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THINKING ABOUT THE INDUSTRIAL REVOLUTION

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THINKING ABOUT THE INDUSTRIAL REVOLUTION

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My purpose is to conceptualize the dynamics of European economic development which culminated in the industrial revolution of the eighteenth century. Hitherto the industrial revolution was considered either as a sudden break with the past or as an outgrowth of processes which began in the Middle Ages or even before. I attempt to synthesize these two views by arguing that the industrial revolution can be thought of as part of a process of economic development begun centuries, perhaps millennia earlier. Yet these same processes could give rise to discontinuities in the growth of many economic and demographic variables during the second half of the eighteenth century. In this way I believe that the apparent contradiction between the evolutionary nature of economic development which culminated in the industrial revolution and the manifest discontinuity in the rate at which output, the labor force and output per capita grew in its wake can be resolved. In this view, the industrial revolution need not be thought of as a structural break with the past, but as an integral part of the economic experience of the previous millenia.[1]

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[1] CARLO M. CIPOLLA, *The Economic History of World Population*, 7th ed. (Harmondsworth, England: Pelican Books, 1978); Eric L. Jones suggests in *The European Miracle, Environments, Economies, and Geopolitics in the History of Europe and Asia* (Cambridge: Cambridge University Press, 1981), p. 225, that industrialization was "... not a thunderstorm that suddenly arrived overhead but a growth deeply rooted in the

From the economic point of view the period extending from the Neolithic agricultural revolution to the industrial revolution can be considered as a unity, because the economies were overwhelmingly agricultural throughout this epoch. The economy of hunters and gatherers, which preceded it, as well as that of the twentieth-century industrial world, which followed in its wake, can both be characterized by a significantly different production relationship from that of the agricultural societies of the intervening millennia. In the nineteenth century the demographic regime was no longer Malthusian and the economy was no longer overwhelmingly agricultural. Moreover, scientific knowledge was applied in earnest to solve technological and economic problems. These characteristics were fundamentally different from the structure which prevailed during the prior millenia. Douglass North suggests in this regard that, "the First Economic Revolution created agriculture and 'civilization'; the Second created an elastic supply curve of new knowledge which built economic growth into the system... Both economic revolutions deserve the title because they altered the slope of the long-run supply curve of output so as to permit continuing population growth without the dismal consequences of the classical economic model".[2]

From the point of view of the demographic system, too, the ten millenia separating the two revolutions can be considered as a unity because population growth was slow and set-backs were frequent. Prior to the Neolithic agricultural revolution population grew at a rate of about .0015 percent per annum. Although this rate was extremely slow, it nevertheless meant that population doubled every 60,000 years. After the agricultural revolution population growth increased perhaps by a factor of 24 to .036 percent per year, a rate maintained until the beginning of our epoch. Thereafter growth accelerated again to .056 percent per year until the middle of the eighteenth century, when it increased by a factor of ten.[3]

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past.", In a similar vein, Jan De Vries suggests that "... the middle of the nineteenth century—one might say the beginning of the railway age—is a worthier candidate for the title of threshold to the era of universal urbanization..." than "the conventional use of 1800 as a dividing line." *European urbanization*, 1500-1800 (Cambridge, Mass.: Harvard University Press, 1984)m p. 44. "... without the preceding millennial rise of the West, the story of England's industrial revolution would have been entirely unthinkable." Daniel Christ, "The Rise of the West," *American Sociological Review*, 50 (1985), pp. 181-195. For another study emphasizing the continuity of economic processes in Europe, see David Herlihy, "The Economy of Traditional Europe", *Journal of Economic History*, 31 (1971), pp. 153-64.

[2] DOUGLASS C. NORTH, *Structure and Change in Economic History* (New York: Norton, 1981).

[3] ANSLEY J. COALE, "The History of Human Population," *Scientific American*, 231 (Sept. 1974), pp. 41-51; JOHN DURAND, "The Modern Expansion of World Population," in Thomas R. Detwyler, ed., *Man's Impact on Environment* (New York: McGraw-Hill, 1971), pp. 36-49, reprinted from *Proceedings of the American*

Moreover, I shall argue that the Industrial Revolution of the eighteenth century was an integral part of the epoch which preceded it, that it grew out of it, and hence ought not to be seen as a great discontinuity. North, too, suggests that the industrial revolution "... was the evolutionary culmination of a series of prior events".[4] Although not reaching as far back as North does into the Neolithic past, Rondo Cameron's view reinforces the notion of continuity in economic development. He argues that events of the eighteenth century were a consequence of "a long, drawn out process, in no sense inevitable, which scarcely deserves the epithet'revolutionary'."[5]

The Malthusian Assumptions

I assume that the epoch under consideration was essentially Malthusian in the sense that there was an incessant contest between population growth and society's resource base, which included natural as well as reproducible capital.[6] The present consensus is that in the pre-industrial world population growth was essentially food controlled.[7] With the capital stock and improved

