CHANGES IN THE STRUCTURE OF GLOBAL FOOD DEMAND

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Abstract

A newly developed demand system is used to estimate the response of food and food product demand to per capita expenditure changes. The resulting Engel elasticities are then used to project food and food product demand in 2020 assuming per capita expenditure and population changes. Results suggest that while food expenditure is projected to grow, it accounts for a smaller proportion of total expenditure. Further analysis indicates change in the composition of food demand away from a grain and towards livestock is projected to occur in lower income countries in 2020.

Keywords: Food demand, Per capita expenditure growth, Forecasting

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Introduction

An issue faced by policy makers in the next millennium is that of food security. In particular, faced with potentially large population growth in the world's poorest countries, many have wondered who will feed the world? At the same time, many of the same countries are expected to experience considerable economic growth. For example, between 1992 and 2020, real per capita GDP is expected to increase by 2.5 percent per annum in OECD countries and seven percent per annum in China (World Bank 1997a). An increase in real per capita GDP leads to higher per capita expenditure levels. However, Engel's Law suggests that as people become wealthier, food's share of total expenditure declines. This is an empirical regularity in the study of demand patterns across expenditure levels (Banks, Blundell and Lewbel (1997), Rimmer and Powell (1992), *inter alia*). Within the composite food category we also expect changes in composition of food demand. In particular, we expect to observe reduced consumption of unprocessed bulk commodities (*e.g.*, grain, rice and cereals) but increased consumption of higher valued consumer-ready products (*e.g.*, fruit, meat and dairy products).

The implications of expenditure and population growth on food demand reach into a number of related areas. For instance, regionalized production may lead some countries to rely on trade to obtain products they do not produce domestically. Accordingly, trade flows may increase, which increases the need for transportation services and infrastructure facilities. In addition, increased demand for further processed food products suggests a needed expansion in food processing capacity in developing, and perhaps developed countries.

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Consequently, a clear understanding of what may happen to food demand, and its composition, is necessary to appreciate the potential changes in the global food economy. The objective of this paper is to project the pattern of global food demand in 2020 for both aggregate food and disaggregate food products (*i.e.*, grain, livestock, horticulture and vegetables, and other food products). To achieve this objective, two goals are set. The first goal is to econometrically estimate demand's response to expenditure changes across the development spectrum for aggregate food and disaggregated food products. The second goal is to use the estimated models to project the structure of food demand patterns for selected countries in 2020.

Results suggest that food expenditure will increase by 2020, but that food's share of total expenditure will decline. As well, countries with initially low per capita expenditure levels are projected to experience larger relative growth in food expenditure than countries with initially high per capita expenditure. Consequently, poorer countries may "catch" up to wealthier countries in terms of food expenditure. At the same time, the composition of the food consumption bundle is predicted to change. In particular, projections suggest grain expenditure will decline, while livestock expenditure increases. However, it must be emphasized that the extent of these changes, in relative and absolute terms, depends on where the country is positioned in the development spectrum. Specifically, projected changes in grain and livestock expenditure are larger, in relative terms, in countries with low per capita expenditure levels than in countries with high per capita expenditure levels. Furthermore, the rate of increase in livestock expenditure outstrips that of grains. Consequently, one may conjecture that food consumption bundles in low income countries will shift towards livestock products, with grain occupying a diminishing role in consumer's budgets.

In the next section the empirical methodology and data are outlined. Following this, the estimated response of food demand to expenditure changes is briefly presented. These responses are then used as a predictive device in determining the impact of per capita expenditure and population growth on demand for food products.

Methodology and Data

The first goal of this paper is to estimate the impact of per capita expenditure changes on food demand. We note that all too often demand's response to an expenditure change is assumed constant across expenditure levels.[2] Such an assumption is inappropriate if the effect of a one percent change in per capita expenditure on demand (*i.e.*, the expenditure elasticity) differs across income levels. In addition, it is sometime convenient, although similarly inappropriate, to project demand changes for one good independent of other goods. In this case, any systematic relationship between demands is ignored.

To address this issue, we model demand using a systems approach that does not limit demand's response to an expenditure change to be constant. In particular, we use a model developed

[2] In technical terms the Engel (or expenditure) elasticity is said to be constant.

by Rimmer and Powell (1996) that is an implicitly, directly additive demand system (AIDADS).[3] Our choice of model is motivated by several notable features of AIDADS. First, AIDADS is a demand *system*, and so reflects the relationship between demands for different goods. Second, AIDADS is derived from a particular utility function and satisfies several important properties of consumer theory.[4] Third, AIDADS does not constrain demand's response to an income change to be constant. Finally, AIDADS constrains the budget share to a theoretically admissible range, namely between zero and one. Other commonly used demand systems (*e.g.*, Deaton and Muellbauer's (1980) Almost Ideal Demand System), do not restrict the budget share in such a manner.

For our purposes, we estimate two demand systems. In the first demand system, we treat food as an aggregate good along with other non-durable goods, services and durable goods. In the second demand system, other non-durable goods, services and durable goods are retained, but food is broken into four product types. These disaggregate food products are grain, livestock, horticulture and vegetable, and other food products. Our intent in decomposing food demand is to represent bulk unprocessed products (grains, rice, and other cereals) and processed, consumer-ready products (livestock, horticulture and vegetable, and other food), while capturing the potential change in demand for different food products as per capita expenditure levels change.

To estimate the two demand systems we use a maximum likelihood program developed by Cranfield *et al*. (1998), and a cross section sample of countries from the 1985 International Comparisons Project.[5] These data are useful in analyzing international demand patterns since they are provided in identical units (*i.e.*, international dollars) and facilitate comparison of prices and quantities for disaggregate commodities across countries. ICP data sets have been compiled for the years 1970, 1973, 1975, 1980, 1985, 1990 and 1995. However, at the time of writing this paper, the 1985 data set was the most up to date publicly available release. The 1985 data set consists of 64 countries, ranging from Ethiopia, with real per capita consumption of $159 (1985 International Dollars) to the USA, with real per capita consumption of $8881 (1985 International Dollars). Of the 113 goods in the data set, food items account for 36 goods. Since the most recent data set, for 1995, was not available, predicted food product demands in 1995 are provided to allow the reader to better

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[3] AIDADS has the following functional form $x_i=\gamma_i+\varphi_i(u)*(M-P'\gamma)/p_i$, where $i=1,\ldots,N$ indexes the goods, x_i is consumption of the ith good, P is a Nx1vector of prices, with elements $p_{i,}$ where p_i is the price of the ith good, M denotes per capita income, $\varphi_i(u)=[\alpha+\beta\exp(u)]/[1+\exp(u)]$ where α_i, β_i and γ_i are unknown parameters, γ is a Nx1 vector with elements γ_i, and u denotes the utility level at the optimal consumption bundle.

[4] Since AIDADS is derived from a particular utility function, it satisfies adding-up, homogeneity of degree zero in prices and expenditure, and Slutsky symmetry. In addition, since it is directly additive, the estimated model results in a net substitute relationship between competing goods, and rules out inferior goods.

[5] Others have used previous ICP data sets for analyzing international demand patterns. For example, Kravis, Heston and Summers (1982), Theil and Clements (1987), and Rimmer and Powell (1992) all used the 1975 ICP data set, Theil, Chung and Seale (1989) used the 1970, 1973, 1975 and 1980 releases, while Wang (1996) used the 1985 data set used in this study.

evaluate the appropriateness of our estimates. Moreover, since the estimated seven good demand system is used as input into a companion paper prepared for the 1998 American Agricultural Economics Association Annual Meetings, the 1995 predictions provide a linkage between the two research efforts.[6]

Once estimated, the two demand systems are used to achieve the second goal of this paper, namely, project food and food product demand in the year 2020. We investigate the impact of per capita expenditure and population growth first on aggregate food demand and then food product demand. In both instances, focus is placed on changes in budget shares and expenditure. In making these projections, several simplifying assumptions are employed. First, preferences are assumed constant across the sample and throughout time. Second, relative prices in each country are held constant from 1985 to 1995 and 2020. Third, changes in population from 1985 to 1995, and from 1995 to 2020 are based on World Bank population data and projections, respectively. Fourth, actual changes in real per capita GDP are used as a proxy for growth in per capita expenditure from 1985 to 1995, while predicted changes in real per capita GDP from 1995 to 2020 proxy changes in per capita expenditure over that time period. Changes in real per capita GDP from 1985 to 1995 are based on data contained in the International Monetary Fund's *International Financial Statistics Yearbook* (International Monetary Fund 1997), while predicted changes in real per capita GDP are based on Table 1-7 of the World Bank's *Global Economic Prospects and Developing Countries* (World Bank 1997b).

