A Post-Mortem on Long-Term Projections of Global Food Requirements

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World population grew from 3.7bn in 1970 to almost 7bn in 2010 and, by 2050, is projected to increase to over 9bn. Because of growing scarcities of essential agricultural inputs, which can take decades to mobilize in sufficient quantities, long-term projections of global food requirements are critical if the "ghost of Malthus" is to be kept at bay. This paper examines long-term, i.e. 30-year, global production and consumption projections of four major agricultural sectors. These projections, whose terminal year was 2000, are then assessed against observed data from the UN's Food and Agriculture Organization's Food Balance Sheets.

INTRODUCTION: THE MAJOR ISSUES FACING GLOBAL AGRICULTURE IN THE 21ST CENTURY

The 2004 run-up of global food prices, reversing a three-decade old pattern of declining or stable prices, in conjunction with the increase in energy prices that began earlier in the decade, is causing concerns in developed and developing countries alike, as well as in international organizations such as the Paris-based International Energy Agency (IEA) at the Organization for Economic Cooperation and Development (OECD), the World Bank, and the Rome-based United Nations Food and Agriculture Organization (FAO). Higher prices for food and energy -- the two principal components of economic wellbeing -- are putting at risk the availability, affordability, and reliability of these two critical resources for hundreds of millions of the world's most vulnerable people. In fact, some of the gains made over the last decade or two in reducing the number of people living in poverty worldwide have already been lost to the sharp increases in food and energy prices. Even though the FAO's global food price index at the beginning of 2012 has receded modestly from its peak in 2010-11, currently, it is still 100% higher than it was in 2000 (Lucas and Fontanella-Khan, 2012).

Increasing geo-political tensions among the leading economic powers such as China, the European Union, Brazil, and the United States, who are trying to lock-in their resource supplies for decades to come, along with mounting scientific evidence of climate change due to the increasing emissions of greenhouse gases that is being attributed to the activities in the energy, manufacturing, transport, and agricultural sectors is painfully making it clear to political leaders and policy-makers that transformational changes in the global energy, transport, manufacturing, and agricultural systems will be required if living standards for most of the world's 7bn people are to increase over the next 40 years, when the world's population is projected to reach more than 9bn people (Parker, 2011).

While policy-makers are still preoccupied with addressing fiscal imbalances, abnormally high – and persistent – unemployment rates, and sharply higher debt levels in the wake of the public and private spending excesses of the last two decades and the economic and financial meltdown in the United States and Europe in 2008-2010, there is a critical need – because of the long lead-times to develop additional food and energy capacities – for long-term projections of global demand for these two indispensible resources if rising geo-political stress and domestic civil unrest are to be contained.

The Paris-based International Energy Agency and the Energy Information Administration, the statistical and analytical arm of the US Department of Energy, regularly publish long-term energy projections. Both of these agencies provide long-term projections, extending out 25 years or more, that are based on alternative – though reasonable – sets of assumptions (scenarios) regarding the major drivers of energy demand such as income and population growth, technological change, environmental policy, etc., in the major energy consuming (and often importing) countries, and projected supply conditions in the major energy producing (and often exporting) countries.

With regard to long-term projections of global food requirements, the US Department of Agriculture (USDA) publishes 10-year projections every year of commodities, trade, and prices based on projected US and world economic and population growth, agricultural policies, and other assumptions that affect the demand and supply conditions in the global agricultural sectors, such as increasing urbanization and changes in diets on the demand side, and estimated oil prices and productivity improvements in the farm sector on the supply side. The United Nations' Rome-based Food and Agriculture Organization recently published long-term projections of global food and nutrition levels for 2050 that include the major commodity groups of cereals, livestock, oil crops, root crops, and sugar (Conforti, 2011). These projections, too, are based on reasonable assumptions regarding prospective per capita daily calorie and protein levels, income and population growth, and likely dietary changes, especially in China and India, who are likely to experience high income growth and high migration flows from the countryside to urban areas over the next 40 years.

Two other important organizations that develop long-term projections, that is, to 2050, of global food and agriculture requirements are the Washington-based International Food Policy Research Institute (IFPRI) that is supported by the Consultative Group on International Agricultural Research (CGIAR), an alliance of 64 governments, private foundations, and international and regional organizations, and the International Institute for Applied Systems Analysis (IIASA), headquartered in Laxenburg, Austria that was founded in 1972 and conducts policy-oriented research on problems that are both global and inter-disciplinary in nature such as energy and climate change, food and water, and poverty and equity. This organization is supported by 18 national member organizations such as the US National Academy of Sciences and the Russian Academy of Sciences. Their recent work on long-term projections of global agricultural requirements to 2050 appears in the FAO report, " Looking Ahead in World Food and Agriculture: Perspectives to 2050" (Conforti, 2011).

Before turning to the subject of this paper - a post-mortem on global food projections carried out more than 30 years ago - it is useful to provide the context for writing it. In September 1981 a symposium, sponsored by the Norwegian Nobel Foundation (that I had the good fortune to participate in), was convened to "explore the long-term perspectives of world demographic and economic growth with particular emphasis on international differentials in demographic and economic characteristics, on resources and supplies, and on implications for emerging patterns of cooperation and conflict" (Faaland, 1982, p. vii). Because of the nature of the phenomena that were examined a 50-year time interval was not inappropriate, even though attempting to divine quantitative estimates of regional income growth or even population growth, not to mention regional cereal production or coal consumption 50 years into the future was then, and arguably is, even today, considered to be an exercise in futility. Nevertheless, after perusing the distinguished list of participants (Faaland, 1982; pp 254-5) in that three-day symposium, one would have to conclude that the papers presented and discussions that followed were "dead serious", even though the quantitative results, with the benefit of hindsight, were almost always "dead wrong". Please see Sohn (2005) and Sohn (2007) for the "errors" in the non-fuel minerals and energy minerals projections, respectively.

While the existential issue of unchecked population growth colliding with the capacity of the earth to feed itself was first raised more than 200 years ago by Thomas Malthus (1798), because of new constraints that have emerged over the years such as global warming and possible climate change on the one hand, and the impressive array of scientific advances and technological breakthroughs on the other, this issue came to a head between the late 1960s and the early 1980s, with the famous debate between Paul Ehrlich (1968), a Stanford University biologist, and Julian Simon (1981), a University of Illinois economist, and the path-breaking studies sponsored by the Club of Rome and carried out by Jay Forrester (1971) and Dennis Meadows and his colleagues (1972). The latter studies, for the first time, elevated the vexing problem of pollution to "center stage" in the public-policy debate.

More recently, while not focusing specifically on the population growth-food supply dilemma, the report of the UN-sponsored Intergovernmental Panel on Climate Change (IPCC, 2007), followed in the same year by the Stern Report (2007) that was commissioned by the British government, strongly implied that fundamental changes will be needed in the global food, energy, and transport sectors if we are to achieve sustainable growth in material well-being in the 21st century in light of the projected growth in population and the mounting evidence of human-induced global warming.