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Philosophical Society, American Philosophical Society, 111 (1967), 136-45; John Durand, "Historical Estimates of World Population: An Evaluation," *Population and Development Review*, 3, (1977), pp. 253-96; COLIN McEVEDY and RICHARD JONES, *Atlas of World Population History* (New York: Penguin Books, 1978); Jean-Nöel Biraben, "Essai sur l'evolution du nombre des hommes," *Population*, 34 (1979), pp. 13-25, p. 23; Robert M. Schacht, "Estimating Past Population Trends," *Annual Review of Anthropology*, 10 (1981), pp. 119-40. For several centuries the population growth rate in the western Mediterranean regions was -0.0013 per annum. McNeill attributes this decline to epidemiological disaster. WILLIAM H. MCNEILL, *Plagues and Peoples* (Garden City, N.Y: Anchor Press, 1976), p. 115.

[4] NORTH, *Structure and Change*, p. 162.

[5] RONDO CAMERON, "The Industrial Revolution: A Misnomer," *The History Teacher*, 15 (1982), pp. 377-84; *Idem*, "A New View of European Industrialisation," *Economic History Review*, 2d ser., 38 (1985), pp. 1-23.

[6] HARVEY LEIBENSTEIN, *A Theory of Economic-Demographic Development* (Princeton, N.J.: Princeton University Press, 1954), p. 8; THOMAS R. MALTHUS, *An Essay on the Principle of Population as It Affects the Future Improvement of Society*, (London: J. Johnson, 1798).

[7] ROGER SCHOFIELD, "The Impact of Scarcity and Plenty on Population Change in England, 1541-1871," *Journal of Interdisciplinary History*, 14 (1983), pp. 265-91; RONALD D. LEE, "Population Homeostasis and English Demographic History," *Journal of Interdisciplinary History*, 15 (1985), pp. 635-60; Zvi Eckstein, T. Paul Schultz, and Kenneth L. Wolpin, "Short-Run Fluctuations in Fertility and Mortality in Pre-Industrial Sweden," *European Economic Review*, 26 (1985), pp. 295-317; Peter Lindert, "English Population, Wages, and Prices: 1541-1913," *Journal of Interdisciplinary History*, 15 (1985), pp. 609-34; PAUL M. HOHENBERG and LYNN HOLLEN LEES, *The Making of Urban Europe*, 1000-1950 (Cambridge: Harward University Press, 1985),

land growing slower than population, and with technological progress sporadic, rapid population growth led to diminishing returns to labour and eventually resulted in a nutritional crisis. Yet population tended to reproduce because there were long periods during which the level of subsistence was above the critical level. Indeed, North noted that as long "as the standard of life was above a certain level, there was a tendency for man to increase in numbers". [8]

Prior to the industrial revolution the human population had a tendency to increase, but as it did, food output per capita eventually declined because of diminishing returns to labour until the quantity of nutrients available per capita became insufficient to sustain a healthy and growing population. In addition, exogenous climatic variations affected food output and thereby had an impact on the nutritional status of the population.[9] The severity of these climatic shocks depended on the degree to which the nutritional status of the population had already deteriorated. [10] Malthusian positive checks (mortality crises) maintained a long-run equilibrium between population size and the food supply. To be sure, not all diseases are nutrition sensitive, but the devastation wrought by epidemics frequently depended on population densities as well as on the experience of the society in dealing with previous calamities. It is true that negative checks, what Malthus called "moral restraint" also played a part in maintaining a balance between the human population and the resource base. These controls, however, were adopted relatively late in human experience, and were not very effective in maintaining homeostasis.

Crises followed by periods when human nutritional status was above the level of subsistence gave rise to cycles. Although the secular trend of economic activity was ever upward, the cycles testify to the continued existence of the "Malthusian population trap": population could not grow beyond an upper bound imposed by the resource and capital constraints of the economic structure in which it was imbedded. [11] The "escape" from this trap occurred

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p. 78; THOMAS MCKEOWN, The Modern Rise of Population (New York: Academic Press, 1976).

[8] North, Structure and Change, p. 83.

[9] PATRICK GALLOWAY, "Long Term Fluctuation in Climate and Population in the Pre-Industrial Era," Population and Development Review, 12 (March 1986), pp.1-24.