To focus attention on "representative" countries, and to provide a focus for the presentation, we select six countries for our analysis. These countries, which span the range of 1985 per capita expenditure in the ICP data, are Ethiopia, Pakistan, Senegal, Korea, France and the USA. Ethiopia and the USA represent the poorest and richest extremes in the sample, respectively, and thus provide insight as to behavior at very low and high levels of per capita expenditure. Korea is included to represent the newly industrialized economies that have led Asian economic growth in the past two decades, while France represents other high income countries. Pakistan and Senegal are included to represent other lower income countries, but also because the composition of their food consumption bundles experience important changes as expenditure grows. Table 1 shows the annualized growth rates in actual (1985-1995) and predicted (1995-2020) real per capita GDP and population for these six countries.

To clarify our terminology, values based on estimated per capita consumption levels in 1985 are referred to *fitted* values, values based on actual changes from 1985 to 1995 are referred to as *predicted* values, while values based on projected changes from 1995 to 2020 are referred to as *projected* values. In the next section, estimation results for the four good demand system are presented, and food demand projections discussed.

Food Demand – Results & Projections

[6] It should be borne in mind, however, that the shares reported here are based on ICP price concepts, which may differ from those used from many other data sets.

Figure 1 shows plots of the marginal and fitted budget shares for food computed using estimates from the four good demand system. To remove the "noise" introduced by price variation across countries in the sample, the marginal and fitted budget shares are evaluated at the mean prices. As a point of reference, the solid vertical lines in Figure 1 denote per capita expenditure levels for each of the six countries in 1985. The assumed per capita expenditure levels for Ethiopia, Korea and France are also shown, with a dotted vertical line for 1995 and a dashed vertical line for 2020.[7] The subscripted capital letter appearing above each vertical line denotes the country by the first letter in its name, while the subscripted number denotes the year. For example, P_{85} denotes Pakistan's per capita expenditure in 1985, while K_{20} denotes Korea's per capita expenditure level in 2020.

Holding prices fixed, the effect of a small change in per capita expenditure on food's budget share can be ascertained by examining the marginal budget share. The marginal budget share is the change in expenditure on the *i*th good, holding price constant but allowing per capita expenditure to change. Figure 1 illustrates that food's marginal budget share decreases as per capita expenditure rises. Thus, Engel's Law appears to hold for this preference structure, and one would expect to observe smaller food budget shares as consumers become wealthier. However, at low per capita expenditure levels (below \$196, or about 5.3 units on the natural logarithm scale) the marginal budget share, evaluated at mean prices, is greater than the fitted budget share. Therefore, the average budget share for food is increasing over this range. Above that point, the marginal share is below the average budget share for food, and the latter decreases with rises in per capita expenditure. Kenya had a per capita expenditure level of about \$196 in 1985. Thus, with prices fixed at their means, food budget shares in countries with per capita expenditure levels below Kenya's 1985 level will increase as expenditure rises, but will eventually fall as expenditure grows beyond \$196.

Since the Engel elasticity is the ratio of the marginal to the fitted budget share, the fact that these plots cross in Figure 1 results in an interesting effect. In particular, the Engel elasticity is greater than one, but falling, for countries to the left of the intersection of the marginal and fitted budget shares, while countries to the right of the intersection point have fitted budget shares decreasing at a faster rate than the marginal budget shares. Consequently, the Engel elasticity in the higher per capita expenditure countries is less than one and falling. Thus, food is a luxury good in some low income countries, but a normal good in most countries in the sample.

Table 2 shows the estimated Engel elasticities in the six representative countries evaluated at *individual country's price levels*. Values in the column labeled Food illustrate that Ethiopia has the most responsive food demand, with a ten percent increase in per capita expenditure resulting in a 9.7 percent increase in food demand.[8] In contrast, the USA has the least responsive food demand, with a 1.5 percent increase in food demand given a ten percent increase in per capita expenditure. Finally, for all six representative countries, the food Engel elasticities are decreasing as per capita

[7] We only show changes in per capita expenditure in Ethiopia, Korea and France as they represent the poorest country in the sample, a country anticipated to experience considerable per capita expenditure growth, and a high income country, respectively.

[8] The reason this elasticity is not greater than one, as predicted by Figure 1, is due to differences between Ethiopian prices and mean prices.

expenditure increases, thus indicating a greater responsiveness of food demand in lower income countries, when evaluated at the respective price *levels*.

While the plots of the marginal and fitted budget shares and the Engel elasticities provide useful pedagogical tools in explaining what might happen as per capita expenditure increases, our objective is to provide quantitative projections of future food demand. In reference to Figure 1, we are particularly interested in what happens to food demand as countries move up the development spectrum. For example, based on our assumed changes in per capita expenditure to 2020, Korea is expected to be in about the same position as France in 1995, while France is expected to be in about the same position as the USA in 1985. Consequently, one may expect budget shares in low income countries to fall towards those in high income countries. Naturally, differences will exist due to relative price levels. If, however, prices were held fixed at their means, Figure 1 shows that Korea's food budget share in 2020 will be close to France's in 1995, and France's in 2020 will be about equal to those in the USA in 1985.

Figure 2 shows the fitted (1985), predicted (1995) and projected (2020) food budget shares for the six countries, from lowest to highest per capita expenditure. These budget shares are computed at each country's individual price level, and thus differ from those reported in Figure 1. Nevertheless, as hypothesized, food budget shares decline in all six countries as per capita expenditure increases (also see Table 3). Focusing on the 1995-2020 projections, we observe large reductions in food budget shares in Korea and France, but smaller reductions in countries with low per capita expenditure and the USA. The large projected decline in Korea's food budget share reflects the projected doubling of Korea's per capita expenditure between 1995 and 2020, as well as the steep decline in the budget share schedule at their expenditure level (see Figure 1).

Nate that changes in the respective food budget shares reflect differences in relative price levels, Engel elasticities, but most importantly, differences in the relative position of a country on the development spectrum. Figure 1 helps illustrate that at mean prices, the increase in Ethiopia's per capita expenditure results in small increases in their fitted food budget share. On the other hand, per capita expenditure changes in Korea shifts their position along a steeper, downward sloping portion of the fitted budget share schedule, which generates large reductions in their respective food budget shares. Finally, at higher per capita expenditure levels (the USA) the fitted food budget shares change little as per capita expenditure increases.

While absolute changes in the food budget shares are informative, they do reflect differences in the initial budget share. To remove these "scale" effects, annualized growth rates are also shown in Figure 2 (also see Table 3). Projections indicate that from 1995 to 2020 Korea's food budget share falls by the largest amount, about three percent per annum or approximately one half. In the USA and France, similar projected reductions amount to about 1.2 and 1.6 percent per annum respectively, close to 0.3 percent per annum in Pakistan and Senegal and less than 0.1 percent per annum in Ethiopia. So in relative terms, the reduction in food budget shares in Ethiopia, Pakistan and Senegal are relatively small, while those in Korea, France and the USA are relatively large. This further illustrates that a country's position in the development spectrum can effect the perception of where change occurs.

Figure 3 shows that at each country's respective price level, total food expenditure (*i.e.*, per capita food expenditure times population) is projected to increase from 1985 to 1995 and 2020. In particular, projections show a large increase in food expenditure in the USA and Pakistan between 1995 and 2020, but smaller changes in Ethiopia, Senegal, Korea and France. In relative terms, however, low per capita expenditure countries have much larger projected increases in food expenditure than higher per capita expenditure countries. For example, between 1995 and 2020, food expenditure in Ethiopia is projected to increase by about 3 percent per annum, but only 0.6 and 0.9 percent per annum in France and the USA. These large relative increases in food expenditure in countries with low per capita expenditure (*e.g.* Ethiopia, Pakistan and Senegal) reflect larger projected population changes relative to countries with high per capita expenditure levels (*e.g.*, Korea, France and the USA). This point is further emphasized by noting that Korea has the largest annualized growth rate for per capita expenditure, the second lowest annualized growth rate for population, but only moderate annualized growth in total food expenditure. Thus the impact of population growth on total food expenditure cannot be understated.