A BRIEF REVIEW OF RECENT LITERATURE ON LONG-TERM STUDIES ON AGRICULTURE, FOOD, AND NUTRITION

Two recent books published within a year of each other that focused on long-term trends provide the facts to support the view that without a successful global agricultural sector that incorporates production, transportation, distribution, changing consumption patterns, improved material well-being in the future - that is characterized by higher life expectancy, improved nutrition, higher incomes, and lower poverty rates - will not be possible.

The study by the 1993 Nobel laureate in economic science, Robert Fogel (2004), highlights, with particular emphasis on Europe and America, the remarkable extension of life expectancy in the 20th century and the decline in mortality rates which he attributes largely to growing (and improved) food supplies that provided increased caloric and nutritional requirements to support the higher energy levels needed for a growing work force that was sufficiently healthy, as a result of higher food intake levels and better nutrition, to fend off a long list of, often fatal, infectious diseases. Fogel makes the case, with the support of statistical data, that improvements in human nutrition contribute to economic growth and development and technological change, and vice versa. Without this synergy it is doubtful that mortality and morbidity rates would have declined sufficiently to achieve the remarkable average life expectancy levels that we are enjoying today in the developed countries, and increasingly in most of the developing countries. He highlights the interdependence of industrial progress and the importance of improvements in public health through advances in science and technological change in agriculture, manufacturing, and services.

Giovanni Federico (2005), a professor of economic history, reviewed the outstanding success of the agricultural sector over the last two centuries. Federico argues that the world agricultural system has successfully fed an ever-growing population with an increasing variety of products at falling prices, and, simultaneously over this 200 hundred-year period since Malthus's hypothesis, it did this while releasing a growing number of workers from agricultural work to the rest of the economy. The author explains how the world was able to feed 6.5bn (in 2005), up from 1bn in 1800, as a result of steady progress in the "primary forces": scientific advance, technological and institutional change, and globalization.

While the author concedes that because of the advances introduced into agriculture over the last 200 years the world should be able to provide the required caloric levels to sustain 7bn (reached in October 2011), but he questions whether the still growing population in the developing countries, which is expected to increase the world's total above 9bn by mid-century, can be provided with the nutritional standards of the developed countries, that is, a changing composition of diets to reflect a much higher proportion of meat and dairy products that are, of course, much more land-intensive than a diet comprised primarily of cereals.

Another important issue that Federico raises is the front burner issue of the "sustainability of modern agriculture", that is, how do we mitigate the environmental damage caused by the excessive use of fertilizers and pesticides, diminishing bio-diversity, increasing scarcities of water and land, and, of course, increasing levels of green-house gas emissions, with the continuing improvement in the nutritional value of food in particular, and material wellbeing in general, in Asia and Africa in the 21st century?

Federico concludes his study with the assertion that in order to feed the (then) world population of 6.5bn in 2005 even with a traditional (and monotonous) cereal-only diet - using traditional techniques of production - would require the work of 75-80% of the world's active population. As a result, living standards in some countries would be at best unchanged, or, more likely, would decline from those of two centuries ago!

While the run-up in global agricultural prices since 2004 that has spawned civil unrest in some 30 food-short developing countries in 2007-08 (Financial Times, 2012), can, in part, be attributed to production shortfalls caused by weather-related events such as floods and droughts in some of the major food producing and exporting countries such as Argentina, Australia, and Russia, the issue of "food security" is becoming as important as the issues of "energy security" and "climate change" in the international public policy debate.

In addition to the above mentioned full-fledged books and the periodic reports published by the FAO and USDA, these emerging issues have spawned an array of recent policy papers by government and academic experts (UK Government Office for Science, 2011; Godfray et al., 2010) and review articles appearing in the international press (Financial Times, 2011; Foley, 2011; Parker, 2011), on the challenges and opportunities for farming and food to the middle of the 21st century when the world's population is projected to increase more than 30% above its current level of 7bn people.

The principal objective of this paper is much more narrow and modest than a comprehensive review of 200 years of agricultural history and increasing living standards, or a description of the complex set of challenges and opportunities that exist in order to feed a world population of more than 9bn people under conditions of declining growth yields of the main crops, higher energy prices, increasing scarcity of water and land (resulting, in part, from increasing urbanization in Africa and Asia), the increasing cost of fertilizers, increasing pressures on land-use and crop-use as a result of bio-fuel policies, and, not least, the increasing contribution that global agriculture is likely to make to the emissions of two toxic greenhouse gasses, methane and nitrous oxide, and the likely effect that climate change will have on the global agricultural system in general, and on cereal crops in particular. Needless to say many of these "negatives" will be cancelled out by scientific advances in genetic engineering, improved land and water management systems, a narrowing of the "yield gap" between the worst (and average) and best yields, in addition to increased output resulting from bringing more land under cultivation, etc.

This paper is primarily concerned with reviewing long-term global projections made more than 30 years ago of four major agricultural sectors: livestock products (including meat, eggs, and milk products); oil crops (which include oilseeds, peanuts, and soybean products, among other crops); grains (which include maize (corn), rice, wheat, barley, and oats, among others); and root crops (which include potatoes and cassava, among others, but not sugar crops), with the observed data from FAO's detailed Food Balance Sheets (FAOSTATS). However, before examining the projections and the observed data it would be of interest to provide an overview of the model used at the end of the 1970s to make these projections, and a description of the representation of the agricultural sectors in that model.

THE UNITED NATIONS WORLD INPUT - OUTPUT MODEL

In the early 1970s with the recognition of the increasingly adverse environmental effects caused by worldwide industrialization - the result, in part, of the increased use of fuel, non-fuel, and agricultural-based resources - and the first major oil crisis in the decade, the United Nations voiced its concerns regarding the growing gap in income, i.e., the standard of living, between the poor, less-developed countries of the world and the richer, highly industrialized ones. As a result, in 1973 the United Nations commissioned the construction of a general-purpose model of the world economy that would be able

> "to investigate the interrelationships between future economic growth and prospective economic issues, including questions on the availability of natural resources,

the degree of pollution associated with the production of goods and services, and the economic impact of abatement policies. One question specifically asked by the study was whether the existing and other development targets were consistent with the availability and geographic distribution of resources" (Leontief et al., 1977).

In hindsight, writing at the beginning of 2012 - more than 35 years later - this modeling effort should still be recognized as an intellectual "tour de force". As far as the resource sectors were concerned, the model - which was constructed by a team of economists and computer programmers under the leadership of Professor Wassily Leontief, who was awarded the 1973 Nobel Memorial Prize in Economic Science - tracked three fuel minerals (oil, natural gas, and coal), six metallic minerals (aluminum, copper, iron, lead, nickel, and zinc), and four agricultural resources (livestock products, oil crops, grains, and root crops). Other agricultural- and food-related variables tracked by the model were irrigation investment, land development, cultivated land area, calories and proteins per day, and fish catch. The model also included 30 manufacturing and service sectors, as well as eight types of major pollutants, and five pollution abatement activities.

