\frac{\partial e_i}{\partial \ln x} = -\frac{\beta_i^2}{s_i^2} < 0 . \tag{8}$$

For a good that is a luxury ($\beta_i > 0$, $e_i > 1$), its income elasticity of demand will decline toward one over time as income increases. This occurs through an increase over time in the good's budget share s_i. A good that is initially a luxury can never become a necessity in the AIDS model, because if the parameter β_i is positive, then e_i will always be greater than one. For a good that is initially a necessity ($\beta_i < 0$, $0 < e_i < 1$), its income elasticity of demand will decline over time income as its budget share shrinks with higher income. The good will eventually become inferior ($e_i < 0$) once its budget share becomes sufficiently small, and continued increases in income will drive its consumption toward zero.

The impacts of an increase in income on own- and cross-price elasticities of demand are as follows:

$$\frac{\partial e_{ii}}{\partial \ln x} = -\frac{\beta_i\left(1+e_{ii}\right)}{s_i}, \tag{9}$$

$$\frac{\partial e_{ij}}{\partial \ln x} = -\frac{\beta_i e_{ij}}{s_i}, \; i \neq j . \tag{10}$$

For a good that is a luxury ($\beta_i > 0$) and has an inelastic own-price demand ($-1 < e_{ii} < 0$), its own-price elasticity will decline over time as income increases. If the luxury good has an elastic own-price demand ($e_{ii} < -1$), its own-price elasticity will increase over time as income increases. In either case, the own-price elasticity of demand will move toward -1. For a good that is a necessity ($\beta_i < 0$) and has an inelastic own-price demand, its own-price elasticity will increase over time as income increases. For a necessity with an elastic own-price demand, its own-price elasticity will decrease as income increases. Cross-price elasticities of demand for a luxury good will move toward zero as income increases, while cross-price elasticities for a necessity will move away from zero toward plus or minus infinity.

59. In sum, consumption of goods that are initially necessities or inferior goods in the AIDS model will eventually be driven to zero as income increases. Demands for goods that are initially luxuries will be driven toward a situation where their income elasticities are all 1, their own-price elasticities are all -1, and their cross-price elasticities are all 0. In other words, as income increases the AIDS model approaches a Cobb-Douglas utility function with respect to goods initially classified as luxuries by the model.

60. Computationally, the AIDS model also has the well-known limitation that the budget shares predicted by equation (5) can move outside of the [0, 1] interval as income and prices change, even if they are initially all within that interval. For example, a good that is a necessity or inferior and has a small initial budget share may see its predicted share become negative as income increases.

61. Lewbel (1991) discusses the concept of the rank of a demand system. A demand system has a rank of one if budget shares are independent of income, such as with a Cobb-Douglas or CES utility function. The limitations of these types of utility functions are well-known. A demand system has a rank of two if it is what Lewbel refers to as "generalized linear." Generalized linearity is necessary and sufficient for demand functions aggregated across consumers to resemble those of a representative consumer. The AIDS model, the translog indirect utility function, and the linear expenditure system are rank two systems. All rank two demand systems are limited in their ability to model changes in consumption as income changes.

62. Rank three systems permit more general Engel curves that are more consistent with actual demand patterns than rank two systems. Examples of rank three systems include the implicit, directly additive demand system (AIDADS), which is a generalization of the linear expenditure system (LES) (Rimmer and Powell 1996); the quadratic expenditure system (QES), which is also a generalization of the LES (Howe *et al.* 1979); and the quadratic AIDS model (QUAIDS), in which budget shares depend not only on the log of income as in equation (5) but also on the square of the log of income (Banks *et al.* 1997). The tradeoff is that rank three demand systems have more parameters to be estimated, which can lead to econometric difficulties. Cranfield *et al.* (2003) compare the ability of several rank two and three demand systems to predict consumer budget shares across countries, both in and out of sample. They find that rank three systems are superior to rank two systems, and that among rank three systems AIDADS and QUAIDS perform best, followed closely by QES.

63. However, rank three systems can present their own issues with regard to modeling consumer responses to changes in income. Of the rank three systems used in the studies reviewed in Section II of this report, the most popular is QUAIDS. The QUAIDS model adds a quadratic term in the log of income to equation (5), so that the budget shares become:

$$s_i = \alpha_i + \sum_k \gamma_{ik} \ln p_k + \beta_i \ln\left(\frac{x}{a(\boldsymbol{p})}\right) + \frac{\lambda_i}{b(\boldsymbol{p})}\left[\ln\left(\frac{x}{a(\boldsymbol{p})}\right)\right]^2, \tag{11}$$

where the λ's are parameters satisfying

$$\sum_k \lambda_k = 0. \tag{12}$$

Income elasticities of demand in the QUAIDS model are:

$$e_i = 1 + \frac{\theta_i}{s_i}, \tag{13}$$

where

$$\theta_i = \beta_i + \frac{2\lambda_i}{b(\boldsymbol{p})} \ln\left(\frac{x}{a(\boldsymbol{p})}\right). \tag{14}$$

The QUAIDS model reduces to the AIDS model if all the λ's are zero.

64. The QUAIDS model can encounter difficulties if the true relationship between budget shares and the log of income is not quadratic. Consider the relationship illustrated in Figure 1. The budget share initially starts at a relatively high level, and then declines in a quadratic-like manner with respect to the log of income until reaching an inflection point. Beyond that point, the budget share declines gradually toward zero as income increases.

65. Figure 2 superimposes three possible QUAIDS models (Options A, B, and C) upon Figure 1. Option A, in which $\beta_i > 0$ and $\lambda_i < 0$, closely replicates the true relationship between the budget share and income up until the inflection point. Beyond that point, it is not capable of predicting a gradual decline in the budget share toward zero. Instead it eventually predicts a negative budget share, with the budget share becoming more negative as income increases. Because the predicted budget share beyond the inflection point is too low, the predicted income elasticity of demand from equation (13) will be too high. Option B, in which $\beta_i < 0$ and $\lambda_i > 0$, does better than Option A beyond the inflection point but over-predicts the budget share at low levels of income. For sufficiently low incomes, option B could predict a budget share greater than one. Because the predicted budget share at low levels of income is too high, the predicted income elasticity of demand from equation (13) will be too low.

66. Which of the two options will perform best, on the whole, depends on the frequency distribution of income in a given dataset. If most of the observations are at low levels of income, then econometric estimation will lead to results along the lines of Option A. If most of the observations are at high levels of income, then the econometric results will be along the lines of Option B. If the dataset contains observations equally distributed among low and high levels of income, then neither Option A nor B may emerge from the econometric estimation. Instead the result may be like Option C in Figure 2 ($\beta_i < 0$ and $\lambda_i \approx 0$). In this case the QUAIDS model is similar to the AIDS model, at least for that good.

b) Studies on economic growth and changing demand elasticities

67. Yu *et al.* (2003) econometrically estimated the AIDADS demand system using international, cross-section data for 1985 for nine groups of goods, including five food groups: cereals, livestock products, horticultural and vegetable products, fish, and other food. They incorporated their demand system into GTAP, a well-known computable general equilibrium (CGE) model. They aggregated the version 4 GTAP database into 13 regions, including China, ASEAN (six ASEAN countries - Singapore, Malaysia, Indonesia, Thailand, the Philippines and Vietnam), MERCOSUR (Argentina, Brazil and Uruguay), and Transition Economies (Central and East Europe and the former Soviet Union). The one BRIIC country not included in the regions just listed, India, is part of a Rest of World region. Yu *et al.* (2003) ran the GTAP model forward to 2020 to obtain projected values of income elasticities of demand for the nine goods in their model. Their assumptions about economic growth and their results for the five food groups are shown in Table 30. The elasticities for the Transition Economies may be called into question because these countries had highly regulated economies with little room for consumer choice in 1985, and the projected elasticities for 2020 are based on the 1985 values.

