RICHARD T. ELY LECTURE

Agriculture and the Wealth of Nations

By D. GALE JOHNSON*

Half of the world's labor force is now engaged in farming. At the time of American independence approximately 90 percent of our labor force was agricultural; now only 3 percent is in farming. The great wealth of today's industrial nations and the remarkable improvements in the well-being of the people of the developing nations over the past half century have been made possible by the farm people who had a crucial role in this transformation of agriculture.

It was not only the farmers themselves, no matter how essential their role, who contributed to the wealth of nations, but many others—those who invented and produced farm machines, who developed new seeds, who discovered the nutritional requirements of plants, who learned how to extract nitrogen from the air, who developed the transport and communication systems that increasingly integrated farming into the rest of the economy, and who brought education to all levels of the rural community. But these efforts were dependent on prior gains in agricultural productivity that until quite recently were primarily due to efforts of farmers. It was only because farmers could produce a surplus over and above their own consumption that cities were possible and resources were released to support those who studied nature and learned some of its important secrets. The Industrial Revolution was made possible by two significant agricultural improvements: rapid increases in labor productivity, which permitted labor to be released from agriculture to produce other useful things; and simultaneous increases in food production to provide for the growing population. During the Industrial Revolution, population in the developed world grew faster than at any previous time.

* Department of Economics, University of Chicago, 1126 E. 59th Street, Chicago, IL 60637. I am grateful to Gary Becker, Robert Fogel, Robert E. Lucas, Jr., David Galenson, Yair Mundlak, Sherwin Rosen, Larry Sjaastad, Nancy Stokey, Lester Telser, and George Tolley for helpful comments and discussions. My greatest debt is to Theodore W. Schultz, teacher, colleague, and friend for six decades. Financial support of the William Francis ImMasche Foundation Endowment is gratefully acknowledged.

I. My Debt to Adam Smith

The use of "Wealth of Nations" in the title recognizes a great debt to Adam Smith. First, I use the term in the same inclusive sense he did—as the productive capacity of a nation or, as he put it, "The annual labour of every nation is the fund which originally supplies it with all the necessaries and conveniences of life which it annually consumes" (Smith, 1937 p. lvii). Second, Smith could very well be called the first growth theorist. The full title of his book is *An Inquiry into the Nature and Causes of the Wealth of Nations.* Much of the book is a policy tract. He was a growth theorist because he recognized that a nation's economic growth is largely determined by the overall domestic and international policies that governments follow, something generally missed by neoclassical growth theory and only recently rediscovered. He set out to understand why it was true: "Nations tolerably well advanced as to skill, dexterity, and judgment, in the application of labour, have followed very different plans in the general conduct or direction of it; and those plans have not all been equally favourable to the greatness of its product" (Smith, 1937 p. lix). He recognized that far more than the rate of savings, the amount of human capital, or the available technology determines the wealth of nations.

Finally, Smith specifically recognized the effect of improvements in agriculture on the wealth of nations or economic growth. He

notes that, when 99 percent of the labor force is used to produce food, there is little left for other forms of consumption: "But when by the improvement and cultivation of land the labour of one family can provide food for two, the labour of half the society becomes sufficient to provide food for the whole. The other half, therefore, or at least the greater part of them, can be employed in providing other things, or in satisfying the other wants and fancies of mankind" (Smith, 1937 p. 63). Thus Smith asserts a significant relationship between productivity improvement in agriculture and the wealth of nations. He argued that such improvement is a necessary condition for increasing the wealth of nations—not simply that there is a relationship between agriculture and general or overall productivity of the economy.[1]

I do not claim that agricultural productivity improvement is a sufficient as well as a necessary condition for economic growth. Nor is there an intent to argue that the sources of agriculture's productivity growth have been found entirely or even largely within the rural community. Many sources have been indigenous, certainly more so some centuries ago than today. What I hope will emerge is an understanding of the remarkable responsiveness of farm people when they have been faced with new challenges and opportunities and when incentives are not significantly distorted by governments.

Smith correctly noted that at very low incomes most of the labor of an economy is required to produce food. While he may have exaggerated how small a percentage was required for housing and clothing (1 percent), there are low-income economies in which 80 percent or even more of the total labor is now or was recently engaged in producing food and fiber. Over a very wide range, the percentage of the labor force engaged in agriculture is a good predictor of the level of real per capita income of a country.