[10] There is an extensive literature on the relationship between mortality and nutrition; see CARL E. TAYLOR, "Synergy among Mass Infections, Famines, and Poverty," Journal of Interdisciplinary History, 14 (1983), pp.483-501; ROBERT FOGEL, Nutrition and the Decline in Mortality Since 1700: Some Preliminary Findings," in ROBERT GALLMAN and STANLEY ENGERMAN (eds.), Long-Term Factors in American Economic Growth, Studies in Income and Wealth, Vol. 51 (Chicago: University of Chicago Press, 1987).
II For a description of the Malthusian dynamics see H. J. HABAKKUK, "English Population in the Eighteenth Century," Economic History Review, 2d ser., (1953), pp. 117-33.

only when the aggregate capital stock was large enough and grew fast enough to provide additional sustenance for the population, which thereby overcame the effects of the diminishing returns that had hindered human progress during the previous millennia. After escaping from the Malthusian trap, population was able to grow unchecked. In historic terms, this escape corresponds to the industrial and demographic revolutions. Through the accumulation of capital, the food-producing sector could accelerate production sufficiently quickly to outpace population growth. Removal of the nutritional constraint, at least for the developed part of the world, resulted in the population explosion.[12]

The warrant for using the Malthusian model comes from investigations that outline the evolution of the population and the economy during the last thousand years. Numerous studies document the "incessant contest" between population growth and the society's resource base.[13] "Before 1800, the situation developed much as Mathus had insisted it must: the faster the population grew, the faster food prices rose, the lower living standards fell, and the grimmer the struggle to exist became. As Malthus had postulated, there were indeed long, slow oscillations in the rate of population growth and in the standards of living".[14] Overpopulation contributed greatly to the utter collapse of the European economy in the fourteenth century: the number of Europe's inhabitants suddenly declined by a third. The plague might have been the proximate cause of this collapse, but the epidemic attacked a nutritionally weakened population. In fact, "in the course of the thirteenth century... agricultural yield, tended to fall off (in England as)... land was nearing exhaustion". [15] In some places the population decline began well before the

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[12] THOMAS McKEOWN, "Food, Infection, and Population," *Journal of Interdisciplinary History*, 14 (1983), pp. 227-47; STEPHEN J. KUNITZ, Speculations on the European Mortality Decline," Economic History Review, 36 (1983), pp. 349-64.

[13] MICHAEL M. POSTAN, *The Medieval Economy and Society. An Economic History of Britain in the Middle Ages* (London: 1972); WILHELM ABEL, *Agrarkrisen und Agrarkonjunktur*, 3rd ed. (Hamburg, Germany: Paray, 1978; 1st ed., 1935); WILHELM ABEL, *Massenarmut und Hungerkrisen im vorindustriellen Europa* (Berlin: 1974).

[14] SCHOFIELD, "Impact of Scarcity and Plenty."

[15] GEORGE, DUBY. "Medieval Agriculture 900-1500," in Carlo Cipolla (ed.), *The Fontana Economic History of Europe*, (Fontana Books, 1972), Vol. 1, pp. 175-220; L.R. POOS, "The Rural Population of Essex in the Later Middle Ages," *Economic History Review*, 2d ser., 38 (1985), pp. 515-30; GALLOWAY, "Long-Term Fluctuations,", p. 20. Climatic deterioration also hampered population growth: increased frequency of volcanic eruptions, and a decline in solar activity caused a decrease in mean temperatures, and a succession of wet years during the second decade of the fourteenth century contributed to the decline in agricultural output even prior to the outbreak of plague. C.U. HAMMER, H.B. CLAUSEN and W. DANSGAARD, Greenland Ice Sheet Evidence of Post-Gracial Volcanism and its Climatic impact," *Nature*, (Nov. 20, 1980), p. 230 as cited by Mary Matossian, "Volcanic Activity and Disease in

outbreak of the epidemic. By the early fourteenth century, the poor were allegedly dying by the millions from hunger.[16] Cannibalism was recorded in Great Britain. "The steadily increasing overpopulation in the thirteenth century must have led to malnutrition... The high mortality... can only be explained as the result of prolonged undernourishment".[17]

The expansion of European commerce during the prior centuries, itself related to increased population size, also contributed to the onset of the plague, because the introduction and transmission of the disease depended critically on the frequency of shipping and the level of urbanization.[18] The spread of the epidemic, too, was a function of population densities. "Opportunities for transfer of disease from one host to another multiply with increased human density, so that, if and when the critical threshold is surpassed, infection can suddenly develop into runaway hyperinfection".[19] The probable reason that the black death was less severe in Eastern Europe than in the Northwest, was that population densities there were also lower.[20] Hence, the fact that the collapse of the European population at the end of the Middle Ages occurred at a time when population densities there were higher than ever before ought not be considered accidental.

Yet the relationship between population densities and demographic crises cannot be considered in a deterministic way, because "there are some very considerable examples, lasting over several centuries, of rural civilizations departing a long way from this 'position of equilibrium', to return to it gradually later on".[21]

Europe 1550-1900," Unpublished manuscript, Department of History, University of Maryland; JOHN A. EDDY, Climate and the Role of the Sun, in ROBERT I. ROTBERG and THEODORE K. RABB, Climate and History: Studies in Interdisciplinary History (Princeton, N.J.: Princeton University Press, 1985), pp.145-67.