68. Yu *et al*. (2003) assume an annual growth rate in real GDP *per capita* for China of 5.8%, which is significantly lower than China's actual growth rate during the last decade and its projected growth rate for 2010-2019 by the US Department of Agriculture (2010a). This would suggest that income elasticities of demand in China in 2020 will be even lower than Yu *et al*.'s (2003) projections. Similarly, their assumed growth rate in real GDP *per capita* in the Transition Economies is significantly less than the actual growth rate during the last decade and the projected future growth rate by the USDA (2010a). Their assumed growth rate for the Rest of World region is much less than India's over the last decade and India's projected growth rate by the USDA (2010a), so that income elasticities of demand for India may decline more by 2020 than the declines they show for the Rest of the World.

69. Yu *et al.* (2003) project that some income elasticities of demand will increase over time, such as income elasticities for livestock products in ASEAN, MERCOSUR, and the Transition Economies. It is unclear whether these projections are plausible or a by-product of their modeling approach. AIDADS shares the unfortunate property with the linear expenditure system (LES) that income elasticities of demand for all goods in the model eventually converge to one as income increases. Yu *et al.* (2003) indicate that this convergence occurs much more rapidly for LES than for AIDADS, but nonetheless their results in these cases might partly reflect this convergence property. On the other hand, the studies of meat and seafood demand for urban China reviewed in Section II suggest that income elasticities for these products may have increased over time. If households purchase refrigerators once they reach a certain level of income, it follows that they are more likely to purchase food items requiring refrigeration such as meat, dairy, and seafood products.

70. Seale and Regmi (2006) econometrically estimated a two-stage-demand system with the Florida-PI model (first stage) and Florida-Slutsky model (second stage) using 1996 cross-country data for 114 countries for nine broad categories of goods and eight food subcategories.[3] The eight food subcategories are beverages and tobacco, cereals, meat, fish, dairy, oils and fats, fruits and vegetables, and other food. They list income elasticities of demand for these subcategories for 14 selected countries. Their results for seven of these 14 countries are shown in Table 31, along with PPP (purchasing power parity) converted real *per capita* GDP for each country in 1996, at 2005 prices (Heston *el al.* 2009). The seven countries span the range from lowest to highest *per capita* GDP among the 14 listed by Seale and Regmi (2006), and are sufficient to illustrate the nature of the results that they obtain.

71. Seale and Regmi (2006) note that the structure of the Florida-Slutsky model makes it inappropriate for cross-country comparisons of Marshallian price elasticities of demand, and they do not report those elasticities. However, this can be done for the first-stage Florida-PI model. Income and own-price elasticities for food, beverages, and tobacco as a whole for the seven countries are shown in Table 32.

72. Seale and Regmi's (2006) results indicate that estimated income elasticities of demand for all eight food products decline as *per capita* income increases. The decline is largest for beverages and tobacco, and smallest for cereals, oils and fats, and fruits and vegetables. For every food product except beverages and tobacco, estimated income elasticities decline gradually until *per capita* income reaches a high level, at which point they decline sharply with further increases in income. For food, beverages, and tobacco as a whole, both the estimated income elasticity and the absolute value of the estimated own-price elasticity decline as *per capita* income increases.

73. The studies by Yu *el al.* (2003) and Seale and Regmi (2006) are in agreement that income elasticities of demand generally decline as income increases. However, they do not agree with respect to the magnitude and nature of the decline. For example, Seale and Regmi (2006) find a relatively large (0.19) income elasticity of demand for cereals for France and, by extension, other countries with a similar *per capita* income. It is difficult to see how the income elasticity for cereals could be so large in a high-income country. The results in Yu *el al.* (2003) for cereals appear to be more plausible. They project that its income elasticity will be nearly zero by 2020 in ASEAN, MERCOSUR, and the Transition Economies. And if a higher growth rate in *per capita* income were applied for China, its income elasticity for cereals would be significantly lower in 2020 than they project.

74. Yu *el al.* (2003) project that income elasticities of demand for livestock products in ASEAN, MERCOSUR, and the Transition Economies will increase between 1985 and 2020. They also project increases in income elasticities for horticultural and vegetable products between 1985 and 2020 in

3 Seale and Regmi (2006) is a revised version of an earlier study using the same dataset and similar methodology by Seale *et al.* (2003).

MERCOSUR and the Transition Economies. Seale and Regmi (2006) find that estimated income elasticities for meat, dairy, and fruits and vegetables decline as *per capita* income increases, over the entire range of *per capita* income in their dataset.

V. Implications for agricultural markets

a) Agricultural commodity prices

75. Over time, trends in real global agricultural commodity prices depend on how quickly global demand is shifting outward relative to global supply. Global demand growth depends on growth in *per capita* income, the responsiveness of demand to *per capita* income, and growth in population. This report is not directed at trends in global population or global agricultural supplies, but it does address the effects of *per capita* income growth on agricultural demand.

76. The studies reviewed in this report suggest that future growth in *per capita* food demand for cereals in the BRIIC countries is likely to be minimal and could be negative. *Per capita* food demand for wheat and rice in the BRIIC countries during the past decade has generally been flat or declining. For Brazil, the study that is most consistent with these trends is Menezes *el al.* (2008), who estimated an income elasticity of demand in urban areas for wheat of 0.24 and for rice and beans of 0.09. For Russia, the results in Shiptsova *el al.* (2004) are most consistent with these trends, with low estimated income elasticities for bread, flour, and pasta. For India, the study most consistent with recent trends is Mittal (2006), who estimated a relatively low income elasticity of 0.17 for cereals. For Indonesia, Fabiosa and Jensen's (2003) estimate of the income elasticity for cereals is 0.02. For China, Gale and Huang (2007) estimated an income elasticity of demand for cereals of 0.06 in rural areas and -0.09 in urban areas. Yu *el al.* (2003) project that the income elasticity for cereals will be nearly zero by 2020 in ASEAN, MERCOSUR, and the Transition Economies.

77. For meat and seafood products, the studies reviewed here suggest that future growth in *per capita* food demand for beef is likely to be significant in Brazil, India, and Indonesia, but small in Russia and China. For pork and chicken, future growth in *per capita* food demand is likely to be significant in all countries except China. Examining recent trends in *per capita* consumption of beef and veal in the Brazil, the study most consistent with these trends is Pintos-Payeras (2009), who estimated income elasticities of 0.73 for high quality beef and 0.41 for lower quality beef. For pork and chicken, the study most consistent with recent trends is Coelho and de Aguiar (2007), who estimated income elasticities of 1.21 for pork and 1.10 for chicken. In the case of Russia, the study most consistent with recent trends for beef is Goodwin *el al.* (2003), who estimated an income elasticity of 0.25. The study most consistent with recent trends for pork and chicken is Elsner (1999), who estimated income elasticities of 0.72 and 0.67, respectively. For India, the estimated income elasticities for meat, fish, and eggs of 0.95 in Chatterjee *el al.* (2007) and 1.30 in Mittal (2006) are both reasonably consistent with recent trends in consumption. For Indonesia, Deaton's (1990) estimated income elasticity of 2.30 for beef is consistent with recent trends. In the case of China, Gale and Huang (2007), Gould (2002), and Zhang and Wang (2003) generally find income elasticities for beef, pork, and poultry in the 0.1-0.4 range, figures that are consistent with recent consumption trends.

78. Studies for urban China imply that income elasticities of demand for beef, pork, and poultry may be rising over time. Yu *el al.* (2003) project that income elasticities for livestock products will increase by 2020 in ASEAN, MERCOSUR, and the Transition Economies.

79. For dairy products, the studies reviewed here suggest that future growth in *per capita* food demand is likely to be significant in Brazil, Indonesia, and especially China. For Russia and India the evidence is mixed on future demand growth. For Brazil estimated income elasticities for dairy products by

Coelho and de Aguiar (2007) and Menezes *el al.* (2008) are in the 0.7-1.2 range. For Indonesia, there are two estimated income elasticities, 0.62 (Fabiosa and Jensen 2003) and 0.71 (Jensen and Manrique 1998). Larger differences in estimated income elasticities among studies are seen for China, but many of them are greater than one, which is consistent with recent trends in dairy products consumption in China. For Russia and India, *per capita* dairy products consumption has grown only modestly over the past decade. These trends are not consistent with the estimated income elasticities for dairy products for these two countries, which are generally close to one or greater than one.