Projection results suggest that countries with low per capita expenditure levels experience larger relative increases in food expenditure and smaller relative decreases in food budget shares. This suggests that the momentum of food demand growth is shifting from high income countries to low income countries. However, the analysis is somewhat incomplete since the composition of the consumer's food bundle may change as per capita expenditure grows. In the next section, we attempt to capture such changes by breaking food demand into its component parts.

Disaggregate Food Demand – Results & Projections

While food demand is projected to rise in 2020, recognize that as consumers become wealthier, items previously unaffordable may now be affordable, and that preferences over food bundles may be such that consumers begin to choose a more diverse food consumption bundle. The seven good demand system allows us to address the latter point by modeling demand for disaggregate food products.

Results from the seven good demand system are summarized in Figures 4 and 5. Like Figure 1, these figures show plots of the marginal and fitted budget shares, evaluated at the mean prices, for the disaggregate food products. For reference, the per capita expenditure levels for the six representative countries in 1985 are indicated with the same solid vertical lines as in Figure 1. As with aggregate food, the marginal budget shares for the disaggregate food products decline throughout the sample. However, at high levels of per capita expenditure the marginal budget shares change very little.[9] Nevertheless, the overall pattern suggests that demand for disaggregate food products in this sample is consistent with Engel's Law. Figure 4 also illustrates that per capita livestock expenditure is more responsive to changes in per capita expenditure than the other three

[9] The behavior of the marginal budget shares at high levels of per capita expenditure is indicative of AIDADS as the cardinal measure of utility becomes large. In fact, Rimmer and Powell (1996, p.1616) show that the marginal and fitted budget share are asymptotic to an estimated parameter of the AIDADS model.

food products. In addition, at high per capita expenditure levels, grain expenditure is the least responsive food product.

The fitted budget shares for the disaggregate food products, evaluated at mean prices and plotted in Figure 5, reveal a number of interesting results. First, grain's budget share is declining over the full range of the sample. In contrast, the budget shares for livestock, horticulture and vegetable and other food products increase at lower levels of per capita expenditure, reach a maximum, and then decline as per capita expenditure grows. Second, the importance of grain relative to the remaining food products changes as per capita expenditure increases. This is of particular note for livestock, which has the largest budget share of the food products when per capita expenditure exceeds an the average level of per capita expenditure roughly equal to that of Pakistan in 1985.

The implication of the changing relative importance of livestock and grain in the consumption bundle is that the composition of food demand will change as per capita expenditure grows. In particular, for a country like Ethiopia, one would expect to observe an increase in livestock's budget share but a reduction in grain's budget share. For a country such as Pakistan, which straddles the point where the grain and livestock budget share plots cross, one would expect to observe a switch in the dominant food product in the consumer's food bundle from grain to livestock. However, for countries with higher per capita expenditure levels, such as Korea, the fitted budget shares suggest that while livestock's budget share will decline as per capita expenditure grows, grain's budget share will decline at a faster rate. For countries in the highest per capita expenditure echelon, the reduction in grain and livestock budget shares are about equal, although grain has the lowest budget share of the food products.

Thus, there appear to be three archetype consumption bundles in this data set, each corresponding to one of three groupings denoted in Figures 1, 4, and 5 as **I**, **II**, and **III**. The first bundle, denoted as **I**, occurs at lower per capita expenditure levels, where grain dominates. The second bundle, denoted as **II**, occurs at mid-range per capita expenditure levels, where livestock dominates, followed by grain. Finally, the third bundle, denoted as **III**, occurs at higher per capita expenditure levels where livestock continues to dominate, this time followed by other food products, then horticulture and vegetable products and finally grain.

A Focus on Grain and Livestock Consumption

Since the main compositional change in food's consumption bundle is between grain and livestock, the discussion of projected disaggregate food product demand focuses on these two goods. Table 2 shows the Engel elasticities for grain to decline across the six representative countries. Also note that across the six representative countries, livestock demand is more responsive to changes in per capita expenditure than grain demand.

Figure 6 shows that when the assumed changes in per capita expenditure are simulated for 1995 and 2020, grain's budget share declines (also see Table 3). Since Figure 6 shows the respective budget shares evaluated at each country's price levels, it does not closely correspond with Figure 5, where the fitted budget shares are evaluated at mean prices. Nevertheless, focusing on the projected changes to 2020, the absolute decline in the grain budget shares is about the same for Pakistan,

Senegal, France and the USA, with a smaller reduction projected in Ethiopia, but a large reduction projected for Korea.

In relative terms, changes in the grain budget shares differ, with per annum reductions range from about 0.1 percent in Ethiopia to about 3.4 percent in Korea. For Korea, this reduction represents a halving of their grain budget share between 1995 and 2020. Projections also indicate that in 2020 grain shares in Korea and France are close to that of the USA in 1985. With respect to Figure 5, the changes in Korea's projected grain shares reflect a move towards the flat part of the grain budget share schedule at higher per capita expenditure levels. A similar occurrence will be noted for any country experiencing large enough per capita expenditure growth.

Figure 7 shows that grain expenditure is projected to increase in all six countries (also see Table 3). Fueled by relatively high population growth rates, large increases in grain expenditure are projected to occur in Ethiopia and Pakistan. In relative terms, however, substantial differences exist in the rate of change. In particular, projections indicate the changes in grain expenditure from 1995 to 2020 range from about 3.3 percent per annum in Ethiopia to less than one percent per annum in Korea, France and the USA.

Figure 8 shows that when per capita expenditure increases to the projected 1995 and 2020 levels, that livestock budget shares decline in all countries except Ethiopia. The increase in Ethiopia's livestock budget shares reflects the hump shape of the fitted livestock budget shares in Figure 5 (assuming prices equal their means). The magnitude of the projected reductions in the remaining countries reflects the shape of the livestock budget share schedule (shown in Figure 5) at higher expenditure levels and a movement down this schedule as per capita expenditure grows. In relative terms, the largest projected reduction occurs in Korea, about one percent per annum, then France at about 0.5 percent, and finally Pakistan, Senegal and the USA with declines of about 0.2 percent per annum, respectively.

Figure 9 illustrates that livestock expenditure is projected to increase in all six countries. In absolute terms, the largest increase from 1995 to 2020 is projected to occur in the USA, followed by France, Korea, and the Pakistan. Even though the USA is projected to have the largest absolute increase, in relative terms this is one of the *smallest* increases. In fact, in annualized terms from 1995 to 2020, the largest relative increase is projected to occur in Ethiopia, with about a 3.4 percent growth per year. Projections also suggest that Pakistan and Senegal experience about an three percent growth per annum, while Korea, France and the USA are projected to have about 3.2, 1.8 and 1.8 percent growth per annum, respectively.

A number of themes emerge when one juxtaposes the grain and livestock projections. First, when Ethiopia's per capita expenditure increases, there appears to be the beginnings of a shift in consumer demand from grain to livestock. This illustrates that countries with very low per capita expenditure levels may move into the second archetype consumption regime given a sufficiently large increase in per capita expenditure.

Second, relative increases in livestock expenditure are larger than the relative increase in grain expenditure, which reflects, in part, more elastic Engel elasticities for livestock than for grain. Consequently, a one percent increase in per capita expenditure generates a larger percentage increase

in livestock demand than in grain demand. Holding prices constant, this means the relative increase in livestock expenditure is larger than the relative increase in grain expenditure, which reflects larger marginal budget shares for livestock than for grain, as illustrated in Figure 4.

Third, for the 1995-2020 period, the relative change in grain's budget share is projected to be larger in absolute value than for livestock. However, the opposite holds true for livestock and grain expenditure. These differences reflect the changing importance of grain and livestock in the consumer's food bundle.

Finally, a country's relative position on the development spectrum determines the impact of a change in per capita expenditure levels. This impact is largely governed by 1) initial per capita expenditure levels, 2) relative prices, and 3) the shape of the Engel curve for the good in question. The shape of a good's Engel curve is at the heart of this paper. Our chosen functional form allows for a variety of Engel responses. In fact, AIDADS allows one to capture differences in demand responses as income levels vary. Consequently, projections based on AIDADS should provide a more realistic representation of how consumers in different countries response to income changes.