[16] EMMANUEL LE ROY LADURIE, Times of Feast, Times of Famine: A History of the Climate since the Year 1000 (Garden City, N.Y.: Doubleday, 1971), pp.8,12,13.

[17] B.H. SLICHER VAN BATH, The Agrarian History of Western Europe, A.D. 500-1850 (London: Edward Arnold, 1963), p.89.

[18] "For ports, the rate of gain of rats would depend on the frequency of arrival of ships... Persistence of populations of rats would have required frequent arrivals of ships from the Mediterranean, where rats were widely distributed." They were present there already in ancient times. "During Roman times, frequent voyages and large port cities encouraged the establishment of rats in Britain and other European countries. But in the early Middle Ages the decline in shipping resulted in the extinction of rats in most cities of the north... But the increase in shipping and the size of ports in Columbian times released an avalanche of rats..." DAVID E. DAVIS, "Scarcity of Rats and the Black Death: An Ecological History," Journal of Interdisciplinary History, 16 (1986), pp.455-70.

[19] MCNEILL, Plagues and Peoples, p. 23; MCKEOWN, "Food," p. 243.

[20] HOHENBERG and LEES, Mating of Urban Europe, p. 9.

[21] EMMANUEL LE ROY LADURIE, The Territory Of the Historian (Chicago: University of Chicago Press, 1979), p.95.

Moreover, population growth tended to be conducive to urbanization and the rapid expansion of this part of the population brought with it the difficulty of producing and transporting sufficient food to the urban sector. Consider that Rome had a population of 150 thousand in 200 B.C.; within the next 300 years, it reached 650 thousand.[22] The problems of food procurement given the agricultural technology of the time must have increased greatly. Pirenne noticed that population growth in the Middle Ages resulted in a "detaching from the land of an increasingly important number of individuals..."[23] Urbanization in the Middle Ages, too, must have brought with it the intrinsic problem of feeding that part of the population which was no longer on the land.

Urbanization had many positive effects on economic development, but it also exacerbated the precarious balance between the food supply and population size. At such a conjuncture climatic variation could have a potent effect on the availability of nutrients. Small changes in weather conditions could then produce great variations in the food supply available to the urban sector. Hence the European population was regularly decimated, but after the demographic crisis the nutritional status of the population could improve. The livestock available on a per capita basis must have increased, which meant that protein intake must have risen. The population could reproduce and recover once again to its previous levels.

Marked improvements in the diet: after the black death, particularly increases in the intake of animal protein, brought about a recovery of the population during the course of the fifteenth century and production grew correspondingly.[24] Thereafter, "the race between population and production was on again." While the recovery of the fifteenth century was quicker than the previous one of the early Middle Ages, by the sixteenth century the

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[22] Increased commercialization and urbanization of Europe after the eleventh century, too, proceeded at a faster rate than population growth itself. The growth of Paris was just as spectacular as the decline of Rome had been. The Paris population was 20 thousand in the tenth century; in 1200 it was already 110 thousand and by 1300 was, at 228 thousand, the largest city in Europe. Yet in 1600 its population was still 250 thousand. Tertius Chandler and GERALD Fox, *3000 Years of Urban Growth* (New York: Academic Press, 1974), pp. 302 ff, 375.

[23] HENRI PIRENNE, *Medieval Cities, Their Origins and the Revival of Trade* (Princeton, N.J.: Princeton University Press, 1925; paperback ed., 1969), p. 114. Herodotus pointed to the vulnerability of towns in the Ancient World by stating: "the cities that were formerly great have most of them become insignificant, and such as are at present powerful, were weak in olden time."' DE VRIES, *European Urbanization*, p. 121; HOHENBERG and LEES, *Making or Urban Europe*, p. 9.

[24] CH. DYER, "Changes in Nutrition and Standard of Living in England, 12001500," in ROBERT FOGEL (ed.), *Long-Term Changes in Nutrition and the Standard of Living* (Berne: 9th Congress of the International Economic History Association
1986), pp. 35-44.

"Malthusian scissors" were opening up again. French tithe statistics confirm that the ceiling on grain output reached during the fourteenth century was not surpassed in the sixteenth or in the seventeenth century.[25] Presumably, the European societies were not yet capable of accumulating resources quickly enough to emancipate the population from the Malthusian menace.