Economic activity was regionalized - the countries of the world were originally aggregated into 15 regional blocks - but were unified by export and import flows of goods and services, capital flows, aid transfers, and "cross border" payments of interest on borrowed capital. (Please see Table A.1 in the Appendix for the country aggregation scheme used in this study). An upgrade of the model around 1980 separated the two countries - Canada and the United States - included in the "North America" region, making a total of sixteen regions.

Once assembled, the model was designed to provide quantitative projections of regional and global resource requirements, pollution levels, cumulative resource use, and required inter-regional financial flows, etc., under varying assumptions regarding future income growth in the developed and developing countries with a view towards narrowing the income gap between the two groups of countries from 12:1 (in 1970) to 7:1 (by the year 2000) in accordance with the goal of UN General Assembly resolution 3201 (S-VI) of May 1, 1974 on the Establishment of a New International Economic Order. Curiously, according to the observed per capita GDP for the year 2000 used in the tables in this paper, the (per capita) income gap between the two groups of countries, in fact, declined from 12:1 in 1970 to 6.6:1 in 2000.

In 1977, with financial support from the US National Science Foundation (along with supplementary funding from the US Bureau of Mines), a team of investigators, again led by Professor Leontief, began a detailed study of the future demand for, and supply of, 26 non-fuel minerals for the US and world economy, embedding 20 "new" minerals into this recently completed World Input-Output Model. One of the principal issues examined in this study was the adequacy of these critical resources to meet national and global requirements to the year 2000 and beyond (Leontief et al., 1983a).

Since its completion in 1976, the World Input-Output Model was enlisted to examine a number of specialized issues ranging from the future of world ports to an expanded study of 20 other non-fuel minerals not included in the original project that was mentioned above (Leontief, Gray and Kleinberg, 1979; Leontief and Duchin, 1983; Leontief et al., 1983b), and the study presented at the symposium sponsored by the Norwegian Nobel Institute in September 1981 that was mentioned above (Leontief and Sohn, 1982).

PROJECTED AND OBSERVED POPULATION AND INCOME GROWTH: THE MAIN DRIVERS OF GLOBAL FOOD REQUIREMENTS

This section presents the data that are among the principal long-term determinants of food consumption - population and income growth - on a regional and global level, for the 1970-2000 interval. Table 1 presents the developed and developing countries' changing population levels and shares of the world total for 1970 and the projected and observed 2000 values.

TABLE 1
PROJECTED AND OBSERVED POPULATION LEVELS (IN BILLIONS) AND SHARES (IN PERCENT), 1970-2000

	1970 Base Year		2000 Projected		2000 Observed	
Region	Level	Share	Level	Share	Level	Share
Developed Countries	1.0	0.3	1.4	0.2	1.4	0.2
Developing Countries	2.6	0.7	4.7	0.8	4.6	0.8
World	3.7	1.0	6.1	1.0	6.1	1.0

Note: For the country and regional aggregation schemes, please see Tables A.1 and A.2 in the Appendix.
Sources: Leontief et al., 1977; World Bank, 2002

The population projections made in the mid-1970s for the year 2000 by the United Nations Population Division, were insignificantly different from the observed global level for 2000, as can be observed in Table 1, above. As expected, the share of the developed countries in total world population declined from 30% to 23% over the interval, with more than three-quarters of the world's population in 2000 residing in the developing countries, a trend that is likely to continue in the 21st century (Magnus, 2009).

Table 2, below, presents the projected and observed regional population, GDP, and GDP per capita growth rates for the projection interval. The lower observed population growth rates for most of the regions (with the exception of Africa, Asia, one European region, and the United States) as compared to the projections are consistent with long-term demographic trends. The demographic changes in two of the European regions WEH (western Europe, high income) and EEM (eastern Europe, medium income) are the result of the re-unification of Germany in the early 1990s and the migration of many eastern-Europeans and others to western-Europe, in part, as a result of the economic stress in the eastern countries in the wake of the collapse of the Soviet Empire in the 1980s. As for the US, the increase in the observed population growth rate in the 1970-2000 period compared with the projected rate for this interval is most likely explained by increased immigration from Central and South America, Asia, the Middle East, the former Soviet Union, and Africa during the last two decades. The observed growth rate for (non-Japan) Asia exceeded the projected rate by less than 10%, and the only substantial "error" appears to be Africa (AF), where the observed rate of population growth exceeded the projected rate by 0.5% per year.

Turning to GDP growth, observed world GDP growth was less than the rate projected by the World Model, despite the formidable growth rates achieved by China (ASC), and India and other Asian countries (ASL), from 1980 to the projection period's terminal year, 2000. The observed lower growth rates in GDP relative to the projected rates over this interval in the middle-eastern oil-producing countries (OIL), Central and South America and the Caribbean (LA), South Africa (SAF), the Soviet Union (SU), and Eastern-Europe (EEM), and the lower observed growth in Japan and Western Europe (WEH), can be attributed to an array of well-known political, social, economic and financial problems that these regions (and countries) confronted during the 1980-2000 interval. These problems also explain, in part, the lower observed world GDP growth rate relative to the projected rate despite the successes in Asia.

The last two columns of Table 2 present projected and observed annual growth in GDP per capita over the projection interval. For economists, per capita GDP (whether calculated at current exchange rates or on a purchasing power parity basis) represents, an imperfect, though adequate statistic to measure relative "living standards" and their growth (or, as the case may be, their decline) over time. The observed changes in per capita GDP in China (ASC), India, South Korea, and Thailand (ASL), and the Soviet Union (SU) over the projection period reveal in the official data what is commonly perceived as the "conventional opinion" on the economic performance of these countries over the 1970-2000 interval.

TABLE 2
PROJECTED AND OBSERVED GROWTH IN POPULATION, GROSS DOMESTIC PRODUCT, AND GROSS DOMESTIC PRODUCT PER CAPITA, 1970-2000
(ANNUAL PERCENTAGE CHANGE)

	Population		Gross Domestic Product		GDP per Capita	
Region	Projected	Observed	Projected	Observed	Projected	Observed
AF*	2.3	2.8	2.9	3.7	0.6	0.9
ASC	1.4	1.5	4.3	8.9	2.9	7.3
ASL	2.0	2.2	3.6	5.4	1.6	3.1
CANADA	1.3	1.2	3.6	5.5	2.2	2.3
EEM***	0.6	-0.2	4.4	2.6	3.8	2.8
JAPAN	0.7	0.6	5.3	3.5	4.6	2.9
LA**	2.3	2.0	6.0	3.6	3.6	1.6
OCH	1.3	1.3	3.8	3.4	2.5	2.1
OIL	3.2	2.9	12.0	2.7	8.5	-0.2
SU	0.8	0.6	3.2	0.0	2.4	-0.6
SAF	2.8	2.3	4.6	2.4	1.8	0.1
USA	0.9	1.1	2.8	3.3	2.3	2.2
WEH***	0.2	0.4	3.3	2.5	3.1	2.1
WEM	1.3	1.2	2.4	3.1	1.0	1.9
WORLD	1.69	1.70	3.96	3.30	2.20	1.57

Notes: * Throughout this paper the region designated by AF combines the two regions, AAF and TAF, from the original regional representation in Appendix Table A.1.
** Throughout this paper the region designated by LA combines the two regions, LAL and LAM, from the original regional representation in Appendix Table A.1.
*** Throughout this paper the data for 2000 are for a unified Germany that is part of the WEH region.
Sources: Leontief and Sohn, 1982; Leontief et al., 1983b; World Bank, 2002

In addition to population and GDP growth, regional and global food requirements are also impacted by a number of other important variables such as urbanization rates, which along with higher living standards (increased GDP per capita), result in changing diets such as, for example, a movement away from root crops to grains, and finally, to increased livestock products, characterized by more meat, eggs and cheese, in daily diets.