Summary and Implications

The objective of this paper was to analyze the change in the structure of global food demand. To accomplish this, we estimated the response of food demand to a change in per capita expenditure. The estimated responses were then used to project food demand in 2020. Results indicated a correspondence of food demand to Engel's Law. In particular, while food expenditure is projected to grow, its share of total expenditure is projected to fall. Moreover, low income countries are expected to account for much of the relative growth in future food demand.

Recognizing that the composition of food demand may change as consumers become wealthier, we estimated the response of disaggregate food product demand to per capita expenditure changes. Again, results indicate a correspondence to Engel's law. We also identified three food consumption bundles differentiated by the size of grain and livestock expenditure relative to total expenditure. In low per capita expenditure countries, grain budget shares were the highest among the food items, followed by livestock. As per capita expenditure rose, the position of grain relative to livestock switched, until eventually, livestock budget shares dominated the other food items, while grain had the smallest budget share of the food goods. Moreover, projections indicate much of the anticipated increase in the level of grain and livestock expenditure will occur in high per capita expenditure countries, with growth in livestock demand exceeding growth in grain demand.

What do these results mean for global food demand? Table 4 provides a simple means to use these results as a predictive device for global food demand. This table shows the four income groups used by the World Bank in their *World Development Report* 1997, the corresponding percent of the world's population in 1995, the countries used in our analysis that loosely correspond to the four income groups, and the annualized growth rates in expenditure on food, grain and livestock from 1995 to 2020. Table 4 shows that more than half the World's population lives in low income countries. This group includes China and India, but is represented here by Ethiopia and Pakistan, where food demand is projected to increase rapidly from 1995 to 2020. Approximately one third of the world's population lives in middle income countries, represented here by Senegal and Korea,

where food expenditure growth is expected to more moderate. The remainder of the world's people (about 16%) live in high income countries, represented here by France and the USA. In these countries relatively low growth is expected. Based on these assignments, our results indicate most of the relative growth in global food demand will occur in low income countries.

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Table 1: Annualized growth rate for per capita expenditure and population from 1985 to 1995 and 1995 to 2020.

	Per capita expenditure		Population[3]	
	1985-1995[1]	1995-2020[2]	1985-1995	1995-2020
Ethiopia	1.54	0.20	2.69	4.25
Pakistan	2.13	0.97	3.04	3.46
Senegal	0.90	0.93	2.85	3.49
Korea	7.73	3.59	0.95	0.98
France	1.60	1.96	0.53	0.48
USA	1.27	1.32	0.95	1.11

Sources:

1) Annualized per capita expenditure growth rates are assumed to equal the annualized growth rate in real per capita GDP for each country. Real per capita GDP is computed using real GDP and population levels contained in the International Monetary Fund's *International Financial Statistics* (1997). Particular details are as follows:
   - i) The growth rate for per capita expenditure in Pakistan, Korea, France and the USA is based on the percentage change in real per capita GDP (1990 base year) from 1985 to 1995.
   - ii) The growth rate for Ethiopia's per capita expenditure is based on an extrapolated percentage change in real per capita GDP to 1995. The extrapolation is based on the actual percentage change in Ethiopia's real per capita GDP (1990 base year) from 1985 to 1993.
   - iii) The growth rate for Senegal's per capita expenditure is based on an extrapolated percentage change in real per capita GDP to 1995. The extrapolation is based on the actual percentage change in Senegal's real per capita GDP (1985 base year) from 1985 to 1989.
2) Annualized per capita expenditure growth rates are approximated using the annualized growth rate for real per capita GDP. To obtain the former, we "deflate" the annualized growth rate for *aggregate* real GDP (from Table 1-7 of the Global Economic Prospects) by the population growth rate for the respective county.
3) Population growth rates are based on World Bank data to 1995 and projections to 2020.

Table 2: Engel elasticities for food, grain and livestock in 1985, evaluated at each country's price level.

	Food	Grain	Livestock
Ethiopia	0.97	0.65	1.47
Pakistan	0.77	0.68	0.87
Senegal	0.76	0.64	0.88
Korea	0.55	0.37	0.68
France	0.26	0.08	0.71
USA	0.15	0.03	0.78

Table 3: Fitted, predicted and projected budget shares, expenditure levels and annualized growth rates for food, grain and livestock in 1985, 1995 and 2020 evaluated at each country's price levels.[1]

	Budget shares			Total expenditure (billions)[4]		
	Fitted 1985	Predicted 1995[2]	Projected 2020[3]	Fitted 1985	Predicted 1995[2]	Projected 2020[3]
FOOD – AGGREGATE DEMAND SYSTEM						
Ethiopia	0.52	0.52	0.51	2.01	3.04	6.91
		(-0.06)	(-0.01)		(4.21)	(3.34)
Pakistan	0.42	0.40	0.37	10.77	16.86	34.58
		(-0.61)	(-0.29)		(4.58)	(2.91)
Senegal	0.41	0.40	0.37	0.93	1.32	2.77
		(-0.30)	(-0.26)		(3.46)	(3.02)
Korea	0.31	0.20	0.09	17.88	26.35	35.37
		(-4.41)	(-2.90)		(3.95)	(1.18)
France	0.16	0.14	0.09	56.45	61.70	71.19
		(-1.22)	(-1.62)		(0.89)	(0.57)
USA	0.11	0.10	0.07	317.04	354.42	437.47
		(-1.09)	(-1.19)		(1.12)	(0.85)
GRAIN – SEVEN GOOD DEMAND SYSTEM						
Ethiopia	0.22	0.21	0.21	0.86	1.23	2.76
		(-0.52)	(-0.07)		(3.73)	(3.28)
Pakistan	0.12	0.11	0.10	3.09	4.71	9.38
		(-0.89)	(-0.41)		(4.29)	(2.79)
Senegal	0.13	0.12	0.11	0.29	0.40	0.82
		(-0.45)	(-0.40)		(3.31)	(2.88)
Korea	0.08	0.04	0.02	4.61	5.73	6.79
		(-6.01)	(-3.38)		(2.21)	(0.69)
France	0.03	0.03	0.02	11.58	12.28	13.34
		(-1.51)	(-1.86)		(0.59)	(0.33)
USA	0.02	0.02	0.01	61.24	66.97	80.47
		(-1.30)	(-1.29)		(0.90)	(0.74)
LIVESTOCK – SEVEN GOOD DEMAND SYSTEM						
Ethiopia	0.12	0.13	0.13	0.46	0.75	1.73
		(0.62)	(0.07)		(4.91)	(3.42)
Pakistan	0.14	0.14	0.13	3.63	5.79	12.14
		(-0.43)	(-0.19)		(4.77)	(3.01)
Senegal	0.14	0.14	0.13	0.32	0.45	0.97
		(-0.21)	(-0.16)		(3.57)	(3.12)
Korea	0.12	0.09	0.07	6.69	11.76	25.81
		(-2.72)	(-0.97)		(5.79)	(3.20)
France	0.08	0.08	0.07	28.52	33.68	52.34
		(-0.45)	(-0.45)		(1.67)	(1.78)
USA	0.07	0.07	0.07	205.59	249.16	390.77
		(-0.29)	(-0.24)		(1.94)	(1.82)