The rapid population growth of the sixteenth century culminated in the crisis of the seventeenth century. The effect of population pressure, however, was no longer as severe as it had been in the fourteenth century.[26] The plague, however, did strike some parts of Europe again early in the century.[27] The economies of Germany, France, Hungary, and Spain were perhaps hurt more by the crisis than those of Holland and England, which escaped the century relatively unscathed.[28] The famine of 1693, one of the worst to visit Western Europe since the Middle Ages, "turned France into a big, desolate hospital without provisions".[29] Population pressure was mitigated by such factors as the creation of market channels with East-European grain markets, which had not existed in the fourteenth century. Preventive checks became more prevalent as a means of keeping population growth within manageable bounds.[30] The conclusion is inescapable: in preindustrial Europe diminishing returns to labour often imposed an effective constraint on further population growth.[31]

Although the seventeenth century witnessed the last prolonged demographic crisis in Europe, in the eighteenth century, too, a Malthusian crisis threatened in the wake of an acceleration in population growth. That nutritional status was deteriorating is shown by the declining height of men born

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[25] EMMANUEL LE ROY LADURIE and JOSEPH GOY, *Tithe and Agrarian History from the Fourteenth to the Nineteenth Centuries: An Essay in Comparative History* (Cambridge: Cambridge University Press, 1982), p. 73. A cooling trend in the weather by the end of the sixteenth century had an unfavourable affect on agricultural production. LE ROY LADURIE, *Times of Feast*, pp. 9, 21, 58, 158; GALLOWAY, ' Long Term Fluctuations;" LE ROY LADURIE, *The Territory of the Historian*, pp. 12, 25, 88.

[26] LE ROY LADURIE, *Times of Feast*, p. 90.

[27] GEORGE ALTER, "Plague and the Amsterdam Annuitant: A New Look at Life Annuities as a Source for Historical Demography," *Population Studies*, 37 (1983), pp. 23-41.

[28] NORTH, *Structure and Change*.

[29] LE ROY LADURIE, *Times of Feast*, p. 90.

[30] ED1VARD A. WRIGLEY and ROGER S. SCHOFIELD, *The Population History of England 1541-1871, a Reconstruction* (Cambridge, MA.: Harvard University Press, 1981).

[31] W.A. COALE and PHYLLIS DEANE, "The Growth of National Incomes," in HJ. HABAKKUK and MICHAEL M. POSTAN, eds. *Cambridge Economic History of Europe.* Vol. 6, *The Industrial Revolution and After. Incomes, Population and Technological Change* (Cambridge, England: 1969), p. 2.

after midcentury.[32] In contrast to prior centuries, a Malthusian crisis was averted in the eighteenth century either because the economy was strong enough to overcome the threat or, as in the Habsburg domains, because the central authorities had sufficient financial resources to come to the aid of the destitute, and had the organizational capability to bring about institutional change, a prerequisite to absorbing the growing labour force into the economy.[33]

A certain organizational sophistication in disaster management was needed to enable the government to avert an impending crisis. Maria Theresia of Austria, for instance, sent substantial aid to the poverty-stricken of Bohemia during the subsistence crisis of 1770 to 1771. In more backward countries the impact of the crisis was more severe. In Moldavia, for example, three hundred thousand died of the plague in 1770.[34]

Rondo Cameron has pointed to the cycles outlined above as characteristic of European economic development, referring to them as logistics because of their similarity to the elongated S-shaped curve described by the mathematical formula with this name. Population grew in each of these logistics, separated by periods of decline or deceleration. He suggests that these logistics provide "a convenient framework for a history of European economic development." He points to the phenomenon of diminishing returns becoming evident during the decelerating phase of each of the logistics, at which time "conditions of life were becoming increasingly difficult." Cameron concludes "that mankind has repeatedly postponed the Malthusian dilemma by means of technological and institutional innovations that have increased the supply of food..." [35]

Over time the cycles became less severe and of shorter duration. Four hundred years elapsed between the apex of population in 200 A.D. and the

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[32] JOHN KOMLOS, "Stature and Nutrition in the Habsburg Monarchy: the Standard of Living and Economic Development in the Eighteenth Century," American Historical Review, 90 (Dec. 1985), pp. 1149-61; Idem, "Patterns of Children's Growth in East-Central Europe in the Eighteenth Century," Annals of Human Biology,13 Jan./Feb.1986), pp.33-48. In prior centuries, as well, human stature fluctuated with the availability of the food supply. HELMUT WURM, "The fluctuations of average stature in the course of German History and the Influence of the Protein Content of the Diet," Journal of Human Evolution, 13 (1984), pp.331-334.

[33] JOHN KOMLOS, "Institutional Change Under Pressure: Enlightened Government Policy in the Eighteenth Century Habsburg Monarchy," Journal of European Economic History, 15 (winter, 1986), pp.427-482.

[34] In Bengal, ten million people perished through famine in 1769 to 1770. JONES, European Miracle, pp.139,29,32.

[35] RONDO CAMERON, "The Logistics of European Economic Growth: A Note on Historical Periodization," Journal of European Economic History, 2 (1973), pp.14548; Idem., "Economic History, Pure and Applied," Journal of Economic History, 36 (1976), pp.21-22.

nadir reached in 600 A.D. The next apex took another 700 years to reach. The next cycle was considerably shorter, about 300 years long, from 1300 to 1600. The subsequent cycle lasted about a century and a half. At last, the downturn could be averted in the second half of the eighteenth century becayse European societies had become sufficiently sophisticated to mobilize resources to overcome the threat and the accumulated capital stock was large enough and grew quickly enough to enable the population to grow unhindered. The overall pattern, in which the severity of the cyclical downturns diminished over time until they vanished entirely, indicates that the ability of socioeconomic and political structures to cope with the rising population increased slowly until the eventual breakthrough of the eighteenth century.