Despite not having access to the documentation regarding the technical relationships governing these regional changes in food diets from decade to decade over the projection interval when writing this paper, it is my understanding that because the World Model tracked both the changing regional urbanization rates and per capita GDP levels from decade to decade, the projections of the regional food requirements were, in part, determined by these factors that were modified region-by-region and decade-by-decade.

GLOBAL AGRICULTURE, 1970-2000: THE PROJECTIONS AND THE OBSERVED DATA

This section presents a number of tables that provide an overview of the projections and observed data for the 30-year projection interval for the four broad-based agricultural sectors represented in the World Model - livestock products, oil crops, grains, and root crops - for the 15 regions (including the world) that are tracked in this study.

Some Caveats About the Data

Before presenting these tables a few warnings are in order regarding some data problems I encountered in order to make the World Model data and regional classification system compatible with the FAO's database over the 30-year interval. Many, though not all, of the inconsistencies and anomalies have been mitigated (if not eliminated) by using annual or total growth rates over the reporting interval in place of reporting the levels of agricultural output and consumption for the projections and the observed data.

For example, in the 1970s the region EEM in the World Model represented all the central European countries in the then Soviet Union's orbit (with the exception of Tito's Yugoslavia). By the early 1990s and the unification of Germany, national accounts data (population and GDP growth statistics), as well as food production and consumption data, were no longer represented separately for East and West Germany, and, as a result, a "unified" Germany, for the observed, i.e., FAO, data in both 1970 and 2000, was included in the western Europe (high income) region.

Similarly in the case of the former Soviet Union, while the model's projections for 2000 are for the (intact) Soviet Union, I was forced to reconstruct the "old" Soviet Union for the observed 2000 data since FAO's database does not report data for the Soviet Union after 1991, following its dissolution. Some of the data problems I encountered could have been resolved in a more satisfactory way, but FAO staff was either unable or unwilling to respond to repeated requests to provide answers to my questions on these subjects.

Other political changes since 1970 proved more challenging in reconciling World Model regions with the FAO database. For example, in the closing years of the "Cold War", circa 1974-76, when the World Model was constructed, South Vietnam and North Vietnam were assigned to different regions; the former to Asia Low Income (ASL) and the latter to Asia Centrally Planned (ASC). Since FAO's database for 1970 does not track data for a divided Vietnam, therefore, the "unified" Vietnam was assigned to the Asia Centrally Planned region (ASC).

And then there is always the intractable problem of Taiwan. FAO, a United Nations organization, no longer recognizes Taiwan with country status, and therefore does not have a separate listing for it in its agricultural database. The World Model, constructed in the mid-1970s, included Taiwan in the ASL region, and Mainland China in the ASC region. Presumably, FAO's data for China, both in 1970 and 2000, include both. But again, without more cooperation from FAO staff on these questions, I am unable to provide any further clarification on this issue.

In the original regional breakdown in the World Model, Latin America (including Mexico and the Caribbean) was divided into two regions (Latin America, low income and Latina America, medium income). In order to accommodate FAO's regional breakdown - Central America (which includes Mexico), the Caribbean, and South America - these three FAO regions were aggregated into one, and the two World Model regions were combined into one, so there is now one "super" region in both sets of data for Latin America (LA). For Africa, a similar aggregation was performed: the World Model represented Africa with three regions - Arid Africa, South Africa, and Tropical Africa. The major oil-producing and -exporting countries in Africa, such as Algeria, Libya, and Nigeria, were consigned to the region designated by OIL that included countries such as Iran, Iraq, and Saudi Arabia. I aggregated the regions Arid Africa and Tropical Africa into one separate region, Africa (AF), while retaining South Africa as a "stand alone" region. This was done to facilitate the assembly of data from FAO's database for 55 African countries that are represented in the World Model.

Other problems resulted from missing or incomplete documentation of technical information on the composition of the four broad-based groups of agricultural products tracked by the World Model. While the Model's base-year is 1970, it is quite possible that the agricultural data may have been from an earlier year, and/or it is likely that revisions in subsequent years were made to the "1970" data by FAO as part of their normal data management procedures. As a result, the base-year 1970 World Model data can vary substantially from the 1970 observed data in the current FAO database. Fortunately utilizing annual and total growth rates over the 30-year interval in place of levels, as mentioned above, can address this problem.

A Comment on "Consumption"

While the "production" of agricultural output is well defined in both the World Model and the FAO database, regional "consumption" in the World Model is derived as a residual to regional production minus exports plus imports, and, as a result, I use the term "domestic supply" instead of "consumption", a term that better aligns with the term used for this "equation" in FAO's Food Balance Sheets. Needless to say, in the World Model projections, there are no increases or reductions in regional inventories or other "frictions" such as crops being used for feed or seed purposes. On the other hand, FAO's Food Balance Sheets provide statistics for these "frictions", and also provide a category for each crop that was used as "food", which appears in some of the tables that follow in addition to "domestic supply". Finally, while the "production" and "domestic supply" growth rates, both annual and total, will be equal for the world in 1970 and 2000 in the World Model projections ("rounding errors" notwithstanding), they need not be equal in the individual regions because of importing and exporting activities. On the other hand, FAO data may not balance even at the world level for 1970 and 2000 because of the other "frictions" mentioned above and/or errors on my part in recording the data flows as I reconstructed some of the "discontinued" regions, a problem that might have been avoided or, at least reduced, if FAO staff had been more cooperative.

The Projections and the Observed Data

Production and Domestic Supply

Tables 3 and 4, respectively, present the projected and observed annual growth rates in production and domestic supply (and, in the case of the observed data, food consumption) of the four broad-based agricultural sectors - livestock products, oil crops, grains, and root crops - for the 30-year projection interval.