80. With regard to fruits and vegetables, the studies reviewed here suggest that *per capita* food demand may grow significantly for many types of fruits and vegetables. Examples include citrus fruits, bananas, grapes, and pears in China, for which Shono *el al.* (2000) estimate income elasticities of demand of about one. Studies for the other BRIIC countries generally estimate income elasticities for all fruits, all vegetables, or all fruits/vegetables. Some of these estimates are close to or greater than one, but they do not indicate which specific products are highly responsive to income.

81. For sugar, the studies reviewed here suggest that future growth in *per capita* food demand is likely to be significant in Russia, India, and China. The average estimated income elasticity of demand for Russia, across two studies, is 0.80, while the average across two studies for China is 0.75 and across two studies for India is 0.64. The studies for Brazil report smaller estimated income elasticities, and there are no studies on sugar demand for Indonesia.

82. For fats and oils, the studies reviewed here suggest that future growth in *per capita* food demand is likely to be significant in Russia. The one available study for Russia, Elsner (1999), estimates the income elasticity of demand for fats and oils to be 0.91. The evidence is mixed for China. *Per capita* domestic food use of soy oil has increased 12% annually since 2000, but the one study that includes soy oil as a separate product (Fang and Beghin 2002) estimates its income elasticity as only 0.17. On the other hand, the estimate of 0.10 for rapeseed oil in Fang and Beghin (2002) is consistent with its 1.5% annual increase in *per capita* domestic food use since 2000, and the estimate of 0.17 for peanut oil is in reasonable agreement with its *per capita* domestic food use, which has declined somewhat since 2000. Estimated income elasticities of demand for Brazil, India, and Indonesia tend to be low.

83. In India, *per capita* domestic food use of palm oil has increased 3.6% annually since 2000, while real *per capita* GDP has increased 5.5% annually during this period. Leaving aside other variables influencing consumption, this suggests an income elasticity of demand of somewhat more than 0.5. The estimate of 0.25 in Pan *el al.* (2008) is somewhat lower. Similarly, the estimate in Pan *el al.* (2008) for the income elasticity of demand for rapeseed oil of 0.06 is lower than that suggested by *per capita* domestic food use, which has also increased 3.6% annually since 2000.

84. This report does not examine feed demand for cereals, oilseeds, or other agricultural commodities. Of course, projections for feed demand depend on projected growth in demand for livestock products, and the income and price elasticities of consumer demand for meat and dairy products reviewed in this report can help inform those projections.

b) Agricultural commodity price volatility

85. Agricultural commodity price volatility can arise from macroeconomic factors, microeconomic factors, or a combination of the two. Macroeconomic factors that can play a role include oil prices, interest rates, inflation rates, and exchange rates. Microeconomic factors consist of shocks to demand or supply specific to the agricultural sector. This report is not directed at any of the macroeconomic factors, but the studies reviewed here do have something to say about how the microeconomic factors may change with continued economic growth in developing and emerging economies.

86. As economic growth continues in developing and emerging economies, the studies reviewed in this report indicate that income elasticities of demand for agricultural commodities are likely to decline, at least for most commodities. These declines in demand elasticities will dampen shocks to demand due to recessions, financial crises, or economic booms. In the limiting case, where all income elasticities of demand for agricultural commodities are zero, shocks to income have no impact on agricultural commodity demands.

87. On the other hand, continued economic growth in developing and emerging economies may lead to greater commodity price volatility from shocks to supply. The homogeneity requirement for consumer demands from economic theory states that the income elasticity of demand plus the sum of the own-price and all-cross price elasticities of demand must equal zero. In terms of the notation used earlier,

$$e_i + e_{ii} + \sum_{j \neq i} e_{ij} = 0 \,. \qquad (15)$$

88. As the income elasticity of demand for a commodity declines toward zero, the sum of its own-price and all cross-price elasticities must also approach zero. Looking at the studies in Tables 1-29 for which there are estimates of both the income and own-price elasticities, the correlation coefficient across all studies, commodities, and countries between the income elasticity and the absolute value of the own-price elasticity is 0.35. This indicates that there is some tendency for the absolute value of the own-price elasticity to decline as the income elasticity declines. For food, beverages, and tobacco as a whole, Seale and Regmi (2006) find that both the estimated income elasticity and the absolute value of the estimated own-price elasticity decline as *per capita* income increases.

89. A decline in the absolute value of the own-price elasticity means a more-price inelastic demand, causing any given shock to supply to lead to a larger change in the price. For example, if supply of an agricultural commodity is reduced because of a drought, a more price-inelastic demand means that the price must increase by more in order to bring demand into line with the reduced supply. If supply increases because of unusually good weather, a more price-inelastic demand means that the price must fall by more in order to induce consumers to purchase the additional supply.

90. At the same time, just as the absolute value of the own-price elasticity of demand is likely to decline as the income elasticity declines toward zero, cross-price elasticities of demand will also tend to move toward zero. This implies that a supply shock specific to one commodity will have smaller spill over effects on demands, and therefore prices, of other commodities. For example, if the cross-price elasticity of demand for rice with respect to the price of wheat is small, and if there is a drought in wheat-growing regions but not rice-growing regions, then the impact of the drought on rice markets will be minimal. If the cross-price elasticity is large, the drought's impacts on rice markets could be significant.

91. Although beyond the scope of this report, an analysis of the effects of economic growth in developing and emerging economies on agricultural commodity price volatility should consider how agricultural policies in these countries may change. For a variety of political economy reasons, agricultural policy tends to become more protective of the agricultural sector as *per capita* income increases (Swinnen 2009). During the commodity price spike of 2007-2008, as well as during previous spikes in the 1970s and 1990s, policy responses in both importing and exporting countries designed to shield domestic markets from world price changes amplified world price volatility (Peters *el al.* 2009).

VI. Recommendations for the AGLINK-COSIMO Model

92. Three principal recommendations emerge from this report for the AGLINK-COSIMO model. First, income and price elasticities of consumer demand for the BRIIC countries may need to be updated based upon recent research. Economists' stock of knowledge about demand and supply elasticities for agricultural commodities turns over slowly. Many of the elasticities in use even today can be traced back to elasticities used in the US Department of Agriculture's SWOPSIM model from the 1980s, which in turn was based in large part on studies from the 1960s and 1970s. The studies reviewed here suggest that income elasticities of demand for most agricultural products have been declining in the BRIIC countries, with the possible exceptions of meat and dairy products. Using old demand elasticities for products such as cereals could significantly overstate the responsiveness of demand to economic growth.

93. Many of the studies listed in Tables 1-29 of this report were published within the past four years, and many of these studies fill in gaps where there had been no studies using recent data. For example, all of the studies estimating demand elasticities for Brazil, for every agricultural product, were published since 2007. All of the studies estimating demand elasticities for meat and seafood in India were published since 2006. Even in the case of China, where there are a large number of studies for most agricultural products, more recent studies yield results that are often at odds with studies using older data. For example, of the seven studies estimating the income elasticity of demand for cereals in rural areas of China, six of them used data from the 1980s or first half of the 1990s, and the average estimated income elasticity across these six studies was 0.62. One study (Gale and Huang 2007) used data since 2000 and obtained an estimate of 0.06. For urban areas of China, the average estimated income elasticities of demand for pork and beef across studies using data prior to 2000 are 0.44 and 0.46, respectively; for studies using data since 2000 the corresponding averages are 0.87 and 0.84.

94. Second, income and price elasticities of consumer demand are not constant over time, but should be permitted to change in the AGLINK-COSIMO model as *per capita* income changes. One option would be to incorporate a rank three demand system into the model. However, as was illustrated in the case of the QUAIDS model, rank three demand systems can present econometric and computational difficulties. A simpler option would be to start with the current demand side of the model, which is straightforward - demands are constant-elasticity functions of prices and *per capita* incomes. Instead of keeping those elasticities constant, they could be made functions of *per capita* income (for example, an elasticity that is a linear function of the log of *per capita* income or the reciprocal of *per capita* income). The parameters of these functions would need to be calibrated in an appropriate manner so that elasticities for each country and region in the model change in a plausible way over time.