II. Agriculture: A Recent Invention

Before the invention of agriculture, food was obtained by fishing, hunting, and gathering from uncultivated trees, bushes, and plants. The date when the first family prepared land, planted, and harvested a crop cannot be determined, but it is known from archeological records that, in terms of the history of mankind, agriculture is a recent invention, dating from some 10 millennia ago (Paul Bairoch, 1988 p. 93). At the time, the world's population might have been 4 million (Michael Kremer, 1993 p. 683). The development of agriculture and food production since that time can only be described as phenomenal. We are here because of the enormous number of problems solved, difficulties confronted and overcome, by hundreds of millions of farm people, aided and abetted by others who created knowledge and organized the production of labor-saving and output-enhancing inputs. Farm people throughout history and now have made remarkably effective use of the resources and knowledge available to them.

The application of scientific knowledge, both basic and applied, to agriculture is a recent event, dating from the middle of the 19th century. The advancements in agriculture that occurred in the previous centuries were derived primarily from the experiences of farm people.[2] While we can be justly proud of the recent rapid improvements in the world's food

[1] Agricultural productivity improvement is a necessary condition for economic growth for the world as a whole, not for an individual nation or region since food can be acquired by trade. However, the availability of food for which other goods or services can be traded requires that somewhere there are farm workers who are able to produce more food than is required for each worker and dependents.

[2] "Much of the invention of technology improvements relevant to agriculture prior to 1840 was the result of the activities of private individuals who had little formal research training but who faced practical production problems or were seeking improved methods of production, e.g., innovative farmers, blacksmiths, estate owners. A large share of the advances from this informal system was mechanical rather than biological" (Wallace E. Huffman and Robert E. Evenson, 1993 p. 15).

The beginnings of agricultural research in formal institutions through the conduct of experiments is often dated from the time of the work of Justus von Liebig in agricultural chemistry, marked by the publication of his important book *Organic Chemistry in Relation to Agriculture and Physiology* in 1840 (Huffman and Evenson, 1993).

supply, we should not denigrate what went before. The world's population reached a billion, in about 1815, before science and inputs provided by industry made significant contributions to farm production, either through labor-saving or output-increasing knowledge and inputs. And while the diet provided for that billion was much less adequate than is available today in nearly all developing countries, it should be acknowledged that providing food for so many without mechanical power (with much of the power provided by humans) and without chemical fertilizer or chemical methods of controlling insects, diseases, and weeds was a very considerable achievement. From the 10th to the 14th century, the world's population increased by only a third, but in the next four centuries population grew by about 160 percent, unfortunately with little improvement in individual well-being. During the present century alone, world population will have increased from 1.6 billion to 6.0 billion or perhaps a little more, with major advances in numerous measures of well-being.

III. When Agriculture Dominated

The rise of the town and city became possible as some farm families produced more food than they themselves consumed. Bairoch (1988 p. 287) estimates that in 1800 approximately 75–80 percent of the working population in the developed world was engaged in farming. At that time the urban population (in cities of 5,000 or more) was approximately 11 percent of the total (Bairoch, 1988 p. 290).[3]

In continental Europe the population probably remained more than 80 percent rural through the beginning of the 19th century. For all of Europe, excluding Russia and England, approximately 10–13 percent of the population lived in towns of 5,000 or more in 1800 (Bairoch, 1988 p. 215). At that date only 5–7 percent of Russia's population was classified as urban, while a century later the 1897 census of the Russian empire so classified only 13 percent (Adna F. Weber, 1899 p. 106).

The first census of the United States found that 95 percent of the population was rural, and it was not until 1830 that the urban population exceeded 10 percent of the total (Bureau of the Census, 1960 p. 14). In the Asian continent the rural population dominated at an even later date, remaining at 85 percent or more of the total population well into the 20th century. The 1891 Census of India found that the urban population was less than 10 percent of the total (Weber, 1899 p. 124). China's population was 89-percent rural in 1949 (State Statistical Bureau, 1984 p. 82). In Japan as late as 1890 only 13 percent of the population lived in cities of more than 10,000 (Weber, 1899 p. 129).

However, in the more industrially developed countries of Europe the agricultural population as a percentage of the total in 1800 was significantly smaller than for the entire developed world, ranging from 36 percent in England to 44 percent for Holland and nearly 60 percent for France (E. A. Wrigley, 1981). In these countries, the transition to urban and industrial-dominated economies was well underway, especially in England and Holland. But note that, even when only 50 percent of the population is agricultural, a farm family produces only enough food for itself and one other family, while today an American farm family produces enough food for itself and more than 30 others.