Capital Accumulation

In addition to the Malthusian demographic regime another important feature of the pre-industrial European economic system was the accumulation of capital and technology in the long run, a feature recently emphasized by E.L. Jones. He referred to the propensity of productivity to increase slowly but incessantly as "technological drift".[36] Under the concept of capital one should include not only human and physical capital in the usual senses but also knowledge, broadly conceived, as well as the creation of institutions that improve the efficiency of markets, because they lower the costs of production, shift the production function, and thereby raise productivity. Jones argues that improvement in the routine administration of government and the creation of a legal framework consistently applied is a very important aspect of the long-run European growth record.[37] Institutions conducive to growth contribute greatly to "the progress and retrogression of sacieties".[38] Of course, institutions can also lead to higher transaction costs and to bottlenecks. Yet the essence of the European experience in the very long run has been to create an institutional infrastructure which fostered development. Clearly, developing efficient property rights is part of this record, since a legal system conducive to economic development is an important feature of economies that grow.[39]

Human capital should, in addition to education, include such gains made by the human species as the increased immunity and resistance to disease that were acquired slowly through recurrent exposure to disease. When an infec-

[36] JONES, *European Miracle*, p. 69.

[37] NORTH, *Structure and Change*, pp. 59, 167.

[38] DOUGLASS C. NORTH and ROBERT P. THOMAS, *The Rise of the Western World; A New Economic History* (Cambridge: Cambridge University Press, 1973).

[39] Economic organization was getting more efficient not only in early modern times, bot even during the long period between the origins of agriculture and the decline of the Roman Empire. North, *Structure and Change*, p. 64.

tion attacks a population previously unexposed to the disease, the epidemic can assume Immense proportions; however, many diseases subsequently produce antibodies, thereby providing a safeguard against future attacks. An example is provided by the decline of the Roman population, which was devestated by the arrival of smallpox or measles. By the sixteenth century, however, in Europe these diseases had become childhood diseases which no longer devastated the population as they did on their first arrival. With the expansion of commerce and European contact with the rest of the world, the "likelihood of a really devastating disease encounter" in Europe was reduced. Increased resistance to disease raised labour productivity and therefore was tantamount to a large-scale increase in the accumulated stock of human capital. One reason why human-capital formation in Africa was more difficult than in Europe was that African populations had to face a different disease environment: "many of the parasitic worms and protozoa that abound in Africa do not provoke... the formation of antibodies in the bloodstream".[40]

Capital depreciation was not an important aspect of the European experience. Important components of the capital stock, as defined here, include organizational know-how, knowledge about how to manipulate the environment, and immunity from certain diseases, which seldom depreciated over time. Knowledge does not diminish by being used, as physical resources do. "The accumulation in the stock of knowledge has largely been irreversible throughout historym" observes North, "but human economic progress has not: the rise and decline of... entire civilization, are certainly indisputable..."[41] In addition, Jones has argued that the European capital stock was quite immune to destruction through disasters, partly because "geophysically and climatically, Europe is quieter than most other parts of the world".[42]

Of course, one can cite examples of capital depreciation even in the European context. Yet Jones's argument is that in Europe, accumulation was much more important than capital destruction. In Europe capital was not systematically destroyed, and that is an important way in which it differed from the Orient.[43] Although there were exceptions, the European instinct

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[40] MCNEILL, *Plagues*, pp. 3, 12, 23, 223. The drawback in conceiving of capital stock so broadly is that it defies quantification. Yet because of lack of data, even ordinary, reproducible capital cannot be measured prior to the eighteenth century. Hence this problem is moot: currently, all capital eludes measurement for the period under consideration. To be sure, some proxies could be constructed to quantify knowledge such as the number of books printed.

[41] NORTH, *Structure and Change*, p. 59.

[42] JONES, *European Miracle*, p. 61.

[43] Is it a mere coincidence that cities mushroomed in the Middle Ages in areas that had previously belonged to the Roman Empire, or did the existence of an infrastructure, even in a dilapidated state, lower the cost of European urbanization? HOHEN-

was to accumulate, and the political and geophysical environment favoured such accumulation.

Boserupian Episodes

In contrast to the Malthusian view, some scholars emphasize the beneficial effects of population growth by arguing that population growth fosters technological change in the long run.[44] Population growth leads to urbanization, which fosters the creation of knowledge.[45] Higher population densities, because they lower transaction costs, are conducive to the widening of the market, which in turn leads to market integration and further division of labour. In addition, as the market for a product grows enterprises can grow in size, thereby capturing economies of scale and enabling externalities to be captured, resulting in decreasing average costs for whole industries. Population pressure can induce governments to institute reforms that foster production. Hence in the long run, population growth can be quite conducive to economic growth.