95. Third, the AGLINK-COSIMO model would benefit from a periodic review of new literature estimating demand and supply elasticities, with the elasticities in the model updated as needed. The studies for the BRIIC countries reviewed in this report suggest that an annual review of the literature is probably not warranted; the number of new studies published each year is too small. However, over a period of four or five years, the literature can evolve significantly. Other organizations such as FAPRI that have their own models requiring the same or similar elasticities as AGLINK-COSIMO may also be helpful in keeping the elasticities up to date.

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Figure 1. Income and budget shares for food products

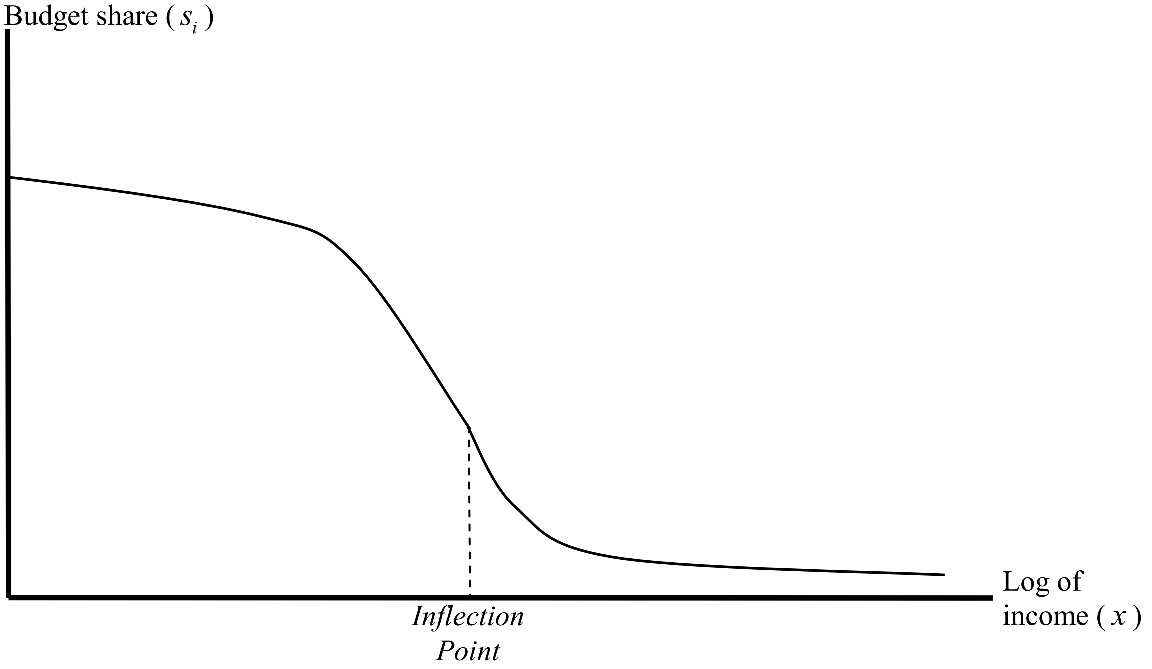

Figure 2. Fitting the QUAIDS Model to Figure 1

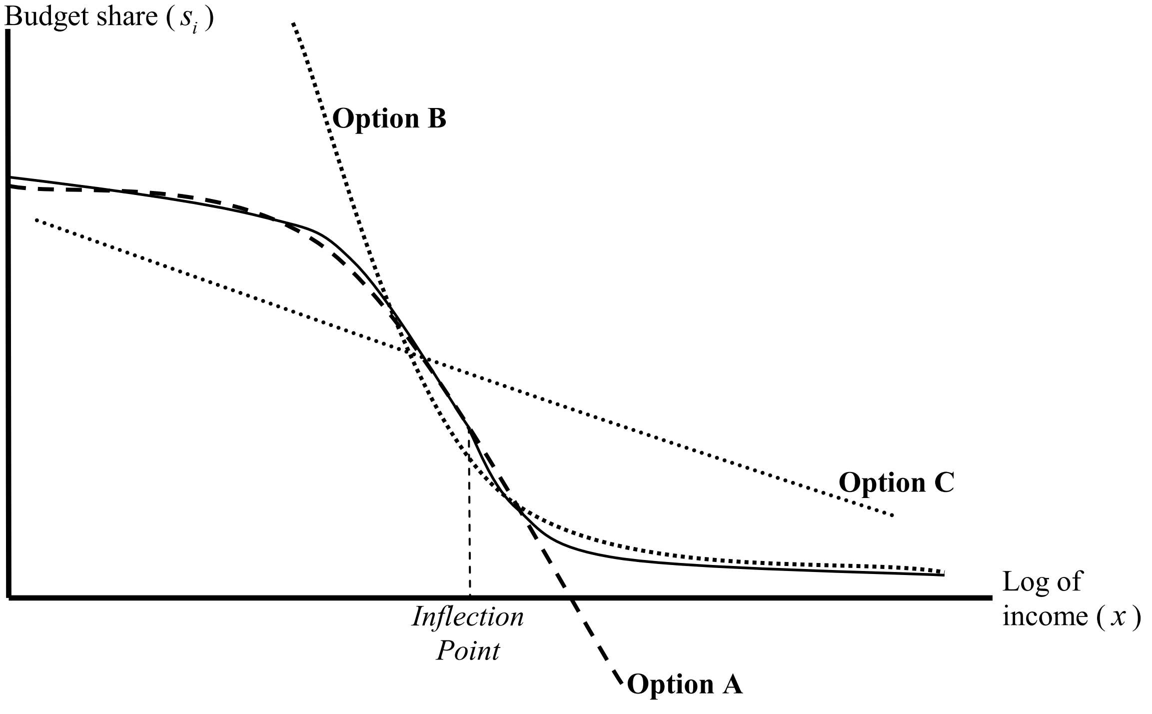

Table 1. Demand elasticities for cereals: Brazil

	Data analyzed					Study results	
Study	**Time period**	**Rural, urban, or both**	**Cross section, time series, pooled, or panel**	**Demand system**	**Commodity**	**Income elasticity**	**Own-price elasticity**
Coelho and de Aguiar (2007)	2002/03	Both	Cross Section	QUAIDS	Rice	1.26	-1.66
					Noodles	1.41	-1.35
					Bread	0.47	-0.89
Menezes *el al.* (2008)	1987/88, 1995/96	Urban	Pooled	Two-Stage LA/AIDS-LA/AIDS	Wheat	0.24	-0.92
					Rice and Beans	0.09	-0.80
Pintos-Payeras (2009)	2002/03	Both	Cross Section	AIDS	Rice	0.31	*
					Other Cereals	0.35	*

Notes: — indicates that the study did not estimate price elasticities of demand

* indicates that the study estimated price elasticities, but the own-price elasticity could not be determined based on the published information

AIDS: Almost Ideal Demand System (Deaton and Muellbauer 1980)

DAIDS: Dynamic AIDS Model (Ray 1984)

LA/AIDS: Linear Approximation to AIDS Model (Deaton and Muellbauer 1980)

LES: Linear Expenditure System (Deaton and Muellbauer 1980)

LINQUAD: Linear-in-Income, Quadratic-in-Prices Demand System (LaFrance *el al.* 2002)

GLES: Generalized LES Model (Blundell and Ray 1984)

QUAIDS: Quadratic AIDS Model (Banks *el al.* 1997)

Table 2. Demand elasticities for cereals: Russia

	Data analyzed					Study results	
Study	**Time period**	**Rural, urban, or both**	**Cross section, time series, pooled, or panel**	**Demand system**	**Commodity**	**Income elasticity**	**Own-price elasticity**
Elsner (1999)	1996	Both	Cross Section	Three Stage, LA/AIDS at Second and Third Stages	Bread	0.51	-0.69
					Rice and Grain	0.44	-0.97
					Flour and Pasta	1.07	-1.80
Shiptsova *el al.* (2004)	1996	Urban	Cross Section	LA/AIDS	Bread	0.13	-0.82
					Flour	0.13	-0.63
					Rice	0.08	-0.44
					Pasta	0.07	-0.53

Note: See notes to Table 1.