TABLE 3
PROJECTED GROWTH RATES IN PRODUCTION AND DOMESTIC SUPPLY IN FOUR AGRICULTURAL SECTORS, 1970-2000 (ANNUAL PERCENTAGE CHANGE)

	Livestock Products		Oil Crops		Grains		Root Crops	
Region	Production	Dom. Supply	Production	Dom. Supply	Production	Dom. Supply	Production	Dom. Supply
AF	2.1	2.1	0.5	0.9	1.8	2.0	-0.6	-0.6
ASC	2.6	2.6	2.0	2.1	1.7	1.8	1.1	1.1
ASL	0.8	0.8	-1.3	-0.8	1.8	1.8	2.2	2.2
CANADA	2.7	2.6	3.0	3.4	2.9	2.3	2.2	1.7
EEM	2.7	2.8	-0.1	1.0	2.5	1.9	0.9	0.8
JAPAN	4.7	5.2	-1.2	2.0	-0.6	2.1	-3.2	-3.3
LA	3.7	3.5	4.4	3.0	2.5	2.7	-0.3	-0.4
OCH	2.3	3.1	3.7	1.0	2.4	1.7	1.3	1.6
OIL	3.6	4.9	1.0	4.7	4.7	5.4	4.7	4.7
SU	2.9	2.9	-2.1	-1.8	1.4	1.8	-0.1	-0.1
SAF	2.0	2.0	-0.7	3.3	3.4	3.3	0.0	0.8
USA	1.1	0.8	1.2	0.0	2.0	1.1	-0.8	-0.5
WEH	2.3	2.3	2.5	2.3	1.5	1.2	-1.6	-1.7
WEM	0.1	0.3	-2.6	-0.2	1.8	1.9	0.7	0.9
WORLD	2.3	2.3	0.7	0.7	1.9	1.9	0.5	0.5

Note: Domestic supply equals production plus net imports.
Sources: Leontief and Sohn, 1982; Leontief et al., 1983b

At the global level the projected annual growth rates are remarkably close to the observed rates, save oil crops, where the observed growth rate is almost 400% higher than the projected rate. Needless to say, this very large discrepancy relative to the other sectors warrants additional investigation in a planned future study. It would be reasonable to expect greater divergence at the regional (or country) level, not only between the projected and observed values, but also even between the values for regional (country) production and domestic supply because of import, export (and, in the case of the observed growth rates, inventory adjustment) activities. This is, indeed, the case. The planned future study will focus on explaining the differences, at the regional level, between the projected and the observed growth rates employing the central explanatory variables - population, GDP, and GDP per capita growth - as the "primary suspects" in explaining away these discrepancies.

TABLE 4
OBSERVED GROWTH RATES IN PRODUCTION AND DOMESTIC SUPPLY IN FOUR AGRICULTURAL SECTORS, 1970-2000 (ANNUAL PERCENTAGE CHANGE)

	Livestock Products			Oil Crops			Grains			Root Crops		
Region	Prod.	Dom. Supply	Food Con.	Prod.	Dom. Supply	Food Con.	Prod.	Dom. Supply	Food Con.	Prod.	Dom. Supply	Food Con.
AF	3.1	2.8	3.1	1.4	1.5	1.2	2.1	2.9	2.6	2.7	2.8	2.7
ASC	7.0	7.4	7.4	3.6	3.0	2.5	2.5	2.5	2.3	1.0	1.0	0.0
ASL	4.3	3.3	4.2	2.8	3.3	2.6	2.6	2.5	2.2	2.8	2.7	2.1
CAN	1.2	1.1	1.2	4.1	5.2	2.3	2.0	1.0	2.1	2.0	1.1	1.1
EEM	-1.2	-1.3	-1.1	-0.8	-1.1	0.6	-1.7	-1.6	-2.0	-6.5	-3.3	-2.2
JAPAN	1.9	2.9	3.0	0.0	1.5	0.8	-1.0	0.9	0.0	-1.5	-0.7	0.8
LA	3.4	3.5	3.6	6.2	5.8	4.0	2.2	2.9	2.3	0.0	0.0	0.0
OCH	1.4	0.6	1.1	10.0	4.7	1.4	3.2	2.5	0.7	1.6	0.2	1.4
OIL	4.7	5.1	5.1	2.4	3.1	10.9	2.4	4.3	3.8	3.7	3.6	3.5
SU	-0.8	-0.7	-0.7	0.0	-0.2	0.0	-1.1	-0.9	-0.9	-0.2	-1.1	-1.1
SAF	1.2	1.8	2.2	2.8	4.3	3.7	1.8	2.1	2.4	3.0	3.3	3.3
USA	1.6	1.4	1.4	2.9	2.4	1.4	2.0	1.5	2.3	1.4	1.2	1.5
WEH	1.0	0.7	-0.2	5.0	2.8	2.2	2.0	0.6	0.4	-1.1	-0.8	-0.2
WEM	2.0	1.9	2.9	2.9	3.2	5.0	1.8	1.5	0.9	0.0	1.5	1.0
WORLD	2.3	2.1	2.4	3.3	3.3	2.5	1.8	1.7	1.9	0.7	0.7	1.0

Note: Domestic supply equals production plus changes in inventories plus net imports.
Source: FAOSTATS, (FAO)

At the global level, the observed growth rates of livestock products, oil crops and grains all exceeded the rate of growth in population and per capita GDP, with only the rate of growth in production of root crops lagging population and per capita GDP growth, for reasons that are not obvious to me at this time.

Regional (or Country) Dependence on Food Imports

Paralleling the growing concerns over "energy security" since the run-up in global food prices in 2004, "food security" has become an issue for countries who rely on food imports to bridge their shortfall between domestic production and food consumption. In addition, the FAO and other international organizations who track the adequacy of food supplies and nutrition levels in low-income countries, have elevated the issue of "food security' to the highest level of public-policy debate.

The World Model tracked regional (and, in some cases, country) import and export activities. Therefore, it would be of interest to examine the changing position of regions (and, where possible, countries) over the 30-year interval of time with respect to their dependence on imports to supplement the domestic production of their food requirements.

Before presenting the projected and observed rates of import dependence in agriculture it is important to remind readers that the degree of import dependency of a region - or more specifically of a country - on energy or food is only one factor among others that comprise the more complex terms "energy security" or “food security”. Some of these other factors include the sources of those imports, the availability of substitutes, the ease or difficulty of increasing efficiency in their use, etc.

TABLE 5
IMPORT DEPENDENCE IN AGRICULTURE, 1970 AND 2000: PROJECTED (WM) AND OBSERVED (FAO) RATIOS (IN PERCENT)