IV. Conditions of Life When Agriculture Dominated

Agriculture dominated economic activity in Europe and the world from the time of its invention to at least 1800 and perhaps a little longer. Let us take 1800 as the date when the rapid growth of towns and cities generally became possible due to the increasing availability of food for nonfarm people. What was life like at that time?

The per capita caloric intake in England and France at the end of the 18th century was significantly less than the prevailing levels in most developing countries in 1965. The daily per capita calorie consumption in the 1790's in France was estimated to be 1,753 (Robert

[3] The rural population includes more than farmers since it includes traders, craftsmen, government officials, and clergy as well as those engaged in cottage or small-scale enterprises at the beginning of the Industrial Revolution. Nonfarmers probably accounted for 15–20 percent of the rural population.

Fogel, 1994a p. 5);[4] in 1965 only one country in the world had a lower intake (Rwanda) (World Bank, 1980). The average intake in France increased to 1,846 during 1803–1812, and only nine countries had a lower intake than that in 1965. The caloric intake in England was higher, at 2,060 in 1790, but even so the amount of food available to most of the population of France and England, and almost certainly the rest of Europe, was only adequate for limited physical labor and resulted in stunting and wasting (Fogel, 1994b pp. 33–36).[5]

Famine persisted in Western Europe until the middle of the 19th century. The great Irish famine of 1846 comes to mind, but there was also a major famine in Austria in the two following years (Weber, 1899 p. 96). France suffered a famine or severe shortage of food as late as 1847 (Cornelius Wolford, 1878 p. 446). Russia faced famine caused by nature and not politics in this century. The emphasis on the late date when famine occurred in Europe is not to indicate that famine was a major source of high levels of mortality; the excess mortality was due much more to the limited nutritional status of the entire population (Fogel, 1994b p. 4). But the persistence of famines indicates how precarious the food supply remained until the recent past, even in the most economically advanced countries.

Improvement in well-being is documented by increases in life expectancy as well as by various related measures of infant and child mortality. Mortality or life expectancy was roughly constant throughout recorded history until 1650, when life expectancy was 25 years or perhaps less (Donald Bogue, 1969 p. 556). The infant mortality rate was about 30 percent. Death rates in England actually increased from the mid-16th century to well into the 18th century and did not decline to the level of about 25 per thousand in 1550 until the early 1800's (Fogel, 1994a fig. 1). In France the death rate exceeded 35 per thousand as late as the mid-18th century (Fogel, 1994a fig. 1). Such death rates are consistent with life expectancy at birth in the range of 25–35 years. Data for six European countries and Massachusetts indicate that as late as 1840 life expectancy in high-income countries was only 41 years (Bogue, 1969 p. 567).

Beijing was the only city in the world with a population of a million in 1800 (Tertius Chandler, 1987 p. 485). And for good reason; cities were little more than sinkholes of disease and pestilence. In the century ending in 1890, the death rate in Vienna was reduced from 60 per thousand to 23 (Weber, 1899 p. 356). In 25 years near the end of the 19th century, London's death rate declined from 50 to 25 per thousand with an estimated increase in life expectancy from 25 to 37 years (Weber, 1899 pp. 355–56). Consequently it might well have been that life expectancy in Europe's larger cities at the beginning of the 19th century was no higher and perhaps even lower than in Roman times a millennium and a half earlier. Many cities remained unhealthy places to live throughout the 19th century; life expectancy in Paris as late as 1890 was estimated to be 28 years (Weber, 1899 pp. 346–47). Life expectancy in the countryside in England and France at the end of the 19th century exceeded that of the cities by more than a decade.

Infant mortality in the developed countries in the 18th century must have been 250 per thousand or perhaps even more. Sweden, primarily rural and not subject to tropical diseases, had infant mortality rates in excess of 200 per thousand, in some years exceeding 250, in the period from 1750 to 1800 (Bogue, 1969 p. 562). Infant mortality did not fall below 150 per thousand until 1850 and reached 100 at the beginning of this century. It is chilling to read, referring to 1896–1890, "...the relatively low infant morality in Vienna and other cities, it being 208 per 1000 living births in Vienna, 227 in 53 cities and from 243 to 260 in the entire state" (Weber, 1899 p. 356). True, the relatively low rate was a comparison between Vienna and rural areas, but it is hard to imagine what life must have been like when an infant mortality rate of 208 per thousand would be deemed to be low, relative to any-

[4] The calorie unit is the large calorie or kcal.