Table 3. Demand elasticities for cereals: India

	Data analyzed					Study results	
Study	**Time period**	**Rural, urban, or both**	**Cross section, time series, pooled, or panel**	**Demand system**	**Commodity**	**Income elasticity**	**Own-price elasticity**
Chatterjee *el al.* (2007)	1987/88, 1993/94, 1999/2000	Rural	Pooled	Two Stage, QUAIDS at Second Stage	Rice	0.45	*
					Wheat	0.68	*
					Other Cereals	0.48	*
Meenakshi and Ray (1999)	1972/73, 1977/78, 1983, 1987/88	Rural	Pooled	Two Stage, QUAIDS at Second Stage	Cereals	0.52	*
		Urban				0.35	*
Mittal (2006)	1983, 1987/88, 1993/94, 1999/2000	Both	Pooled	Two Stage, QUAIDS at Second Stage	Cereals	0.17	-0.48

Note: See notes to Table 1.

Table 4. Demand elasticities for cereals: Indonesia

	Data analyzed					Study results	
Study	**Time period**	**Rural, urban, or both**	**Cross section, time series, pooled, or panel**	**Demand system**	**Commodity**	**Income elasticity**	**Own-price elasticity**
Deaton (1990)	1981	Rural	Cross Section	AIDS	Rice	0.49	-0.42
					Wheat	1.57	-0.69
					Maize	0.09	-0.82
Fabiosa and Jensen (2003)	1996	Both	Cross Section	LINQUAD	Cereals	0.02	-0.43
Jensen and Manrique (1998)	1981, 1984, 1987	Both	Pooled	LA/AIDS	Rice	0.10	-0.58
Teklu and Johnson (1988)	1980	Urban	Cross Section	LA/AIDS	Rice	0.33	-0.58

Note: See notes to Table 1.

Table 5. Demand elasticities for cereals: China

	Data analyzed					Study results	
Study	**Time period**	**Rural, urban, or both**	**Cross section, time series, pooled, or panel**	**Demand system**	**Commodity**	**Income elasticity**	**Own-price elasticity**
Dong and Gould (2007)	2001	Urban	Cross Section	QUAIDS	Rice	0.97	-0.63
					Other Cereals	0.64	-1.01
Fan *el al.* (1994)	1982-1990	Rural	Pooled	DAIDS	Rice	0.31	-0.55
					Wheat	0.59	-0.46
					Coarse Cereals	0.03	-0.46
Fan *el al.* (1995)	1982-1990	Rural	Pooled	Two-Stage LES-AIDS	Rice	0.50	-0.63
					Wheat	0.77	-0.54
					Coarse Cereals	0.26	-0.24
Gale and Huang (2007)	2002-2003	Rural	Pooled	None (Unlinked)	Cereals	0.06	—
		Urban			Cereals	-0.09	—
Gao *el al.* (1996)	1990	Rural	Cross Section	Two-Stage GLES-QUAIDS	Cereals	0.52	-0.99
Gould (2002)	1995-1997	Urban	Pooled	Two-Stage, Translog at Second Stage	Cereals	0.25	*
Gould and Villarreal (2006)	2001	Urban	Cross Section	QUAIDS	Rice	1.16	-0.64
Huang and Rozelle (1998)	1993-1994	Rural	Cross Section	LA/AIDS	Cereals	0.86	-0.57
Katchova and Chern (2004)	1994	Rural	Cross Section	AIDS	Cereals	0.87	-0.55
Liao and Chern (2007)	2002-2003	Urban	Panel	DAIDS	Cereals	0.54	-0.73
Shono *el al.* (2000)	1995	Urban	Cross Section	None (Unlinked)	Cereals	0.08	—
Yan and Chern (2005)	1995	Rural	Cross Section	QUAIDS	Cereals	0.97	-0.74
Ye and Taylor (1995)	1989	Rural	Cross Section	Two Stage, AIDS at Second Stage	Cereals	0.26	—
Yen *el al.* (2004)	2000	Urban	Cross Section	Translog	Cereals	0.82	-0.90
Zhang *el al.* (2001)	1986-1995	Rural	Panel	AIDS	Cereals	0.26	-0.31
Zhang and Wang (2003)	1998	Urban	Cross Section	Two-Stage AIDS-AIDS	Rice	0.44	-1.26
					Wheat	0.55	-1.90

Note: See notes to Table 1.

Table 6. Demand elasticities for meat and seafood: Brazil

Data analyzed						Study results	
Study	**Time period**	**Rural, urban, or both**	**Cross section, time series, pooled, or panel**	**Demand system**	**Commodity**	**Income elasticity**	**Own-price elasticity**
Coelho and de Aguiar (2007)	2002/03	Both	Cross Section	QUAIDS	Beef (high quality)	1.57	-0.82
					Beef (lower quality)	1.12	-1.21
					Chicken	1.10	-0.91
					Pork	1.21	-1.67
Menezes *el al.* (2008)	1987/88, 1995/96	Urban	Pooled	Two-Stage LA/AIDS-LA/AIDS	Beef	0.65	-0.92
					Pork	0.84	-0.87
Pintos-Payeras (2009)	2002/03	Both	Cross Section	AIDS	Beef (high quality)	0.73	*
					Beef (lower quality)	0.41	*
					Chicken	0.38	*
					Other Meat	0.47	*
					Seafood	0.52	*

Note: See notes to Table 1.

Table 7. Demand Elasticities for Meat and Seafood: Russia

Data analyzed						Study results	
Study	**Time period**	**Rural, urban, or both**	**Cross section, time series, pooled, or panel**	**Demand system**	**Commodity**	**Income elasticity**	**Own-price elasticity**
Elsner (1999)	1996	Both	Cross Section	Three Stage, LA/AIDS at Second and Third Stages	Beef and Veal	1.06	-1.21
					Pork	0.72	-0.97
					Poultry	0.67	-0.91
					Processed Meat and Sausages	0.48	-1.12
					Other Meat and Fish	1.16	-1.30
Goodwin *el al.* (2003)	1996	Urban	Cross Section	LES	Beef	0.25	-0.41
					Pork	0.29	-0.17
					Chicken	0.20	-0.33
					Fish	0.18	-0.32
					Processed Meat	0.07	-0.08

Note: See notes to Table 1.

Table 8. Demand elasticities for meat and seafood: India

Data analyzed						Study results	
Study	**Time period**	**Rural, urban, or both**	**Cross section, time series, pooled, or panel**	**Demand system**	**Commodity**	**Income elasticity**	**Own-price elasticity**
Chatterjee *el al.* (2007)	1987/88, 1993/94, 1999/2000	Rural	Pooled	Two Stage, QUAIDS at Second Stage	Meat, Fish, and Eggs	0.95	*
Dey *el al.* (2008)	2002	Both	Cross Section	QUAIDS	Fish	1.62	-0.92
Mittal (2006)	1983, 1987/88, 1993/94, 1999/2000	Both	Pooled	Two Stage, QUAIDS at Second Stage	Meat, Fish, and Eggs	1.30	-2.26

Note: See notes to Table 1.

Table 9. Demand elasticities for meat and seafood: Indonesia

Data analyzed						Study results	
Study	**Time period**	**Rural, urban, or both**	**Cross section, time series, pooled, or panel**	**Demand system**	**Commodity**	**Income elasticity**	**Own-price elasticity**
Deaton (1990)	1981	Rural	Cross Section	AIDS	Meat	2.30	-1.09
					Fresh Fish	1.08	-0.76
					Dried Fish	0.57	-0.24
Dey *el al.* (2008)	1999	Both	Cross Section	QUAIDS	Fish	1.46	-0.84
Fabiosa and Jensen (2003)	1996	Both	Cross Section	LINQUAD	Meat	0.29	-0.77
					Fish	0.24	-0.59
Jensen and Manrique (1998)	1981, 1984, 1987	Both	Pooled	LA/AIDS	Meat	0.25	-0.91
					Fish	-0.82	-0.66
Teklu and Johnson (1988)	1980	Urban	Cross Section	LA/AIDS	Fish	0.81	-0.87

Note: See notes to Table 1.