	Livestock Products				Oil Crops				Grains				Root Crops			
	1970		2000		1970		2000		1970		2000		1970		2000	
Region	WM	FAO	WM	FAO	WM	FAO	WM	FAO	WM	FAO	WM	FAO	WM	FAO	WM	FAO
AF	3.8	0.0	4.2	6.0	0.0	0.0	7.6	1.0	5.9	18.0	0.0	28.0	0.0	0.0	0.0	0.0
ASC	0.0	1.0	0.0	0.0	0.0	18.0	2.2	1.0	0.0	5.0	5.1	2.0	0.0	0.0	0.0	0.0
ASL	2.9	2.0	4.0	2.0	0.0	7.0	10.5	7.0	4.4	1.0	2.4	1.0	0.0	0.0	0.2	0.0
CAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.7	0.0	0.0	0.0
EEM	0.0	0.0	0.0	0.0	34.0	2.0	52.4	0.0	21.9	1.0	6.5	0.0	0.0	0.0	0.0	0.0
JAPAN	7.5	12.0	18.8	36.0	81.5	98.0	92.9	98.0	32.7	56.0	69.8	77.0	4.5	31.0	0.0	24.0
LA	0.0	12.0	0.0	3.0	1.1	0.0	15.2	0.0	8.8	0.0	5.9	13.0	1.4	0.0	0.5	0.0
OCH	0.0	0.0	0.0	0.0	66.7	0.0	25.0	0.0	0.0	0.0	0.0	0.0	10.0	0.0	0.0	0.0
OIL	6.5	25.0	34.9	25.0	0.0	0.0	51.2	0.0	10.1	55.0	25.6	55.0	1.0	13.0	0.5	1.0
SU	0.0	3.0	0.9	0.0	0.0	0.0	10.6	0.0	0.0	0.0	10.3	0.0	0.0	0.0	0.1	1.0
SAF	0.0	1.0	0.0	7.0	0.0	0.0	50.0	13.0	0.0	0.0	0.0	7.0	0.0	0.0	20.0	4.0
USA	5.5	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.9	2.0	0.0	1.0
WEH	0.0	0.0	0.0	0.0	91.6	76.0	90.3	48.0	11.8	17.0	3.3	0.0	3.3	8.0	0.0	9.0
WEM	0.7	0.0	6.7	5.0	6.7	18.0	54.8	27.0	6.2	0.0	9.2	13.0	5.1	0.0	0.0	35.0

Note: An “import dependence” ratio is defined as net imports as a percentage of domestic supply.
Sources: Leontief and Sohn, 1982; Leontief et al., 1983b; FAOSTATS, (FAO)

The changing rates of projected and observed dependency on agricultural imports are presented in Table 5. While there are relatively large differences between the projected and observed data regarding the degree, i.e., the percent, of import dependency in 2000, generally speaking there is broad agreement between the projected and observed data regarding the regions (or countries) that are most dependent on imports to supplement their domestic production. The planned follow-up study will analyze these differences in conjunction with the differences already cited in population and GDP growth over the 30-year period.

Table 6 describes the changing role of world trade in agricultural commodities observed from 1970 - 2000. Since the proportion of world production of these agricultural products that were shipped across

TABLE 6
GLOBAL AGRICULTURE: THE CHANGING RATIOS OF WORLD IMPORTS TO WORLD PRODUCTION, 1970 AND 2000 (IN PERCENT)

	Livestock Products	Oil Crops	Grains	Root Crops
World Imports / World Production in 1970	6.2	15.4	11.0	2.0
World Imports / World Production in 2000	11.1	19.7	15.3	5.8
Cummulative change from 1970 to 2000	79.0	27.9	39.1	190.0
Annual Rate of Growth in Imports: 1970 to 2000	4.1	4.1	2.9	4.3
Annual Rate of Growth in World Production: 1970 to 2000	2.3	3.3	1.8	0.7

Source: FAOSTATS, (FAO)

regional (or country) borders increased for all four groups from 1970 to 2000, the annual rate of growth in world imports of these agricultural products exceeded the annual rate of growth in the world output of all four agricultural groups. Nevertheless, the liberalization of global agricultural trade over the 1970-2000 interval is progressing more slowly than total world merchandise imports, which grew by 10.6% per year according to the World Trade Organization (World Trade Organization).

Per Capita "Consumption" of Livestock Products and Grains: The Projections and the Observed Values in 1970 and 2000

Table 7 presents the projected and observed annual per capita domestic supply (in kilograms) of two of the four agricultural sectors in this study: livestock products and grains. Grains were selected because grains was the largest commodity group (by far), in tonnage, of the four agricultural sectors included in the study, and livestock products were selected because increased per capita consumption of livestock products is closely associated with higher living standards. (Readers are reminded that "domestic supply" - domestic production and inventory changes plus net imports - is distributed to uses such as food, feed, seed, processing, etc).

At the global level the 2000 projections of per capita domestic supply was 17% above the observed FAO level, though most of the difference, 11%, is due to the higher base year level. For livestock products, the projected global level agrees well with the 2000 observed level, even though FAO's base year level was 5% above the World Model 1970 level.

With a few exceptions - to be examined in the follow-up paper - generally speaking, per capita domestic supply of livestock products and grains increased in those regions where living standards advanced, in particular, in ASC (China) and ASL (India), and declined in those regions where living standards stagnated or fell (AF, EEM, and SU). These trends are more sharply discerned in Table 8, which presents only the observed changes in annual per capita consumption of livestock products and grains as <u>food</u> from 1970 to 2000.

TABLE 7
PROJECTED (WM) AND OBSERVED (FAO) ANNUAL PER CAPITA DOMESTIC SUPPLY OF LIVESTOCK PRODUCTS AND GRAINS, 1970 AND 2000 (IN KILOGRAMS)

	1970				2000			
	Livestock		Grains		Livestock		Grains	
Region	WM	FAO	WM	FAO	WM	FAO	WM	FAO
AF	28.9	25.2	180.9	163.5	23.3	25.5	164.5	173.4
ASC	21.7	11.3	262.5	207.2	30.9	61.0	298.2	274.3
ASL	13.5	16.5	233.9	174.9	9.5	27.8	218.7	195.4
CANADA	158.9	188.5	785.0	1041.9	231.7	187.0	1050.8	1002.0
EEM	122.7	199.0	687.0	958.6	233.2	145.3	1010.4	639.1
JAPAN	38.4	38.8	260.8	259.5	140.0	76.2	389.8	281.9
LA	65.9	64.8	256.5	224.9	93.7	100.7	282.0	286.7
OCH	233.8	256.4	474.0	384.6	393.0	206.5	532.8	543.5
OIL	24.9	20.2	190.9	178.9	40.1	38.1	355.0	270.3
SU	110.4	150.5	728.6	673.0	205.4	102.0	971.6	425.1
SAF	90.9	78.1	355.0	342.1	71.4	66.6	409.8	313.5
USA	221.9	192.1	805.1	797.1	215.3	204.8	868.5	887.1
WEH	138.3	181.2	418.4	431.2	261.2	198.2	574.4	467.1
WEM	124.9	88.3	431.1	463.3	92.4	116.4	503.7	516.2
WORLD	57.7	60.4	339.7	305.8	68.8	69.0	361.9	308.7

Notes: a. Domestic supply equals production plus net imports plus inventory changes.
b. 1 kilogram equals approximately 2.2lbs.
Sources: Leontief and Sohn 1982; Leontief et al., 1983; FAOSTATS, (FAO)

TABLE 8
OBSERVED (FAO) CHANGES IN ANNUAL PER CAPITA FOOD CONSUMPTION OF LIVESTOCK PRODUCTS AND GRAINS, 1970 AND 2000 (IN KILOGRAMS)