[5] Fogel's analysis of the state of nutrition in Britain during the 18th century resulted in this conclusion: "Yet by current standards, even persons in the top half of the income distribution were stunted and wasted, suffered far more extensively from chronic diseases at young adult and middle ages than is true today and died 30 years sooner than today" (1994b pp. 33–34) (Stunting refers to a low height, and wasting to a low weight relative to height.)

thing. In 1890 the infant mortality rate in New York City was 264 per thousand, more than double the rural rate of 121 (Weber, 1899 p. 346). The mortality rate in France at the end of the 19th century for children under age 5 was 451 per thousand (Jacques Vallin, 1991 p. 56).

The high rates of mortality in the two previous centuries were due to many factors, but Fogel (1994a, b) has argued persuasively that the poor state of nutrition was a major factor. While mortality rates declined during the 19th century, the decline was modest compared to what followed in the 20th century. In Sweden, which has the most accurate data, life expectancy increased by about 13 years during the 19th century; it increased by that many years again in the next three decades (Nathan Keyfitz and Wilhelm Flieger, 1968 p. 37). The reduction of mortality that occurred in the 19th century was due to several factors in addition to improved nutrition, including inoculation against smallpox, control of the spread of the bubonic plague, and the understanding of water-borne diseases such as cholera and typhoid and infections such as dysentery. It was the incidence of cholera in Europe in the early and mid-19th century that led to the introduction of water and sewage systems—what might be called the "urban sanitary revolution" (William H. McNeill, 1976). Sanitation and clean water had many desirable consequences in addition to controlling or eliminating cholera and typhoid; dysentery and other infectious diseases transmitted by water or poor sanitation were far more endemic and harmful than cholera or typhoid, especially among children.[6]

It is not my intention to argue that improved nutrition was of greater importance than the knowledge of the cause of diseases and the improved purity of water and sanitation in reducing mortality during the 19th century. Clearly the factors reinforced each other. Had one occurred without the others, the improvements in life expectancy or capacity to work would have been significantly less than they were. Much food that is ingested is wasted today in developing countries because dysentery and other diseases result in poor utilization of the food that is consumed, and this also was true in the developed countries within the past century. When it is said that hundreds of millions of the world's population are malnourished, this may not mean that the food intake is too low, but that much of the intake is poorly utilized due to such afflictions as dysentery.

Why have I emphasized the modest changes in life expectancy, the high rates of infant mortality, and the poor living conditions in cities in the 18th and 19th centuries? One reason was to depict some aspects of the poor quality of life when agriculture remained the world's dominant productive activity. The other was to provide a transition to a consideration of the remarkable changes in agriculture and in people's well-being that followed from the developments since the beginning of the 19th century. And the improvement of life in the cities and the great increase in agricultural productivity had much the same source: invention and scientific development. I shall argue that it was the growth of agricultural productivity, as measured by increased food production and reductions in labor requirements, that made the Industrial Revolution possible. Once the Industrial Revolution was underway, it in turn contributed to the rapid improvements in agricultural productivity during the last and current centuries.

V. Improvements in Agricultural Productivity

Ester Boserup (1965) makes a convincing case that throughout most of recorded history labor was the scarcest factor of production in agriculture; for centuries agricultural progress resulted from finding ways to save labor, not land. Land was not an important factor in limiting the growth of agricultural output in Europe until well into this century, if then. For centuries grain yields were measured not in

[6] McNeill (1976 p. 275) graphically describes the effects of the improvements in sanitation on urban life: "By 1900, therefore, for the first time since cities had come into existence almost five thousand years previously, the world's urban population became capable of maintaining themselves and even increasing their numbers without depending on migration from the countryside. This was a fundamental change in age-old demographic relationships. Until the nineteenth century, cities had everywhere been population sumps, incapable of maintaining themselves without constant replacement from a healthier countryside."

terms of output per unit of land, but in terms of the ratio of output to seed (B. H. Slicher Van Bath, 1963). And for good reason—in Western Europe output-to-seed ratios of 3 or 4 to 1 persisted until well into the 18th century though ratios of 6 or 7 to 1 were more common by that time, with considerably higher ratios in England and the Netherlands.[7]

As noted above, in 1800 there was only one city in the world (Beijing) with a population of a million, but a century later there were 16. The 19th century saw rapid urbanization in Europe, especially in the United Kingdom. The urban population in the United Kingdom in 1900 was 68 percent of the total compared to 19 percent in 1800, while on the continent it was 33 percent urban in 1900 and only 11 percent in 1800 (Bairoch, 1988 p. 290). The total population of Europe more than doubled during the 19th century (Kremer, 1993 p. 714); thus the increase in the century was greater than in all the time that had gone before. The increase in urbanization was a response to the advance of the Industrial Revolution with its rapidly growing demand for labor. It was a remarkable achievement for agriculture to release millions of workers for urban employment while more than doubling food production, an increase in output greater than had been achieved in all previous time.