Table 10. Demand elasticities for meat and seafood: China

	Data analyzed					Study results	
Study	**Time period**	**Rural, urban, or both**	**Cross section, time series, pooled, or panel**	**Demand system**	**Commodity**	**Income elasticity**	**Own-price elasticity**
Dey *el al.* (2008)	1997, 2001	Both	Cross Section	QUAIDS	Fish	0.92	-0.46
Dong and Gould (2007)	2001	Urban	Cross Section	QUAIDS	Beef	1.14	-0.97
					Pork	1.28	-0.58
					Poultry	1.13	-0.88
					Seafood/Fish	0.98	-0.61
Fan *el al.* (1994)	1982-1990	Rural	Pooled	DAIDS	Meat	1.78	-0.60
Fan *el al.* (1995)	1982-1990	Rural	Pooled	Two-Stage LES-AIDS	Meat	0.90	-0.31
Gale and Huang (2007)	2002-2003	Rural	Pooled	None (Unlinked)	Pork	0.24	—
					Beef and Mutton	0.39	—
					Poultry	0.66	—
					Aquatic Products	0.93	—
		Urban			Pork	0.13	—
					Beef	0.19	—
					Mutton	0.18	—
					Poultry	0.38	—
					Aquatic Products	0.52	—
Gao *el al.* (1996)	1990	Rural	Cross Section	Two-Stage GLES-QUAIDS	Pork	1.15	-0.98
					Beef	0.78	-1.04
					Poultry	0.29	-0.53
					Fish	0.89	-0.81
Gould (2002)	1995-1997	Urban	Pooled	Two-Stage, Translog at Second Stage	Pork	0.23	*
					Beef/Mutton	0.19	*
					Poultry	0.12	*
					Seafood	0.14	*
Gould and Villarreal (2006)	2001	Urban	Cross Section	QUAIDS	Beef	1.18	-0.97
					Pork	1.20	-0.66
					Poultry	1.20	-0.89
					Seafood/Fish	1.40	-0.57
Huang and Rozelle (1998)	1993-1994	Rural	Cross Section	LA/AIDS	Meat	0.33	-0.74
Katchova and Chern (2004)	1994	Rural	Cross Section	AIDS	Pork	1.24	-0.20
					Poultry	1.36	-0.85
Liao and Chern (2007)	2002-2003	Urban	Panel	DAIDS	Meat	1.34	-0.82
					Poultry	1.48	-1.00

	Data analyzed					Study results	
Study	**Time period**	**Rural, urban, or both**	**Cross section, time series, pooled, or panel**	**Demand system**	**Commodity**	**Income elasticity**	**Own-price elasticity**
					Fish	1.34	-0.44
Liu *el al.* (2009)	2005	Both	Cross Section	LA/AIDS	Pork	0.77	-1.00
					Poultry	0.90	-1.55
					Beef	1.34	-1.75
					Mutton	1.38	-2.00
					Aquatic Products	1.21	-1.23
Shono *el al.* (2000)	1995	Urban	Cross Section	None (Unlinked)	Pork	0.46	—
					Beef	0.50	—
					Mutton	0.67	—
					Carp	0.86	—
					Shrimp	0.76	—
Wang *el al.* (1998)	1986-1992	Urban	Pooled	AIDS	Pork	0.83	-0.85
					Beef and Mutton	0.85	-0.67
					Poultry	1.49	-1.34
					Fish	1.19	-1.03
Yan and Chern (2005)	1995	Rural	Cross Section	QUAIDS	Pork	1.07	-0.66
					Poultry	1.08	-0.34
					Aquatic Products	1.14	-0.24
Ye and Taylor (1995)	1989	Rural	Cross Section	Two Stage, AIDS at Second Stage	Beef	1.04	—
					Pork	0.82	—
Yen *el al.* (2004)	2000	Urban	Cross Section	Translog	Beef	1.41	-0.96
					Pork	0.94	-0.21
					Poultry	1.26	-0.75
					Fish	1.41	-0.37
Zhang *el al.* (2001)	1986-1995	Rural	Panel	AIDS	Meat	0.70	-0.28
					Fish	0.85	-0.84
Zhang and Wang (2003)	1998	Urban	Cross Section	Two-Stage AIDS-AIDS	Pork	0.25	-0.72
					Beef and Mutton	0.30	-0.27
					Poultry	0.33	-0.53
					Aquatic Products	0.34	-0.39

Note: See notes to Table 1.

Table 11. Demand elasticities for dairy products: Brazil

Study	Data analyzed: Time period	Rural, urban, or both	Cross section, time series, pooled, or panel	Demand system	Commodity	Study results: Income elasticity	Own-price elasticity
Coelho and de Aguiar (2007)	2002/03	Both	Cross Section	QUAIDS	Milk Powder	1.05	-0.81
					Fluid Milk	0.74	-1.25
					Butter	1.13	0.38
					Cheese	1.05	-1.34
Menezes *el al.* (2008)	1987/88, 1995/96	Urban	Pooled	Two-Stage LA/AIDS-LA/AIDS	Fluid Milk	0.72	-0.98

Note: See notes to Table 1.

Table 12. Demand elasticities for dairy products: Russia

Study	Data analyzed: Time period	Rural, urban, or both	Cross section, time series, pooled, or panel	Demand system	Commodity	Study results: Income elasticity	Own-price elasticity
Elsner (1999)	1996	Both	Cross Section	Three Stage, LA/AIDS at Second and Third Stages	Fluid Milk	1.07	-1.27
					Cheese	1.23	-1.05
					Other Dairy Products	1.45	-1.10

Note: See notes to Table 1.

Table 13. Demand elasticities for dairy products: India

	Data analyzed					Study results	
Study	**Time period**	**Rural, urban, or both**	**Cross section, time series, pooled, or panel**	**Demand system**	**Commodity**	**Income elasticity**	**Own-price elasticity**
Chatterjee *el al.* (2007)	1987/88, 1993/94, 1999/2000	Rural	Pooled	Two Stage, QUAIDS at Second Stage	Dairy Products	0.96	*
Meenakshi and Ray (1999)	1972/73, 1977/78, 1983, 1987/88	Rural	Pooled	Two Stage, QUAIDS at Second Stage	Dairy Products	0.94	*
		Urban				0.87	*
Mittal (2006)	1983, 1987/88, 1993/94, 1999/2000	Both	Pooled	Two Stage, QUAIDS at Second Stage	Fluid Milk	1.19	-0.78

Note: See notes to Table 1.

Table 14. Demand elasticities for dairy products: Indonesia

	Data analyzed					Study results	
Study	**Time period**	**Rural, urban, or both**	**Cross section, time series, pooled, or panel**	**Demand system**	**Commodity**	**Income elasticity**	**Own-price elasticity**
Fabiosa and Jensen (2003)	1996	Both	Cross Section	LINQUAD	Milk and Eggs	0.62	-0.05
Jensen and Manrique (1998)	1981, 1984, 1987	Both	Pooled	LA/AIDS	Fluid Milk	0.71	-0.64

Note: See notes to Table 1.

Table 15. Demand elasticities for dairy products: China

	Data analyzed					Study results	
Study	**Time period**	**Rural, urban, or both**	**Cross section, time series, pooled, or panel**	**Demand system**	**Commodity**	**Income elasticity**	**Own-price elasticity**
Bai *el al.* (2008)	2005	Urban	Cross Section	None (Unlinked)	Fluid Milk	0.48	-0.44
Dong and Gould (2007)	2001	Urban	Cross Section	QUAIDS	Dairy Products	1.19	-0.41
Fuller *el al.* (2007)	2001	Urban	Cross Section	None (Unlinked)	Fluid Milk	0.82	—
					Yogurt	0.32	—
					Milk Powder	-0.17	—
					Ice Cream	0.21	—
Gale and Huang (2007)	2002-2003	Rural	Pooled	None (Unlinked)	Dairy Products	0.70	—
		Urban			Dairy Products	0.64	—
Gould (2002)	1995-1997	Urban	Pooled	Two-Stage, Translog at Second Stage	Dairy Products/ Eggs	0.27	*
Gould and Villarreal (2006)	2001	Urban	Cross Section	QUAIDS	Dairy Products	1.00	-0.39
Shono *el al.* (2000)	1995	Urban	Cross Section	None (Unlinked)	Fluid Milk	1.05	—
					Milk Powder	0.99	—
					Sour Cream	1.51	—
Wang *el al.* (1998)	1986-1992	Urban	Pooled	AIDS	Fluid Milk	1.27	-0.29
Yen *el al.* (2004)	2000	Urban	Cross Section	Translog	Fluid Milk	1.40	-1.40
Zhang and Wang (2003)	1998	Urban	Cross Section	Two-Stage AIDS-AIDS	Fluid Milk	0.27	-1.20
					Milk Powder	0.12	-0.81
					Yogurt	0.18	-0.86

Note: See notes to Table 1.