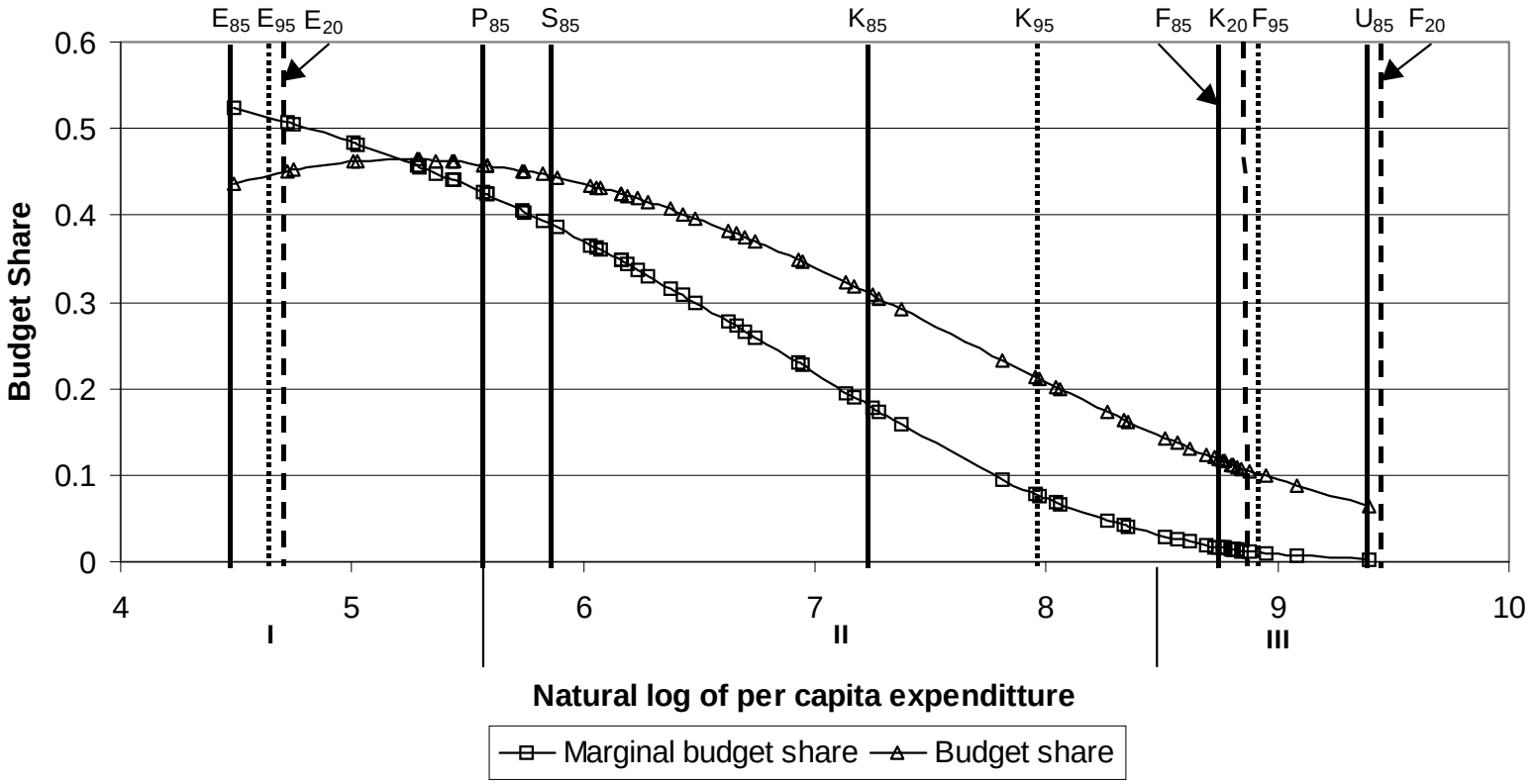
Notes: 1) Figures in parentheses are annualized growth rates.
2) Annualized growth rates in this column is between 1985 and 1995.
3) Annualized growth rates in this column is between 1995 and 2020.
4) Total expenditure is predicted per capita consumption times price times population.

Table 4: Food demand projection summary

Income Category	Percent of World's 1995 population	Representative countries	Annualized growth rate in expenditure from 1995-2020		
			Food	Grain	Livestock
Low	56	Ethiopia	3.3	3.3	3.4
		Pakistan	2.9	2.8	3.0
Lower-Middle	20	Senegal	3.0	2.9	3.1
Upper-Middle	8	Korea	1.2	0.7	3.2
High	16	France	0.6	0.3	1.8
		USA	0.9	0.7	1.8

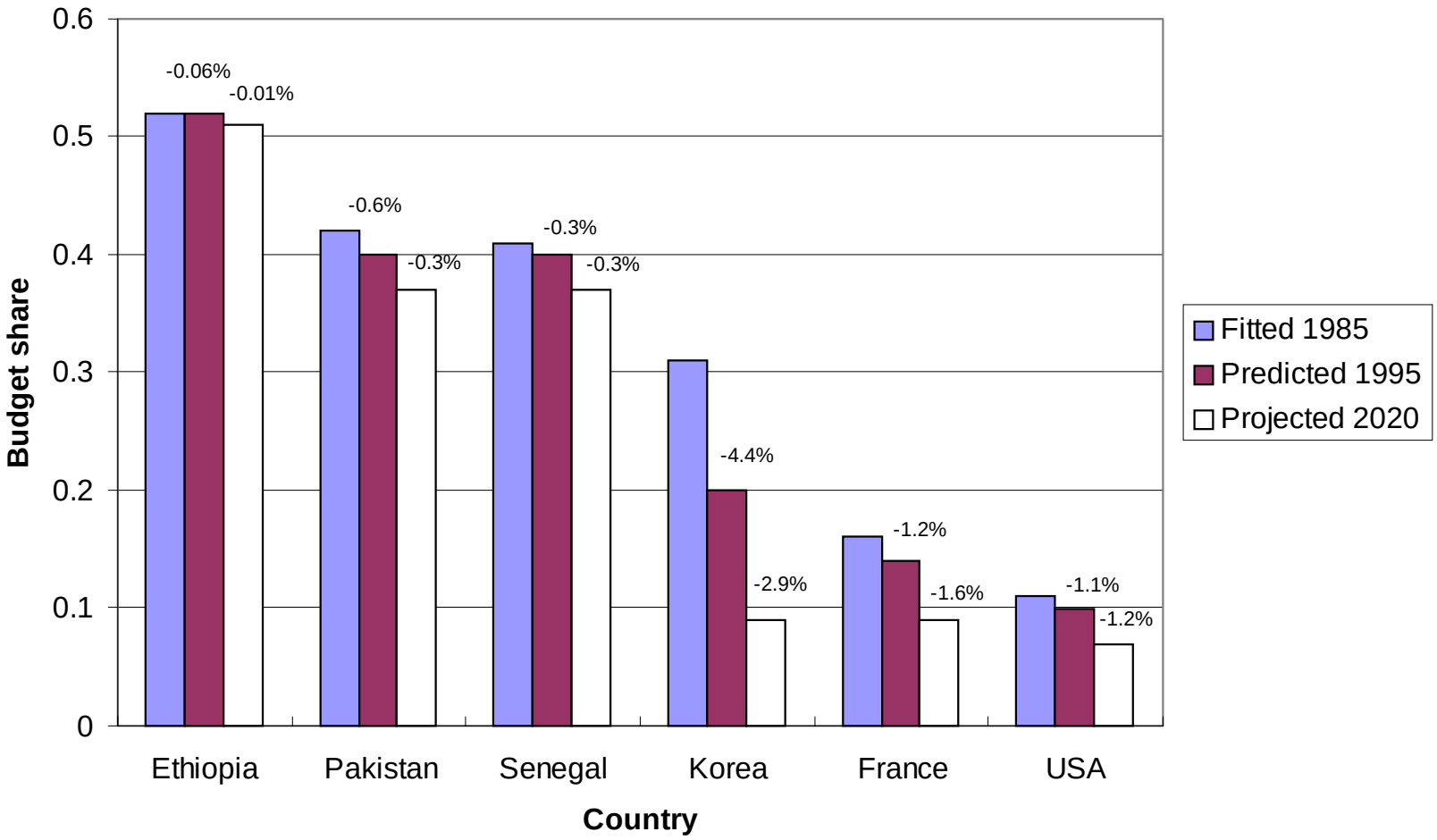
Source: World Bank (1998)

Figure 1: Marginal and fitted budget shares for food (evaluated at mean prices).