The rapid urbanization and growth of the total population of the developed countries that occurred in the 19th century was made possible by very great improvements in agricultural labor productivity. Some of the improvement in labor productivity and output occurred outside Europe and permitted the export of food to that continent. For example, the labor used in the United States to produce a ton of wheat fell by 70 percent, and the labor used to produce a ton of corn fell by almost 60 percent during that century (Martin R. Cooper et al., 1947 p. 3). But similar developments were occurring in Europe. In France the amount of wheat produced by a man-day of labor more than doubled between 1800 and 1892 (George P. Grantham, 1991 p. 349).

The increase in labor productivity in the United Kingdom must have been even greater, since agriculture's share of total employment declined from 36 percent in 1800 to 8.5 percent during 1900–1910 (Grantham, 1991 p. 341). It is true that by the beginning of this century the United Kingdom was importing approximately half of its food, but during the same period its population nearly tripled (Bairoch, 1988 p. 290).

Harvesting was the critical labor period for small grains such as wheat, barley, or rice. For centuries it was extremely labor-intensive and needed to be done in a relatively brief period of time in order to save the crop from weather damage. Labor-saving techniques for harvesting came very late in history. There seems to have been no decrease in labor use during harvesting from at least the 14th century until early in the last century (Slicher Van Bath, 1963 p. 184). The reason was quite simple: the sickle remained the tool used to harvest grain. It was used in the United States well into the past century. It coexisted with the scythe or the cradle for some time, then was rapidly replaced by various forms of reapers, then by the binder, and in the current century by the combine. Prior to the binder, which became common only after the mid-19th century, the stalks of grain were collected into bundles by a time-consuming hand operation. The binder performed this function mechanically with a great saving in time. With the sickle, one man could harvest a third to a half an acre per day; the binder permitted a man with 2–4 horses to harvest 8–18 acres per day, a reduction in labor requirements of 90 percent or more (Yujiro Hayami and Vernon Ruttan, 1985 pp. 80–81).[8]

[7] Jean Gimpel (1977 p. 44) concluded that there was no significant increase in the output-to-seed ratio compared to those at the end of the 13th and early 14th centuries for the next several centuries: "It was not until the agricultural revolution of the eighteenth century that yields rose to a substantially higher level than those reached in the 13th and early 14th centuries. It took nearly half a millennium before medieval agricultural technology was overtaken." Prior to the 18th century increases in grain and food output were achieved primarily by expansion of the cultivated area or increasing the intensity of cultivation by reducing the length of fallow.

[8] In a visit to Xian, China, in June 1996, I saw several millennia of harvest technology in one wheat field. In that

A significant increase in food production in Western Europe started well before the application of modern science. Prior to two centuries ago, food production increased primarily as a result of more intensive use of land, rather than from increased yields per unit of sown area of the principal grains. Boserup (1965) relates how farmers responded to the increased demand for food generated by the rising population of Europe in the centuries prior to the Industrial Revolution. Throughout most of the agricultural era, farmers followed various fallow systems, each year leaving much of the land idle as a means of regenerating its productive capacity. Slash and burn (the clearing of forested and brush land by fire and hard work) existed in Europe for millennia and is still used in parts of Africa. As the population grew and demand increased, the periods of fallow were gradually reduced and, in Western Europe, eliminated. Other methods of replenishing the nutrients taken from the soil by crops were introduced (e.g., human and animal manure, marl or lime, the production of leguminous crops) as annual cropping predominated. As a result, yields per hectare of land sown to crops increased, admittedly slowly, before the introduction of chemical fertilizer.

The transfer of plants and seeds from the Americas added to the food supply. Particularly important were the potato, which could produce many more calories per unit of labor and land than any of the cereals, and corn or maize, which had the enormous advantage of a high output-to-seed ratio, which became important primarily in the south of Europe.

The indigenously developed farm practices noted above resulted in a significant departure from the grain yields achieved in medieval times. English yields probably started to increase after 1725, at the very beginning of the Industrial Revolution (Mark Overton and Bruce M. S. Campbell, 1991 p. 39). The rapid growth of the urban and total population of England in the first half of the 19th century was made possible by an estimated annual growth of agricultural output of approximately 0.8 percent and an estimated annual growth of labor productivity of 0.5 percent (Overton and Campbell, 1991 p. 44).