The European experience shows that population growth and economic growth were intertwined. During the three main phases of economic expansion, in the Middle Ages, during the sixteenth century and also during the eighteenth, population grew rapidly. In contrast, during the crisis of the seventeenth century European population declined or stagnated.

BERG and LEES, *Making of Urban Europe*, p. 27. In 1500 71 percent of European cities with a population in excess of 10,000 were located in the formerly Romanized world. DE VRIES, *European Urbanization*, p. 28. The spread of forests in Europe in the late fourteenth and early fifteenth centuries indicates that agricultural capital built up by earlier generations deteriorated. Yet subsequently it was much easier to clear the forests again than it had been initially.

[44] ESTER BOSERUP, *Population and Technological Change: A Study of Long-Term Trends* (Chicago: University of Chicago Press, 1981); JULIAN SIMON, *Theory of Population and Economic Growth* (Oxford: Basil Blackwell, 1986); GUNTER STEINMANN, "A Model of the History of Demographic-Economic Growth," in GUNTER STEINMANN (ed.), *Economic Consequences of Population Change/ in Industrialized Countries. Proceedings of a Conference on Population Economics Held at the University of Paderborn*, June 3 1983, *Studies in Contemporary Economics*, Vol. 8 (Berlin: Springer-Verlag, 1984), pp. 29-49.

[45] SIMON KUZNETS noticed that high population densities foster the creation of knowledge. He suggested that "creative effort flourishes in a dense intellectual atmosphere, and it is hardly an accident that the locus of intellectual progress... has been preponderantly in the larger cities not in the bucolic surroundings of the thinly settled countryside." SIMON KUZNETS, "Population Change and Aggregate Output" in Universities-National Bureau of Economic Research, *Demographic and Economic Change in Developed Countries; A Conference of the Universities-National Bureau of Economic Research* (Princeton, N.J.: Princeton University Press, 1960), p. 329.

The Synthesis

These three strands of thought can now be synthesized. Population tended to grow until food supply became limited or until population densities increased the probability of epidemics given the state of public health and medical technology of the time.

Although a crisis eventually ensued, the incessant process of capital accumulation meant that the European societies faced each subsequent crisis with a higher capital/labour ratio than previously. The nutritional or epidemiological crisis might decimate the population, but the decline in population density increased the amount of food available per capita. Hence demographic crises were followed by long periods of rising nutritional status and population growth.

Thus the cycle continued. Population growth fostered urbanization, knowledge creation and the expansion of the market, but the degree to which it could continue was constrained by the availability of nutrients. Because agricultural technology was slowly improving, and because trade was bringing new agricultural regions within reach of Northwestern Europe, each episode of population growth led to higher population densities than ever before. These episodes fostered the expansion of the market, even if a crisis might ensue. The cycle of population growth, capital accumulation, market expansion, crisis, followed by population growth again could proceed until by the eighteenth century the European societies were sufficiently advanced to break out of the Malthusian trap.

The industrial revolution can therefore be conceptualized as a break out of the Malthusian demographic regime. It was a period of both economic and demographic expansion similar to the ones which Europe had experienced in prior centuries. The major difference in the eighteenth century turned out to be that a crisis could be averted because the supply of nutrients sufficed to maintain a growing population. This was achieved not only because domestic agriculture was more productive than during the previous expansionary phase of the sixteenth century, but also because East European and colonial food supplies were available to a greater degree than ever before.

Thus this model retains the Malthusian effects, but superimposes on them "Boserupian episodes" during which rapid population growth had positive economic effects. In the meantime capital accumulation led to slow shifts in the production function and to rising labor productivity. Each episode of population growth led to a Malthusian crisis, but each subsequent crisis was faced with a larger resource base, thereby increasing the probability that eventually the accumulated stock of capital would suffice to overcome the Malthusian threat. Although the Malthusian effect dominated during the pre-industrial epoch, the Boserupian effect did eventually gain the upper hand: the Malthusian ceiling was permanently lifted during the industrial revolution.

Conclusion

This conceptualization stresses, as does Jones, the importance of the slow but persistent accumulation of capital through time, which enabled the Europeans to ultimately emancipate themselves from the Malthusian menace. Once the food constraint was lifted for Europeans, population growth could proceed, leading to further economic gains; this process had important feedback effects. Thus economic growth became "self-sustaining" after the industrial revolution, differing from the experience of the previous upswings only in that the nutritional constraint was removed and therefore population could expand unhindered by positive checks. While slow population growth hindered economic expansion prior to the eighteenth century, in the nineteenth this was no longer a factor. Thousands of years of very slow economic growth could be followed by a period of extremely rapid growth without a fundamental transformation in the relations of production and reproduction. Although there was no structural break in the economy, output and per capita output could grow faster for a longer period of time than ever before.