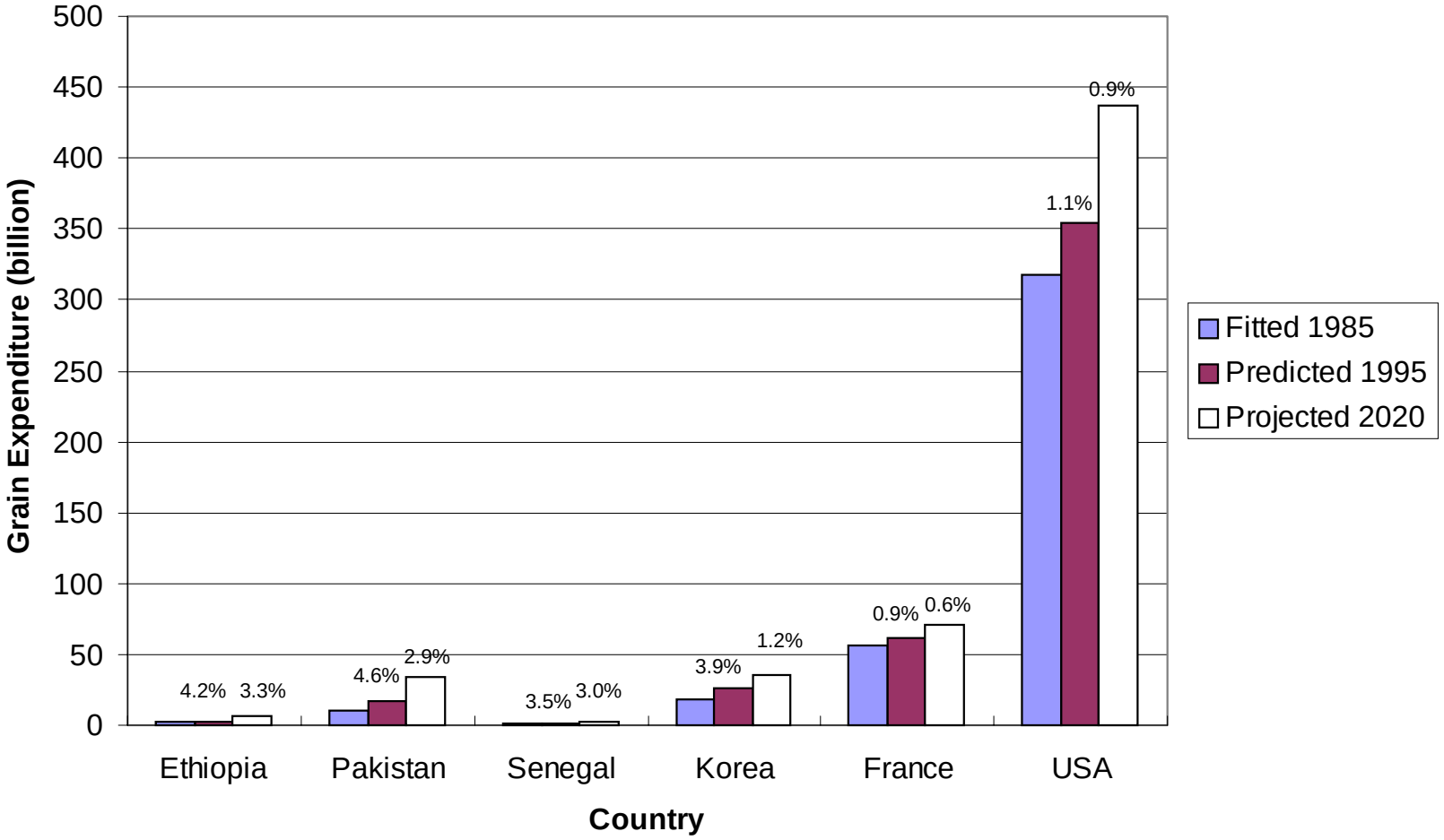
Notes: The solid vertical line denotes per capita expenditure in each of the six countries in 1985: E=Ethiopia, P=Pakistan, S=Senegal, K=Korea, F=France, U=USA, the subscript 85, 95 and 20 represent the years 1985, 1995 and 2020 respectively.
The dotted line demarks per capita expenditure in Ethiopia, Korea and France in 1995, while the dashed line demarks per capita expenditure for the same countries un 2020.
The subscripted capital letters appearing above the graph denote the country year combination for per capita expenditure. The capital letter is the first letter from the country's name, while the subscripted number denotes the year.
The Roman numerals I, II and III demark the regions of the plots used to identify three archetype consumption bundles.

Figure 2: Fitted, predicted and projected food budget shares (at each country's price level) and corresponding annualized growth rate



Notes: Values shown above the bars show the annualized growth rate in the budget share from the previous year in the analysis.

Figure 3: Fitted, predicted and projected food expenditure (at each country's price level) and corresponding annualized growth rate



Notes: Values shown above the bars show the annualized growth rate in the budget share from the previous year in the analysis.

Figure 4: Marginal budget shares for food products (evaluated at mean prices).

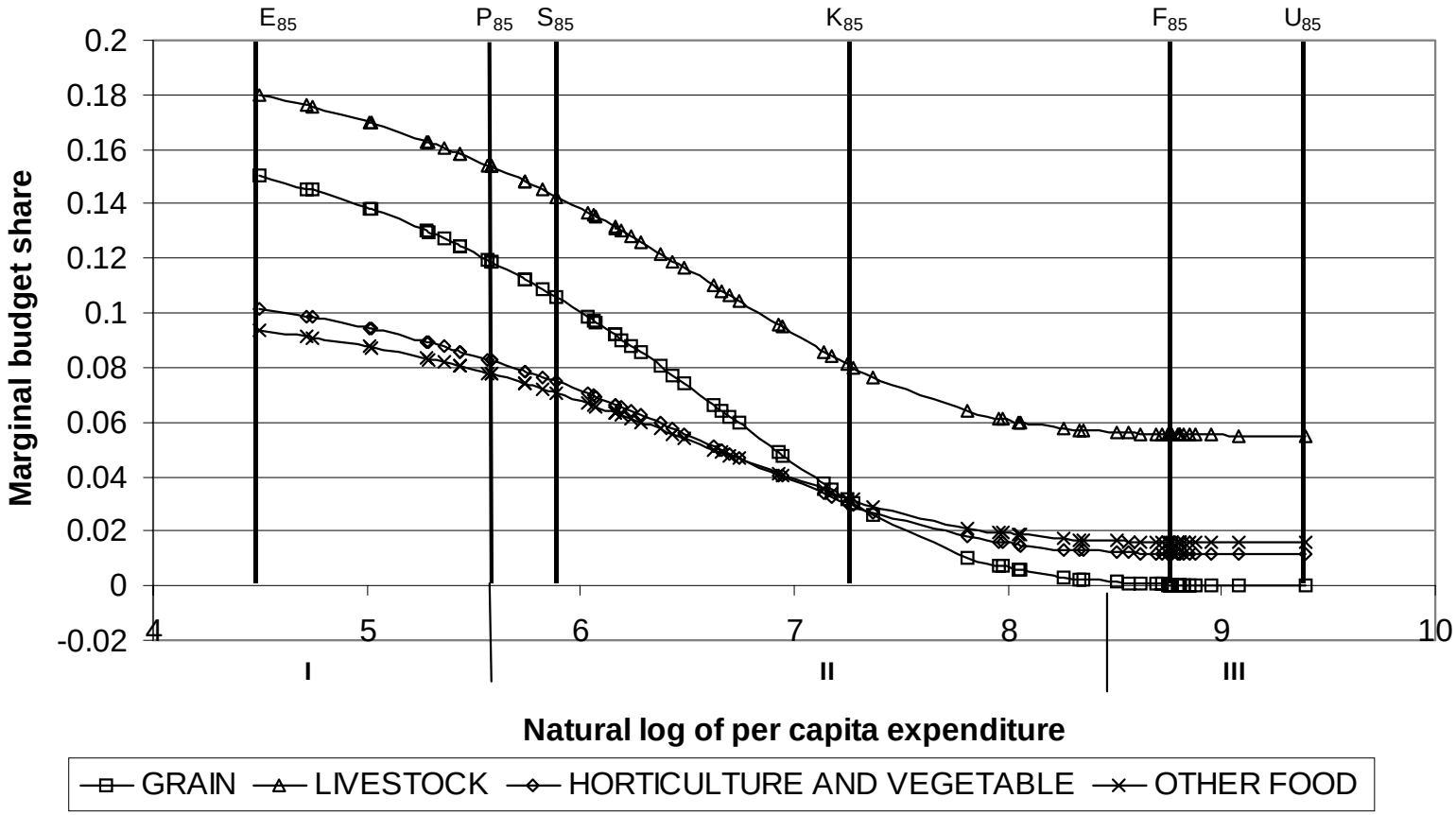


Figure 5: Fitted budget shares for food products (evaluated at mean prices).