The revolution in labor-saving during the 19th century was only the beginning, a modest beginning in fact. By the 1980's the labor used on farms to produce a ton of wheat or corn in the United States was but 1–2 percent of what it was in 1800, and for a bale of cotton, only 1 percent (Cooper, 1947; U.S. Department of Agriculture, 1988). There has been an enormous substitution of capital and knowledge for farm labor. While the data given are for the United States, approximately the same degree of labor-saving has occurred in the other developed countries.

While American agriculture achieved very large labor savings during the last century, which made it possible to continue expanding the cultivated area with a declining share of the labor force, output per unit of land increased hardly at all (Cooper, 1947 p. 3). Even without increases in land productivity, it is estimated that the number of individuals who were provided with food and fiber by one farm person increased from 1.25 (including the farmer) in 1820 to nearly three persons in 1900 (Cooper, 1947 p. 5).

The stagnation in grain yields per unit of land in the United States continued until the fourth decade of the current century (Cooper, 1947, Johnson and Robert Gustafson, 1962 p. 8).[9] The revolution in land productivity based on important scientific advances began very recently; its beginnings were in the 1930's

field wheat was being harvested by a sickle, a scythe, a binder, and a combine. While the wheat field was large, under the household responsibility system the field was divided among many farm families who were engaged in harvesting their small plots of perhaps a half acre, almost certainly not more than an acre. Consequently each of these technologies could result in completing the harvest in a timely manner. At the existing rates of return to farm labor in China, it would take quite modest differences in harvest losses of the different technologies for the return to labor to be approximately the same for the four different methods of harvesting.

[9] Since the land under crops shifted over this period of time from the more humid and higher-yielding east to the drier and lower-yielding areas of the Great Plains, there was some increase in yields in comparable areas. However, the yield increases for wheat and corn were very small, almost certainly not more than 10 percent.

with the development of hybrid corn and followed over the next several decades with equally major improvements in the yields of grain sorghum, wheat, rice, and cotton.

After having stagnated for so long, corn yields in the United States have increased by more than 250 percent in six decades. The yield revolution has not been confined to the United States. Yield increases in this century in Western Europe have been as great or greater. Wheat yields in the United Kingdom, France, and Italy more than trebled, from 2.1 tons per hectare during 1909–1913 to 7.0 tons during 1992–1993 in the United Kingdom, for example, with most of the increase occurring after 1950 (P. Lamartine Yates, 1960 p. 197; European Commission, 1995a p. T/168). The United Kingdom is once again a grain exporter in sharp contrast to having imported two-thirds of its grain at the beginning of the century (Yates, 1960 p. 238). But more important for the world's welfare, grain yields in Asia are now nearly three times what they were during 1948–1952, having increased from 1,095 kilograms to almost 3,000 kilograms per hectare today (Food and Agricultural Organization, 1970, 1993). The application of modern biological and chemical science to agriculture, primarily during the past six decades, has made possible grain yields that are at least treble what yields were in the 1930's. As noted, the yield increases of approximately the same order have occurred in both the developing and developed world.[10]

Let me be absolutely clear. The large increases in land and labor productivities have not been achieved by repealing the law of diminishing returns. It is still as alive and well as it was when it was of such concern to David Ricardo. The productivity improvements have been achieved by repeated outward shifts of the production frontier. The difference between Ricardo's time and the recent past is that it has been possible to change the relevant production functions to permit radical shifts in factor proportions while increasing the real marginal products of labor and land, not by a little but by a lot.

[10] Hayami and Ruttan (1985 appendix B) have estimated the increases in farm output, output per male worker, and output per hectare of agricultural land for the United States, Japan, Denmark, France, and the United Kingdom for 1880–1980. With levels in 1880 set equal to 100, the unweighted averages of the indexes for 1980 for the countries other than the United States were as follows: farm output, 421; output per male worker, 1,304; output per hectare, 415 For the United States, the indexes were, respectively, 434, 2,110, and 236.

VI. The Developing Countries

The improvements in nutrition and in life expectancy that occurred in the industrial countries during the 19th century have occurred in a much shorter time in the developing countries during the last half century. Life expectancy for low-income countries, as classified by the World Bank, has increased from about 35 years in 1950 to 56 years in 1994 (excluding both China and India, with life expectancies of 69 and 62, respectively, in 1994) (World Bank, 1980 p. 34; 1996 p. 188). In the developing countries, the per capita caloric supplies increased from 1,940 during 1961–1963 to 2,473 during 1988–1990, an increase of 27 percent, a remarkable achievement in less than three decades (Food and Agricultural Organization, 1993). The absolute increase exceeded that for all of previous history. This was achieved while population grew far more rapidly than it ever did in the developed countries.