	Livestock Products		Grains		Change in Consumption	
Region	1970	2000	1970	2000	Livestock Products	Grains
AF	23.4	24.6	137.4	130.2	1.2	-7.3
ASC	11.1	60.7	133.1	166.7	49.7	33.5
ASL	13.9	25.0	153.1	154.7	11.1	1.6
CANADA	165.9	167.4	87.6	117.3	1.5	29.7
EEM	162.9	124.2	281.7	154.0	-38.7	-127.7
JAPAN	37.3	75.0	143.5	121.5	37.7	-22.0
LA	60.7	96.0	113.7	122.9	35.3	9.2
OCH	179.5	169.6	100.6	85.2	-9.9	-15.4
OIL	18.2	34.5	128.5	166.6	16.2	38.2
SU	108.7	81.8	190.7	154.6	-27.0	-36.1
SAF	61.8	59.3	184.5	184.8	-2.5	0.2
USA	186.9	199.8	81.8	115.4	12.9	33.6
WEH	140.1	116.6	113.2	115.6	-23.5	2.4
WEM	72.3	119.3	173.7	161.3	47.0	-12.3
WORLD	51.0	63.3	139.4	147.9	12.3	8.5

Note: 1 kilogram equals approximately 2.2lbs.
Source: FAOSTATS, (FAO)

Calories and Protein: The "Stuff" of Life

The ongoing global increase in daily calorie and protein levels and the decline in poverty rates, particularly in East Asia over the last two decades and more recently in Sub-Saharan Africa, is well documented (Perry, 2006). According to Fogel (2005), two critical "ingredients" - the total daily calorie level and the amount of daily protein intake - play a crucial role in improving labor productivity, both physical and mental, which, for economists, is the single most important factor responsible for raising the level of material well being.

Table 9 presents the projections and the observed levels of daily per capita calorie and protein levels for 1970 and 2000. For the world, the World Model projected (or targeted) only a very modest increase in the daily calorie level, from 2400 in 1970 to 2500 in 2000, an increase of only 4.2%, along with an increase of 12% in daily per capita protein levels over their 1970 levels. On the other hand, globally, the observed data indicate more impressive gains in both calorie and protein levels over the 30-year interval: a 13.6% increase in global daily per capita calories along with a 15% increase in daily per capita protein levels.

It is of interest to note the observed changes recorded over the projection interval in three key regions: ASC, which is dominated by China; North America, that incorporates both Canada and the United States; and the former Soviet Union. The observed changes in the first region attest to the well-documented improvement in material well being in China over the projection interval, the result of the widespread reform program that began in the late 1970s, including China's re-engagement with the world economy. The changes in the second region provide some additional proof of the ongoing "obesity crisis" in North America with the large observed - though arguably unnecessary - increase in daily calorie levels in both Canada and the US from an already relatively elevated 1970 base year level. The changes in the former Soviet Union portray a region in crisis, with both daily per capita calorie and protein levels falling over the projection interval. In particular, readers will recall that the 1990s was a decade of enormous economic and political stress in the former Soviet Union, accompanied by falling living standards that is borne out in these data and the data on population and income growth (Table 2, above).

TABLE 9
PROJECTED (WM) AND OBSERVED (FAO) LEVELS OF DAILY PER CAPITA CALORIES AND PROTEINS, 1970 AND 2000

	CALORIES				PROTEINS (grams)			
	1970		2000		1970		2000	
Region	WM	FAO	WM	FAO	WM	FAO	WM	FAO
AF	2356	2122	2310	2222	67.7	55.5	67.9	56.7
ASC	2025	1900	2220	2834	57.9	47.4	68.3	83.4
ASL	2048	2240	2158	2349	52.7	50.7	56.9	55.5
CANADA	3138	2920	3153	3515	91.8	93.3	97.7	106.7
EEM	3129	3278	3168	3218	93.6	96.5	107.0	94.2
JAPAN	2427	2723	3268	2879	73.0	82.1	125.3	95.5
LA	2345	2440	2987	2809	58.1	64.0	82.3	77.2
OCH	3167	3158	3214	3027	92.3	104.8	100.1	98.6
OIL	1985	1968	3314	2733	53.2	49.0	116.1	80.8
SU	3154	3354	3087	2759	91.2	102.4	100.0	80.0
SAF	2776	2799	2925	2862	79.2	73.3	90.5	76.1
USA	3211	3035	3175	3732	95.8	98.5	98.9	113.5
WEH	3046	3254	3219	3496	92.0	94.5	106.8	105.7
WEM	2746	3012	3003	3351	79.2	89.5	94.8	101.7
World	2400	2398	2500	2725	66.0	64.8	74.0	74.6

Note: A "pint" (14oz or 414ml) of Häagen-Dazs ice cream contains 1050 calories.
Sources: Leontief and Sohn, 1982; Leontief, 1983b; FAOSTATS, (FAO)

SUMMARY AND COMPLETING THE "UNFINISHED BUSINESS"

To sum up, at the global level the 30-year projected growth rates of three of the four agricultural sectors - oil crops notwithstanding - were surprisingly close to their observed rates from the FAO database. This is in contrast to the relatively large differences recorded between the projected and observed values for the fuel and non-fuel minerals, also included in the World Model projections (Sohn, 2005; Sohn, 2007). Part of the explanation for this may be due to the well-known successes during the 1970-2000 interval of substituting one metal for another, such as aluminum for steel, and using non-metallic materials in place of metal components, such as plastics and composites replacing metals in new aircraft.

With regard to the energy projections, unanticipated large reductions in the energy intensity of the economy over the projection period, i.e., declining energy use per dollar of GDP, because of increased efficiency in the production, distribution, and consumption of energy provided ample opportunities to slow the growth in energy use, even when accompanied by continued population and income growth.

To be sure, as living standards increase, per capita calorie and protein levels increase (often excessively as in the US), along with the gradual shift to grain and livestock products at the expense of slower growth in the production and consumption of root crops. This appears to be borne out by the observed data, which closely follow the projections at the global level.

The "conventional wisdom" regarding minimum required daily calorie levels suggest levels at approximately 2100 calories per capita (Parker, 2011). According to the observed data reported in Table 9, above, at the global level this was easily met even in 1970, not to mention the 14% increase by 2000. It is important to note, that over the 30-year projection interval of this study, the world's population also increased by 65% over its 1970 level (Table 1).

The "unfinished business" that will be part of the planned future work on this subject includes an investigation into the reason(s) for the large discrepancy between the projections and the observed data in oil crops (Tables 3 and 4); an in-depth analysis of the projections and the observed data at the regional level beginning with population and income growth data and ending with regional calorie and protein levels; and the incorporation of two other critical components of the food and agriculture sectors tracked by the World Model - projected and observed acreage under cultivation, and projected and observed fish catch.

The proposed follow-up study will also examine the major issues that those who are engaged in today's long-term modeling efforts, i.e., to 2050 and beyond, will have to incorporate into their projections. These include: a projected 30% increase in the world's current population by 2050; the growing scarcity of agricultural inputs (land and water) and outputs (maize and sugar cane) due to their diversion to the production of bio-fuels and driven by higher population levels and living standards, along with increased urbanization rates, particularly in Asia and Africa; the expected environmental impacts from global warming on agricultural output on the one hand, and, on the other, the projected elevated levels of methane and nitrous oxide emissions as livestock output and fertilizer use increase along with population levels and living standards, particularly in China, and other high-growth countries in Asia and Africa.