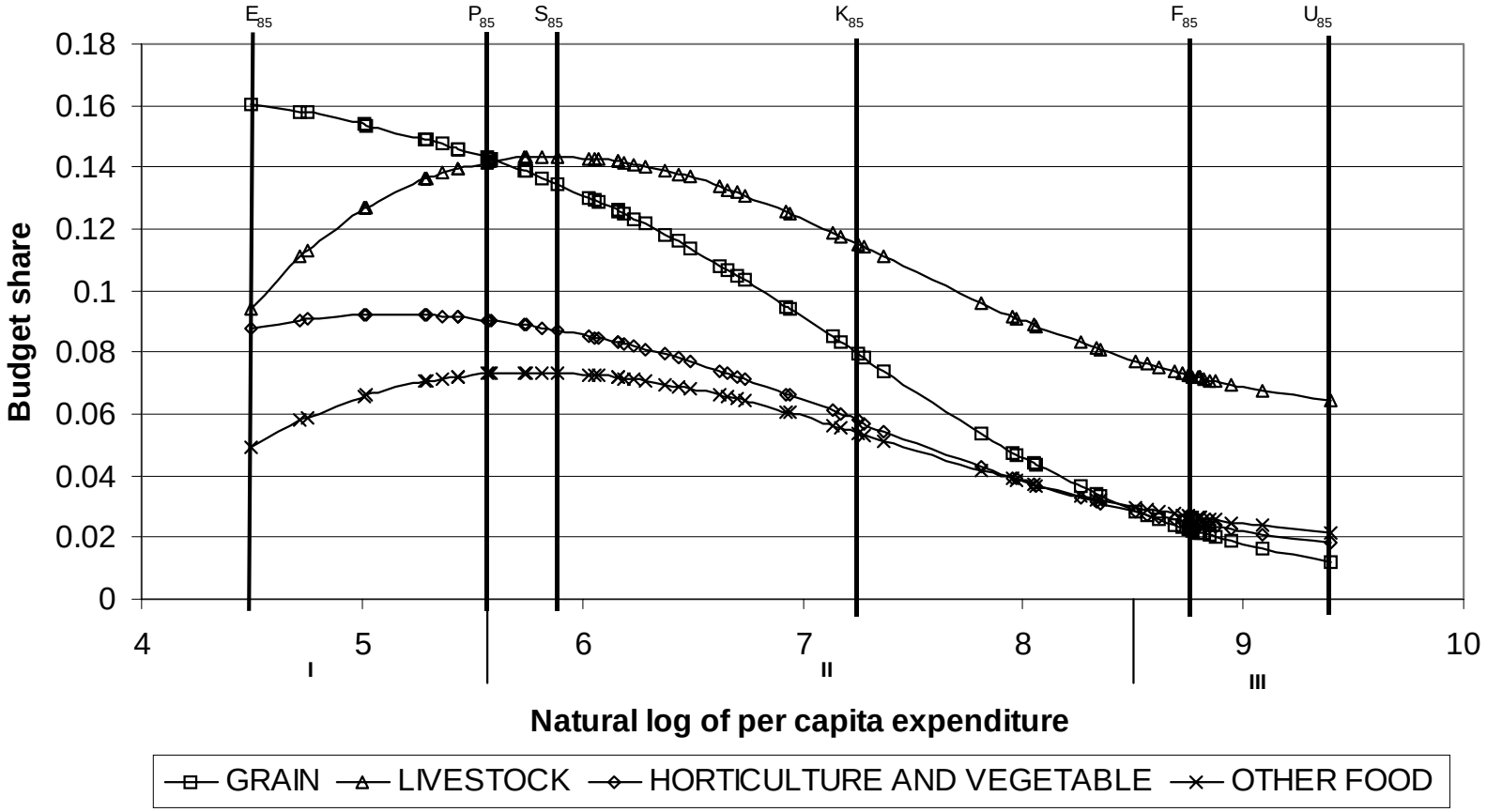
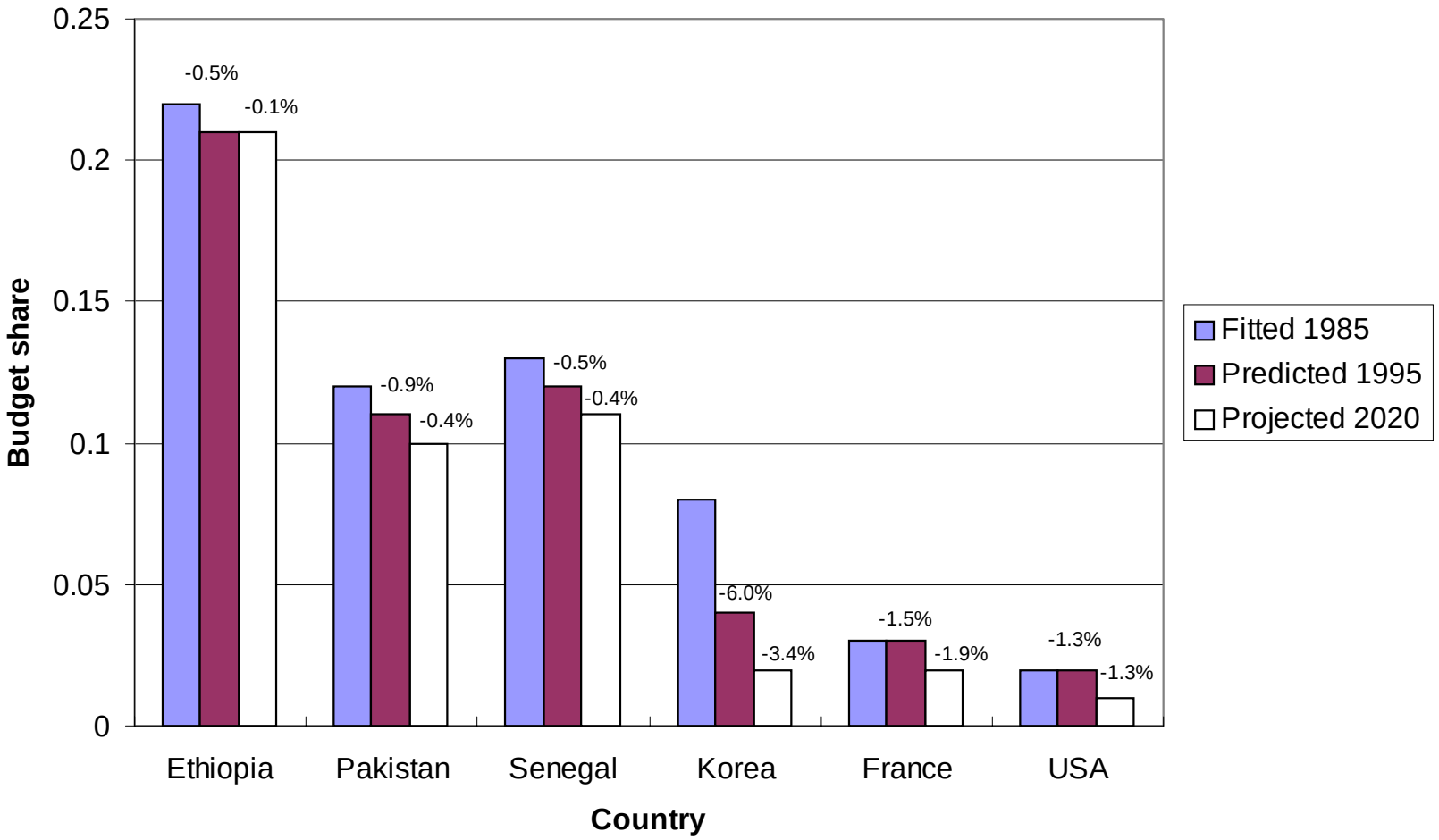
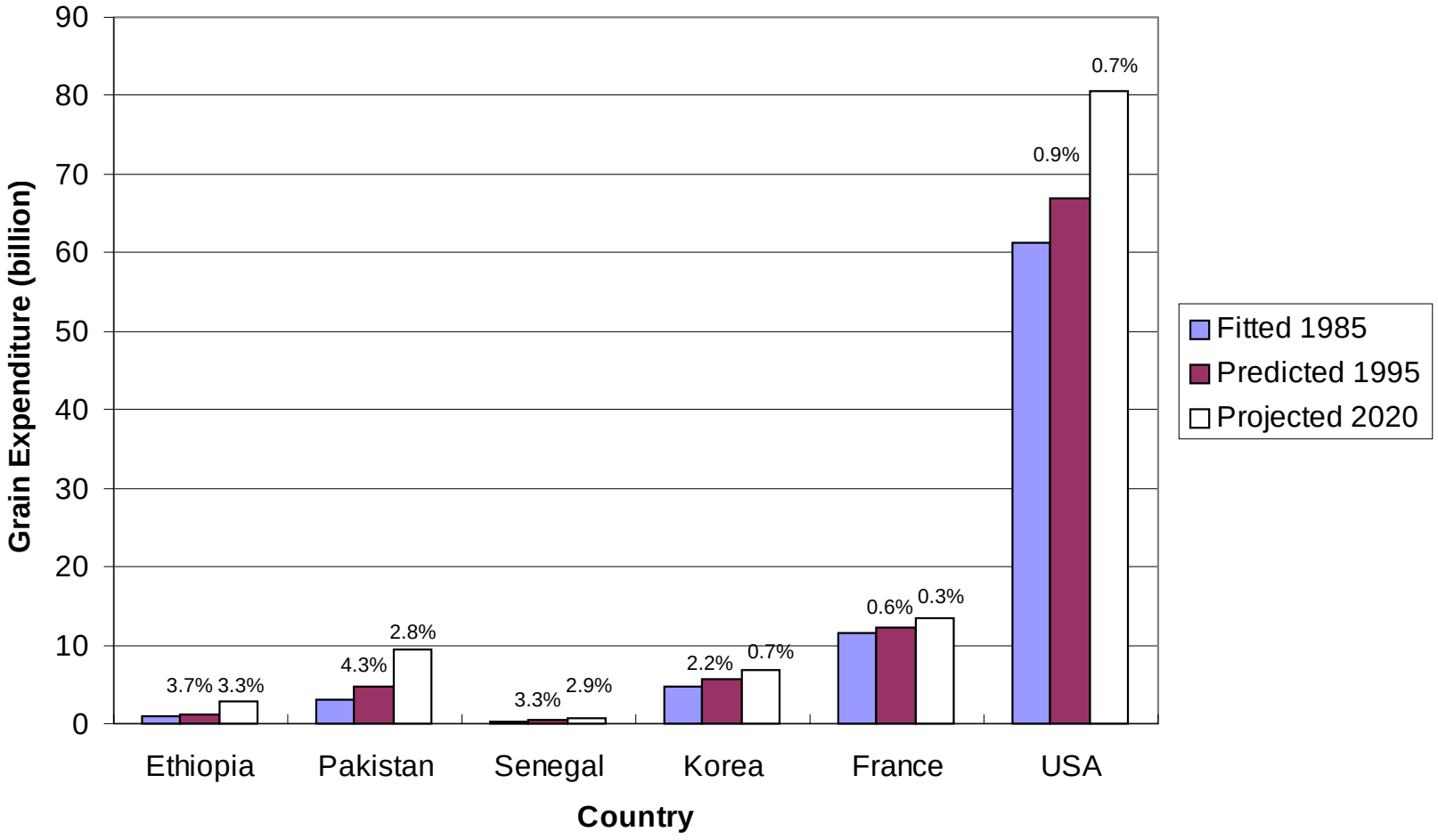