VII. Farmers and the Economic Man

My colleague, Theodore W. Schultz (1964), was the first to attack systematically the canard that poor farmers were bound by tradition and thus were inefficient. The large differences in yields and productivity in agriculture between the developed and developing countries were generally considered to be due to the backward mentality of farmers in the developing countries. Schultz showed conclusively that the productivity differences were due to the technological constraints under which they operated; farmers in the developing countries were efficient and responded to economic incentives as did farmers everywhere. Confirmation of his view soon became evident, as the productivity of land and labor rapidly increased in the majority of the developing countries, not because the farmers

changed, but because the opportunities available to them changed and constraints were alleviated.

Schultz's *Transforming Traditional Agriculture* should have been adequate warning to the numerous governments that accepted the conventional wisdom that there was surplus labor in agriculture that could be withdrawn at little or no cost to provide labor for the development of industry, which was claimed to be the real engine of economic growth. Governments throughout the developing world continued to exploit agriculture through export taxes, parastatals, price controls, and protection of the agricultural input sectors. This exploitation generally persisted until well into the 1980's. The history of that exploitation fully justifies the position taken by Smith, namely, that agriculture should not be discriminated against.

A remarkable study undertaken by Anne Krueger, Maurice Schiff, and Alberto Valdes at the World Bank of the rates of protection (largely negative) of agriculture in 18 countries clearly documents the folly of the policies that exploited agriculture for the benefit of urban areas. The rates of taxation were very high in some cases: a group of three countries had a nominal rate of protection of a −52 percent. That is, farmers received less than half the equivalent border prices (Schiff and Valdes, 1992 p. 71). A second group of ten had a rate of protection of −36 percent; three others had protection of −16 percent; and two provided a modest degree of positive protection, 10 percent. Did high rates of taxation of agriculture result in rapid economic growth? Definitely not. For 1960–1985 the heavy taxers had zero annual real GDP growth per capita; the representative taxers had 2.5 percent growth; the moderate taxers had slightly higher growth at 2.8 percent; and the two modest protectors exhibited the highest growth rate, at 4.7 percent (based on growth rates for total GDP reported by Schiff and Valdes [1992 p. 77] and World Bank estimates of population growth). Clearly the heavy taxers did not gain from their policies.

A detailed simulation of the effects of Argentine policies that seriously discriminated against agriculture from 1930 to 1984 provides support for the negative impacts found in the World Bank study. Yair Mundlak et al. (1989 p. 121) estimated that the trade-distorting and macroeconomic policies that discriminated against agriculture reduced Argentina's level of real income for that period compared to what it would have been with an open economy by more than 40 percent. The simulation result is likely to be an underestimate of the negative impact, because the simulated growth for Argentina approximates the actual growth of the Australian economy over the same period of time and actually lags behind Canada's growth. Argentina's natural resources are probably superior to those of the other two countries.

Other evidence of agriculture's role in contributing to the wealth of nations is found in data on productivity change. Generally speaking, labor productivity growth in agriculture has been greater than in the other sectors of the economies in the industrial countries. This was especially true during the postwar period up to 1980. From 1967–1968 to 1983–1984, for 17 of 18 industrial countries for which there were data on changes in GDP in constant prices, labor productivity growth in agriculture exceeded that in other sectors. The unweighted average annual growth rate for agriculture was 4.3 percent compared to 2.6 for other sectors (Johnson, 1991 p. 57).

It might be argued that the greater increases in labor productivity growth in agriculture represented only the substitution of nonfarm inputs for labor. This is part of the explanation, but far from all. It is clearly true that modern agriculture is capital-intensive. In the United States, agriculture has a capital-to-labor ratio that is six times the ratio in manufacturing (Johnson, 1991 p. 65). If one excludes the value of land from capital, farmers still utilize more capital per worker than does manufacturing. And they utilize the capital, as well as the labor, with considerable effectiveness as indicated by data on total factor productivity.

The growth of total factor productivity in the OECD countries in agriculture has been greater than in manufacturing during the past quarter century or more. The difference has not been small: one study indicates that total factor productivity growth was approximately 2.7 percent in agriculture compared to 1.5 percent in manufacturing for the period from

1960 to 1990 (Will Martin and Devashish Mitra, 1993 p. 15).

Is it not quite remarkable that millions of independent farmers have been so responsive to new and improved opportunities to save resources that they have had a higher rate of productivity change than the industrial sector? True, farm people have benefited from research (much of it undertaken at public expense), from the supply of nonfarm inputs, from improvements in infrastructure such as roads and communication, and in the industrial countries from a significant degree of protection. Even so, the record is a remarkable one.