Yet, the saving rate did not need to increase for output to expand exponentially. For the economy to escape permanently from the Malthusian constraint two criteria had to be satisfied. First, the level of capital stock had to be sufficiently large so that enough nutrients could be produced or imported to sustain a growing population increasingly concentrated in the urban-industrial sector. Moreover, productivity in the industrial sector had to be sufficiently high to enable its products to be exchanged for nutrients through international trade on favourable terms. Once this level of performance was reached, enough food could be obtained to maintain the nutritional status of a growing population above the minimum needed for subsistence. The capital-diluting effect of population growth could be overcome by a rise in the rate at which the capital stock grew, but initially this was brought about not by a rise in the rate of saving, but through a rise in the share of the population producing capital. Thus it was extremely important that the eighteenth century growth in population started from a high technological base and with a large segment of the population already in the urban sector.

That the share of the population in the commercial-industrial-urban sector must fall within a critical range at the time of escape is intuitively plausible. If the share of population in this sector were too large, the foodproducing sector could not have produced enough nourishment to maintain the nutritional status of the population. If, however, the share of the population in the non-agricultural sector were below a threshold level, then capital could not be augmented fast enough to overcome the capital-diluting effect of population growth. Once these critical conditions were met in the eighteenth century, the economy was poised for an escape from the Malthusian trap.

In this model the industrial revolution is conceptualized as the culmina-

tion of a process extending back to the Neolithic agricultural revolution, rather than as a structural break with the past. Population growth is seen as having had both positive and negative economic consequences. On the one hand population growth led to a deterioration of nutritional status and consequently to innumerable subsistence crises, which temporarily hindered further growth. Yet over time the capital stock was augmented, which became useful to subsequent generations. In spite of recurrent setbacks, the nonnutrient-producing population was able to expand in the long run precisely because each new phase of population expansion began with a greater stock of accumulated capital. Hence, over many cycles both population and capital stock increased. Eventually, with the accumulation of capital and the increase of the share of the population in the urban-industrial sector, the stock of capital grew fast enough to overcome the Malthusian constraints permanently. The industrial revolution was under way. Population growth was therefore the proximate cause of the industrial revolution, but the achievements of the previous millennia were the preconditions for sustaining the economic momentum precipitated by the rise in population.

The industrial revolution of the eighteenth century, in the words of Davide Landes, "lifted beyond visible limits the ceiling of Malthus's positive checks".[46] The industrial revolution, too, like the previous population expansions, of the thirteenth and sixteenth centuries, brought about the beginning of a subsistence crisis.[47]By the eighteenth century, however, the accumulated stock of capital and the rate of urbanization sufficed to enable the European societies to break out of the Malthusian trap and reverse the decline in nutritional status. While this model is Malthusian, it nonetheless allows the effects of population growth to be other than capital diluting in the long run. It thereby synthesizes the Malthusian and Boserupian world views and integrates the industrial revolution into the economic and demographic processes of the preindustrial world.[48] Almost half a century ago,

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[46] DAVID S. LANDES, *The Unbound Prometheus: Technological Change and Industrial Development in Western Europe from 1750 to the Present* (London: Cambridge University Press, 1970), P.41.

[47] KOMLOS, "Stature and Nutrition."

[48] For other synthesis of the Malthusian and Boserupian ideas see RONALD DEMOS LEE, "Malthus and Boserup: A Dynamic Synthesis," in David Coleman and ROGER SCHOFIELD (ed.), *The State of population Theory. Foreward from Malthus* (Oxford: Basil Balckwell 1986); FREDERICK L. PRYOR and STEPHEN B. MAURER, On Induced Economic Change in Precapitalist Societies," *Journal of Development Economics*, 10 (1982), PP. 325-53; WARREN ROBINSON and WAYNE SCHUTJER, Agricultural Development and Demographic Change: A Generalization of the Boserup Model," *Economic Development and Cultural Change*, 32 (1984), PP.355-66; Gunter Steiman and John Komlos. "Population Growth and Economic Development in the Very long Run: a Simulation Model of three revolutions," *Mathematical Social Sciences*, 16 (1988), PP. 49-63; Marc Artzrouni and John Komlos, "Population Growth through

Sir John Hicks anticipated this conceptualization of the lndustria1 revolution when he noted in an obscure footnote that "...one cannot repress the thought that perhaps the whole lndustria1 Revolution of the last two hundred years has been nothing else but vast secular boom largely induced by the unparalleled rise in population

History and the Escape from the Malthusian Trap: a Homeostatic Simulation Model," *Genus*, 41 (1985), pp. 21-39.

49 JOHN R. HICKS, *Value and Capital, An Inquiry into some Fundamental Principles of Economic Theory* (Oxford: Clarendon Press, Second Edition, 1939), p. 302.