Figure 6: Fitted, predicted and projected grain budget shares (at each country's price level) and corresponding annualized growth rate



Notes: Values shown above the bars show the annualized growth rate in the budget share from the previous year in the analysis.

Figure 7 Fitted, predicted and projected grain expenditure (at each country's price level) and corresponding annualized growth rate

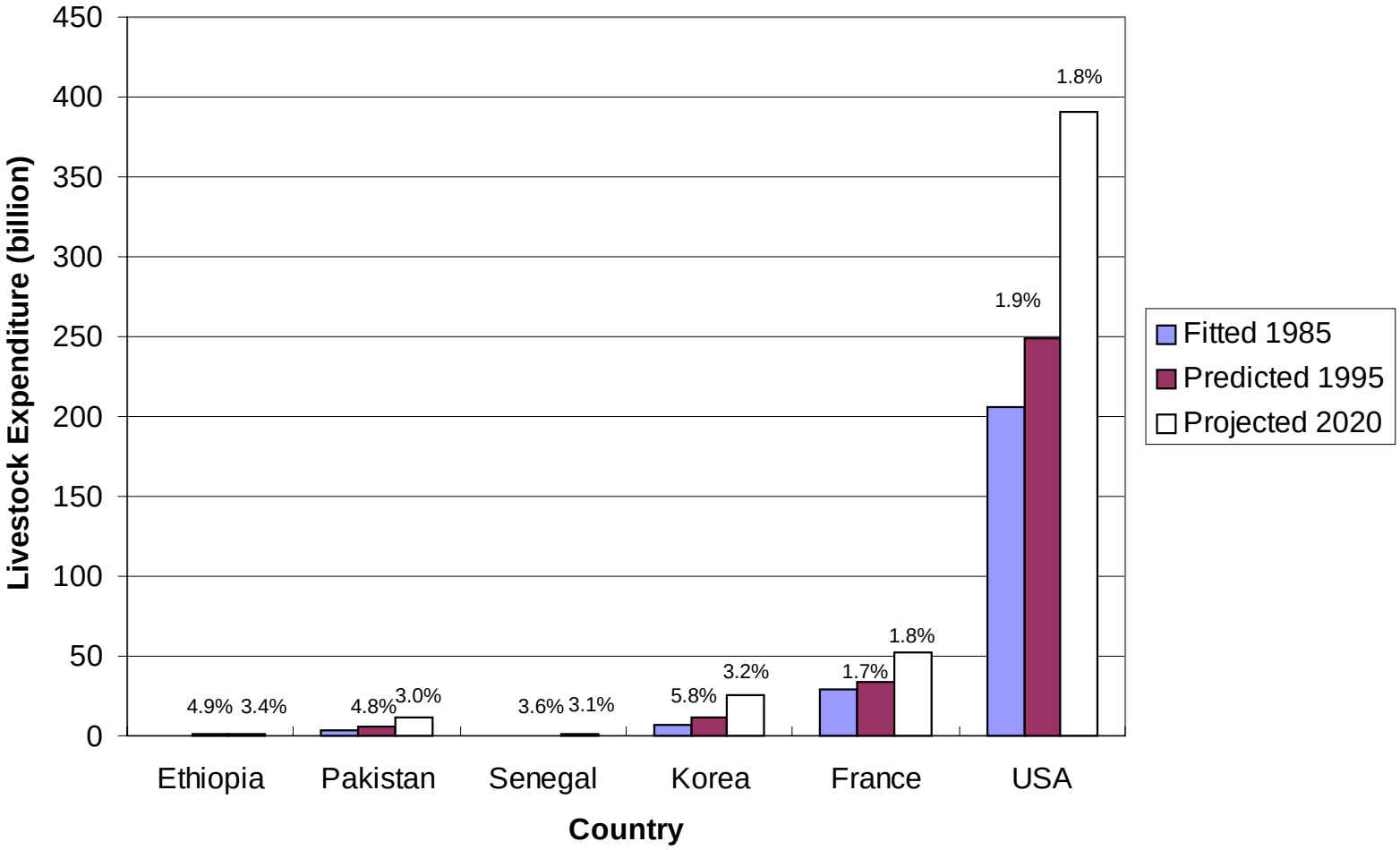


Notes: Values shown above the bars show the annualized growth rate in the budget share from the previous year in the analysis.

Figure 8: Fitted, predicted and projected livestock budget shares (at each country's price level) and corresponding annualized growth rate

Notes: Values shown above the bars show the annualized growth rate in the budget share from the previous year in the analysis.

Figure 9: Fitted, predicted and projected livestock expenditure (at each country's price level) and corresponding annualized growth rate



Notes: Values shown above the bars show the annualized growth rate in the budget share from the previous year in the analysis.