VIII. Concluding Comments

Repeatedly since World War II there has been concern that the demand for food would outgrow supply. The evidence that the contrary has occurred is abundant and incontrovertible. But the view still persists that population growth will eventually overcome the capacity of the world to feed itself. This conclusion is based on a particular model of economic growth which gives great weight to natural resources, accumulated capital, the rate of savings, and exogenous technological change while ignoring the possible relationships that may exist among population, demand growth, and productivity improvement. In addition, many of the neoclassical growth analyses have ignored the role of policies as a major factor affecting economic growth, ignoring what Smith told us more than two centuries ago. It is difficult to understand how the role of policies can be ignored, given the enormous differences in the economic performances of the planned and market economies between 1950 and 1990 and the sharp change in the rate of growth in China following the reforms of the late 1970's.

I shall close with comments on three related points. The first is that the periods of rapid economic growth in the world have been periods of rapid population growth. While I do not wish to argue which variable has been endogenous, Kremer (1993) has made a strong case supporting population growth as an exogenous factor in generating productivity improvement and thus economic growth. But, in any case, rapid population growth has not "spoiled" per capita economic growth.

Throughout most of the world's history the rate of population growth was less than 0.2 percent annually and did not exceed 0.5 percent until the middle of the 18th century (Kremer, 1993). From 1800 until 1950, the rate of population growth was greater in the developed than in the developing countries and so was the growth in real per capita incomes. But after 1950 the population growth rate in the developing countries was the highest ever achieved and so was the growth in real per capita incomes. From 1820 to 1950 the increase in real per capita GDP in 11 Asian countries was only 25 percent, while their population was increasing at the low annual rate of less than 0.5 percent (Angus Maddison, 1995). But from 1950 to 1992 the real per capita incomes of the same countries increased fivefold while population grew at an annual rate of almost 3 percent. Real per capita GDP grew hardly at all between 1820 and 1950 in China and India, less than 15 percent. But between 1950 and 1992 India's per capita GDP more than doubled, while the rate of population growth increased by a factor of almost four.

The second point is that the improvements in productivity in agriculture, combined with the effects of Engel's law of consumption, have resulted in a large decline in the percentage of consumer expenditures devoted to food in both the developed and developing countries. In the United States in 1955 approximately 23 percent of consumer expenditures was devoted to food consumed at home (U.S. Department of Agriculture, 1988). In Western Europe the percentage ranged from a low of 27 percent (Switzerland) to a high of 45 percent (Greece) (U.S. Department of Agriculture, 1972 table 110).

In 1992 consumers in the United States allocated only 8 percent of total consumer expenditures to food consumed at home. In Western Europe the percentage ranged from about 12 percent (United Kingdom) to 21 percent (Ireland), with a rough average of about 16 percent. It was not so long ago that consumers in developing countries allocated 80 percent or more of their consumption expenditures to food. This was true in Indonesia in

1976 (World Bank, 1980 p. 61). As recently as 1992 in four developing countries (India, Philippines, Sudan, and Sierra Leone) families allocated 50–67 percent of their consumption expenditures to food (U.S. Department of Agriculture, 1994 table 100).

Finally, it is obvious that natural resources have become an unimportant factor in the economies of the industrial nations. Food accounts for under a fifth of total consumer expenditures, including food consumed in restaurants, and agriculture's GDP is now less than 3 percent of GDP in the industrial countries of Western Europe and the United States. If land accounts for as much as half of agriculture's GDP (a high estimate), agricultural land now accounts for no more than 1.5 percent of the resources of the industrial nations. In the United States, total value added in agriculture is 16 percent of what consumers spend on food (Howard Elitzak, 1994). If land accounts for half of the value added in agriculture, then no more than 8 percent of the total cost of food to the consumer, including restaurants, can be attributed to land.

While land accounts for a higher share of the resources in developing countries, there is no doubt that the share is declining as the percentage of income devoted to food declines. How rapidly it declines depends on the rate of economic growth. It may strike one as somewhat odd that much of the concern over future world food supplies is based on the assumption that land is the limiting resource. This is putting the emphasis in the wrong place. The major factors that may limit the growth of food production in developing countries are knowledge and research, the availability of nonfarm inputs at reasonable prices, and the governmental policies that affect incentives. If policies provide for the first two and do not discriminate against agriculture in trade and macroeconomic policies, farmers will do the rest.

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