Table 16. Demand elasticities for fruits and vegetables: Brazil

	Data analyzed					Study results	
Study	**Time period**	**Rural, urban, or both**	**Cross section, time series, pooled, or panel**	**Demand system**	**Commodity**	**Income elasticity**	**Own-price elasticity**
Coelho and de Aguiar (2007)	2002/03	Both	Cross Section	QUAIDS	Bananas	0.65	-1.28
					Tomatoes	0.67	-0.49
Menezes *el al.* (2008)	1987/88, 1995/96	Urban	Pooled	Two-Stage LA/AIDS-LA/AIDS	Fruits	0.82	-1.00
					Vegetables	0.61	-1.00
Pintos-Payeras (2009)	2002/03	Both	Cross Section	AIDS	Fruits and Vegetables	0.67	*

Note: See notes to Table 1.

Table 17. Demand elasticities for fruits and vegetables: Russia

	Data analyzed					Study results	
Study	**Time period**	**Rural, urban, or both**	**Cross section, time series, pooled, or panel**	**Demand system**	**Commodity**	**Income elasticity**	**Own-price elasticity**
Elsner (1999)	1996	Both	Cross Section	Three Stage, LA/AIDS at Second and Third Stages	Vegetables	1.40	-1.19
					Fruits	1.05	-1.05

Note: See notes to Table 1.

Table 18. Demand elasticities for fruits and vegetables: India

	Data analyzed					Study results	
Study	**Time period**	**Rural, urban, or both**	**Cross section, time series, pooled, or panel**	**Demand system**	**Commodity**	**Income elasticity**	**Own-price elasticity**
Chatterjee *el al.* (2007)	1987/88, 1993/94, 1999/2000	Rural	Pooled	Two Stage, QUAIDS at Second Stage	Fruits and Vegetables	0.56	*
Mittal (2006)	1983, 1987/88, 1993/94, 1999/2000	Both	Pooled	Two Stage, QUAIDS at Second Stage	Fruits and Vegetables	0.72	-0.98

Note: See notes to Table 1.

Table 19. Demand elasticities for fruits and vegetables: Indonesia

	Data analyzed					Study results	
Study	**Time period**	**Rural, urban, or both**	**Cross section, time series, pooled, or panel**	**Demand system**	**Commodity**	**Income elasticity**	**Own-price elasticity**
Deaton (1990)	1981	Rural	Cross Section	AIDS	Vegetables	0.67	-1.11
					Legumes	0.85	-0.95
					Fruits	1.39	-0.95
Fabiosa and Jensen (2003)	1996	Both	Cross Section	LINQUAD	Vegetables	0.14	-0.37
					Fruits	0.75	-0.46
Jensen and Manrique (1998)	1981, 1984, 1987	Both	Pooled	LA/AIDS	Fruits	0.43	-0.77
Teklu and Johnson (1988)	1980	Urban	Cross Section	LA/AIDS	Fruits and Vegetables	0.85	-0.70

Note: See notes to Table 1.

Table 20. Demand elasticities for fruits and vegetables: China

	Data analyzed					Study results	
Study	**Time period**	**Rural, urban, or both**	**Cross section, time series, pooled, or panel**	**Demand system**	**Commodity**	**Income elasticity**	**Own-price elasticity**
Ahmadi-Esfahani and Stanmore (1997)	1988-1990	Urban	Pooled	LA/AIDS	Cabbage	0.39	-0.41
					Chive	0.42	-0.08
					Potato	0.40	-0.14
					Carrot	0.12	0.14
					Cucumber	0.62	-0.22
					Tomato	0.40	-0.20
					Spring Onion	0.37	-0.15
					Ginger	0.56	-0.31
					Garlic	0.96	-0.52
Dong and Gould (2007)	2001	Urban	Cross Section	QUAIDS	Vegetables	0.95	-0.68
					Fruits	0.72	-0.70
Fan *el al.* (1994)	1982-1990	Rural	Pooled	DAIDS	Vegetables	1.20	-0.47
Fan *el al.* (1995)	1982-1990	Rural	Pooled	Two-Stage LES-AIDS	Vegetables	0.67	-0.36
Gale and Huang (2007)	2002-2003	Rural	Pooled	None (Unlinked)	Fruit and Melons	0.48	—
		Urban			Fruit	0.35	—
					Melons	0.32	—
Gould (2002)	1995-1997	Urban	Pooled	Two-Stage, Translog at Second Stage	Vegetables	0.20	*
					Fruits	0.21	*
Gould and Villarreal (2006)	2001	Urban	Cross Section	QUAIDS	Vegetables	0.95	-0.66
					Fruits	0.85	-0.71
Huang and Rozelle (1998)	1993-1994	Rural	Cross Section	LA/AIDS	Vegetables	1.70	-0.82
					Fruits	1.20	-0.54
Katchova and Chern (2004)	1994	Rural	Cross Section	AIDS	Vegetables	0.95	-0.91
					Fruits	1.12	-1.32
Liao and Chern (2007)	2002-2003	Urban	Panel	DAIDS	Fresh Vegetables	0.74	-0.62
					Fresh Fruits	1.07	-0.69
Liu *el al.* (2008)	1993, 2001	Urban	Pooled	None (Unlinked)	Fruits	0.34	-0.31
					Vegetables	0.22	-0.06
Shono *el al.* (2000)	1995	Urban	Cross Section	None (Unlinked)	Cabbage	0.20	—
					Onion	0.47	—
					Ginger	0.54	—
					Eggplant	0.31	—
					Pepper	0.40	—
					Apricot	0.75	—
					Citrus Fruits	1.03	—

Study	Time period	Rural, urban, or both	Cross section, time series, pooled, or panel	Demand system	Commodity	Income elasticity	Own-price elasticity
	Data analyzed					Study results	
					Peach	0.82	—
					Pear	0.98	—
					Banana	1.06	—
					Grape	1.07	—
					Watermelon	0.77	—
Yan and Chern (2005)	1995	Rural	Cross Section	QUAIDS	Vegetables	1.08	-0.44
					Fruits	1.20	*
Ye and Taylor (1995)	1989	Rural	Cross Section	Two Stage, AIDS at Second Stage	Vegetables	0.82	—
					Fruits	0.61	—
Yen *el al.* (2004)	2000	Urban	Cross Section	Translog	Vegetables	0.83	-0.72
					Fruits	0.60	-0.76
Zhang *el al.* (2001)	1986-1995	Rural	Panel	AIDS	Vegetables	0.37	-0.16
Zhang and Wang (2003)	1998	Urban	Cross Section	Two-Stage AIDS-AIDS	Vegetables	0.36	-0.73
					Fruits	0.31	-0.85

Note: See notes to Table 1.

Table 21. Demand elasticities for sugar: Brazil

Study	Time period	Rural, urban, or both	Cross section, time series, pooled, or panel	Demand system	Commodity	Income elasticity	Own-price elasticity
	Data analyzed					Study results	
Menezes *el al.* (2008)	1987/88, 1995/96	Urban	Pooled	Two-Stage LA/AIDS-LA/AIDS	Sugar	0.39	-0.92
Pintos-Payeras (2009)	2002/03	Both	Cross Section	AIDS	Sugar	0.29	*

Note: See notes to Table 1.

Table 22. Demand elasticities for sugar: Russia

Data analyzed						Study results	
Study	**Time period**	**Rural, urban, or both**	**Cross section, time series, pooled, or panel**	**Demand system**	**Commodity**	**Income elasticity**	**Own-price elasticity**
Elsner (1999)	1996	Both	Cross Section	Three Stage, LA/AIDS at Second and Third Stages	Sugar	0.96	-1.10
					Sweets	0.63	-1.15

Note: See notes to Table 1.