On the production side, increasing food output by a projected 70% by 2050 (Parker, 2011) will require the development and adoption of new technologies such as improved irrigation methods, more widespread planting of genetically modified crops that are resistant to herbicides and pesticides, and the introduction of plants that are drought and/or flood tolerant, reducing the "yield gap" between the "best", "worst", and "average" yielding land, and reducing the amount of food in both developed and developing countries that is lost to waste, currently estimated to be 30-40% of the total (Godfray et al., 2010).

Finally, even though daily calorie levels on a per capita basis in all 15 regions in this study are above the minimum required 2100 calories (Table 9), in 2010, according to the FAO, 925m people were classified as "hungry" (World Hunger), and, according to Save the Children, the international NGO that promotes children's rights, one in four children in the world is malnourished (Associated Press, 2012). Therefore, one of the major challenges in the 21st century is the implementation of food "safety nets" for these vulnerable people through policy and institutional initiatives to the end of reducing, if not eliminating, the daily struggle for food of more than 13% of the world's population.

APPENDIX

TABLE A.1
COUNTRY AND REGIONAL CLASSIFICATION FOR THE WORLD MODEL

REGION	COUNTRY OR TERRITORY	
Africa, arid (AAF) *	1. Chad	10. Mauritania
	2. Comoro Islands	11. Morocco
	3. Egypt	12. Niger
	4. Ethiopia	13. Somalia
	5. Djibouti	14. Sudan
	6. Israel	15. Syrian Arab Republic
	7. Jordan	16. Tunisia
	8. Lebanon	17. Upper Volta
	9. Mali	18. Western Sahara
Asia, centrally planned (ASC)	1. China	4. Democratic Republic of Vietnam
	2. Democratic Kampuchea	5. Mongolia
	3. Democratic People's Republic of Korea	

Asia, low-income (ASL)	1. Afghanistan 2. Bangladesh 3. British Solomon Islands 4. Brunei 5. Bhutan 6. Burma 7. Fiji Islands 8. Hong Kong 9. India 10. Indonesia 11. Republic of Korea 12. Laos 13. Malaysia 14. Maldives Islands	15. Macao 16. Nepal 17. New Hebrides 18. Pacific Territories and Islands, n.e.c. 19. Pakistan 20. Papua New Guinea 21. Philippines 22. Republic of South Vietnam 23. Sikkim 24. Singapore 25. Sri Lanka 26. Taiwan 27. Thailand
Canada (CAN)	1.Canada	
Eastern Europe (EEM)	1. Albania 2. Bulgaria 3. Czechoslovakia 4. German Democratic Republic	5. Hungary 6. Poland 7. Romania
Asia, high-income (JAP)	1. Japan	2. Ryukyu Islands
REGION	**COUNTRY OR TERRITORY**	
Latin America, (LAL)**	1. Barbados 2. Bolivia 3. British Honduras 4. Colombia 5. Costa Rica 6. Dominican Republic 7. Ecuador 8. El Salvador 9. Fr. Guyana 10.Guadeloupe 11.Guatemala 12.Guyana	13. Haiti 14. Honduras 15. Jamaica 16. Martinique 17. Nicaragua 18. Panama 19. Paraguay 20. Peru 21. Surinam 22. Trinidad and Tobago 23. Venezuela
Latin America, Medium-income (LAM)**	1. Argentina 2. Bahamas 3. Bermuda 4. Brazil 5. Chile 6. Cuba	7. Mexico 8. St. Lucia/Grenada/ St.Vincent/Dominica/St.Kitts/Nevis/Anguilla/ Netherlands/Antilles/ Turks and Caicos Islands/ Montserrat 9. Uruguay
Oceania (OCH)	1. Australia	2. New Zealand
Middle East-Africa (oil producers) (OIL)	1. Algeria 2. Bahrain 3. Democratic Yemen 4. Gabon 5. Iran 6. Iraq 7. Kuwait	8. Libyan Arab Republic 9. Muscat/ Trucial/ Oman 10. Nigeria 11. Qatar 12. Saudi Arabia 13. United Arab Emirates 14. Yemen

Soviet Union (SU)	1. USSR	
Southern Africa (SAF)	1. South Africa and Namibia	
Africa, tropical (TAF)*	1. Angola 2. Benin 3. Botswana 4. Burundi 5. Cameroon 6. Cape Verde 7. Central African Republic 8. Congo 9. Equatorial Guinea 10. Gambia 11. Ghana 12. Guinea 13. Guinea-Bissau 14. Ivory Coast 15. Kenya 16. Lesotho	17. Liberia 18. Madagascar 19. Malawi 20. Mauritius 21. Mozambique 22. Rwanda 23. Sao Tome and Principe 24. Senegal 25. Seychelles Islands 26. Sierra Leone 27. Zimbabwe 28. Swaziland 29. Togo 30. United Republic of Tanzania 31. Uganda 32. Zaire 33. Zambia
REGION	**COUNTRY OR TERRITORY**	
United States (USA)	1. United States of America, including Puerto Rico, The Canal Zone, and U.S.Virgin Islands.	
Western Europe, high income (WEH)	1. Andorra 2. Austria 3. Belgium 4. Denmark, including Greenland 5. Faeroe Islands 6. Finland 7. France 8. Germany, Federal Republic of 9. Iceland	10. Ireland 11. Italy 12. Luxembourg 13. Netherlands 14. Norway 15. Sweden 16. Switzerland 17. United Kingdom of Great Britain and Northern. Ireland (including the Channel Islands and Isle of Man).
Western Europe, medium-income (WEM)	1. Cyprus 2. Gibraltar 3. Greece 4. Malta	5. Portugal 6. Spain 7. Turkey 8. Yugoslavia

Note: a. Regions followed by an asterisk (*) were aggregated to form a single region, AF, in this study.
b. Regions followed by two asterisks (**) were aggregated to form a single region, LA, in this study.
Source: (Leontief et al., 1977)

TABLE A.2
AGGREGATED REGIONAL CLASSIFICATION[1]

I. Developed Countries

A. United States (USA)
B. Other "OECD"[2] countries

1. Western Europe (high-income) (WEH)
2. Western Europe (medium-income) (WEM)
3. Japan (JAP)
4. Oceania (OCH)
5. Africa (medium-income) (SAF)
6. Canada (CAN)

C. Developed Centrally Planned Countries

1. Soviet Union (SU)
2. Eastern Europe (EEM)

II. Developing Countries

1. Latin America (low income) (LAL)
2. Middle East-Africa (OIL)
3. Africa (tropical) (TAF)
4. Africa (arid) (AAF)
5. Asia (low-income) (ASL)
6. Asia (centrally planned) (ASC)
7. Latin America (medium-income) (LAM)

1. A complete listing of the countries which comprise the sixteen aggregated regions appears as Table A.1, above.
2. Due to the way in which the country and regional aggregations were performed the other "OECD" group includes some countries that were not members of OECD such as, for example, South Africa and Yugoslavia.

Source: (Leontief et al., 1977).

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