Table 23. Demand elasticities for sugar: India

Data analyzed						Study results	
Study	**Time period**	**Rural, urban, or both**	**Cross section, time series, pooled, or panel**	**Demand system**	**Commodity**	**Income elasticity**	**Own-price elasticity**
Chatterjee *el al.* (2007)	1987/88, 1993/94, 1999/2000	Rural	Pooled	Two Stage, QUAIDS at Second Stage	Sugar and Spices	0.46	*
Mittal (2006)	1983, 1987/88, 1993/94, 1999/2000	Both	Pooled	Two Stage, QUAIDS at Second Stage	Sugar	0.82	-0.73

Note: See notes to Table 1.

Table 24. Demand elasticities for sugar: China

Data analyzed						Study results	
Study	**Time period**	**Rural, urban, or both**	**Cross section, time series, pooled, or panel**	**Demand system**	**Commodity**	**Income elasticity**	**Own-price elasticity**
Gao *el al.* (1996)	1990	Rural	Cross Section	Two-Stage GLES-QUAIDS	Sugar	0.79	-0.90
Ye and Taylor (1995)	1989	Rural	Cross Section	Two Stage, AIDS at Second Stage	Sweets	0.71	—

Note: See notes to Table 1.

Table 25. Demand elasticities for fats and oils: Brazil

		Data analyzed				Study results	
Study	**Time period**	**Rural, urban, or both**	**Cross section, time series, pooled, or panel**	**Demand system**	**Commodity**	**Income elasticity**	**Own-price elasticity**
Menezes *el al.* (2008)	1987/88, 1995/96	Urban	Pooled	Two-Stage LA/AIDS-LA/AIDS	Oil	0.55	-0.99

Note: See notes to Table 1.

Table 26. Demand elasticities for fats and oils: Russia

		Data analyzed				Study results	
Study	**Time period**	**Rural, urban, or both**	**Cross section, time series, pooled, or panel**	**Demand system**	**Commodity**	**Income elasticity**	**Own-price elasticity**
Elsner (1999)	1996	Both	Cross Section	Three Stage, LA/AIDS at Second and Third Stages	Fats and Oils	0.91	-1.15

Note: See notes to Table 1.

Table 27. Demand elasticities for fats and oils: India

		Data analyzed				Study results	
Study	**Time period**	**Rural, urban, or both**	**Cross section, time series, pooled, or panel**	**Demand system**	**Commodity**	**Income elasticity**	**Own-price elasticity**
Chatterjee *el al.* (2007)	1987/88, 1993/94, 1999/2000	Rural	Pooled	Two Stage, QUAIDS at Second Stage	Edible Oils	0.49	*
Mittal (2006)	1983, 1987/88, 1993/94, 1999/2000	Both	Pooled	Two Stage, QUAIDS at Second Stage	Edible Oils	0.55	-0.80
Pan *el al.* (2008)	2000-2001	Both	Cross Section	Two-Stage, LINQUAD at Second Stage	Peanut Oil	0.40	-1.27
					Liquid Butter Oil	0.12	-0.58
					Rapeseed Oil	0.06	-0.28
					Palm Oil	0.25	-0.75

Note: See notes to Table 1.

Table 28. Demand elasticities for fats and oils: Indonesia

	Data analyzed					Study results	
Study	**Time period**	**Rural, urban, or both**	**Cross section, time series, pooled, or panel**	**Demand system**	**Commodity**	**Income elasticity**	**Own-price elasticity**
Fabiosa and Jensen (2003)	1996	Both	Cross Section	LINQUAD	Oils and Fat	0.15	-0.82

Note: See notes to Table 1.

Table 29. Demand elasticities for fats and oils: China

	Data analyzed					**Study results**	
Study	**Time period**	**Rural, urban, or both**	**Cross section, time series, pooled, or panel**	**Demand system**	**Commodity**	**Income elasticity**	**Own-price elasticity**
Dong and Gould (2007)	2001	Urban	Cross Section	QUAIDS	Fats and Oils	1.22	-0.71
Fang and Beghin (2002)	1992, 1994-1998	Urban	Pooled	LINQUAD	Rapeseed Oil	0.10	-0.72
					Soy Oil	0.17	-0.87
					Peanut Oil	0.17	-0.48
					Other Vegetable Oil	0.26	-0.92
					Animal Fat	0.07	-0.43
Gale and Huang (2007)	2002-2003	Rural	Pooled	None (Unlinked)	Edible Oils	0.23	—
		Urban			Edible Oils	-0.08	—
Gould and Villarreal (2006)	2001	Urban	Cross Section	QUAIDS	Fats and Oils	1.34	-0.75
Liao and Chern (2007)	2002-2003	Urban	Panel	DAIDS	Oils	0.78	-1.08
Shono *el al.* (2000)	1995	Urban	Cross Section	None (Unlinked)	Edible Oils	0.17	—
Yan and Chern (2005)	1995	Rural	Cross Section	QUAIDS	Oils	1.17	-0.66
Yen *el al.* (2004)	2000	Urban	Cross Section	Translog	Fats and Oils	0.98	-0.55
Zhang and Wang (2003)	1998	Urban	Cross Section	Two-Stage AIDS-AIDS	Fats and Oils	0.32	-0.54

Note: See notes to Table 1.

Table 30. Estimated (1985) and Projected (2020) Income Elasticities of Demand from Yu *el al.* (2003)

	China (5.8%/year)		**ASEAN (3.5%/year)**		**MERCOSUR (3.0%/year)**		**Transition Economies (3.1%/year)**		**Rest of World (2.1%/year)**	
Food Group	1985	2020	1985	2020	1985	2020	1985	2020	1985	2020
Cereals	0.81	0.22	0.53	0.04	0.12	0.03	0.26	0.02	0.76	0.47
Livestock Products	1.46	0.69	0.80	0.84	0.70	0.82	0.70	0.87	1.07	0.79
Horticultural and Vegetable Products	1.33	0.46	0.66	0.60	0.43	0.57	0.47	0.64	0.99	0.64
Fish	1.43	0.23	0.56	0.00	0.12	0.00	0.27	0.02	0.99	0.53
Other Food	0.96	0.61	0.71	0.79	0.63	0.67	0.62	0.82	0.88	0.71

Note: The figures in parentheses below each region refer to assumed annual growth rates in real GDP *per capita.*

Table 31. Income Elasticities of Demand for Selected Countries from Seale and Regmi (2006)

Country	GDP *Per capita*, 1996	Beverages and Tobacco	Cereals	Meat	Fish	Dairy	Oils and Fats	Fruits and Vegetables	Other Food
Vietnam	USD 2 029	1.43	0.59	0.79	0.88	0.83	0.55	0.64	0.79
Peru	USD 4 775	0.93	0.47	0.69	0.75	0.72	0.41	0.54	0.69
Brazil	USD 8 196	0.87	0.44	0.66	0.71	0.68	0.37	0.52	0.66
Poland	USD 8 839	0.79	0.40	0.62	0.66	0.64	0.33	0.48	0.62
Korea	USD 17 613	0.63	0.31	0.50	0.54	0.52	0.24	0.38	0.50
France	USD 24 203	0.41	0.19	0.34	0.36	0.35	0.12	0.26	0.34
United States	USD 34 287	0.12	0.05	0.10	0.10	0.10	0.03	0.07	0.10

Note: GDP *per capita* is PPP converted, in 2005 prices, and is the chain series from Heston *el al.* (2009).

Table 32. Income and Own-Price Elasticities of Demand for Food, Beverages, and Tobacco from Seale and Regmi (2006)

Country	**GDP *Per capita*, 1996**	**Income elasticity**	**Own-price elasticity**
Vietnam	USD 2 029	0.74	-0.76
Peru	USD 4 775	0.65	-0.66
Brazil	USD 8 196	0.62	-0.62
Poland	USD 8 839	0.58	-0.58
Korea	USD 17 613	0.47	-0.47
France	USD 24 203	0.32	-0.32
United States	USD 34 287	0.09	-0.09

Note: GDP *per capita* is PPP converted, in 2005 prices, and is the chain series from Heston *el al.* (2009).