CHAPTER 5

The Enigma of China, India, and Europe

Chapter 5 constitutes a defense against a possible criticism of this essay. Because the chapter is not an element in the central argument, it combines some materials used elsewhere in the essay with some additional materials.

The following issue is frequently raised: If more people generate more ideas and knowledge, stimulate growth of markets and cities, and, hence, produce higher productivity and income, why did the modernization revolution not begin in India and China? Why did China and India lag further and further behind Europe even though their population sizes and densities were greater? The same answer fits both forms of the question.

Mokyr makes this a central question in understanding the history of world population growth. He speaks of "The immense difficulty of the question of why China fell behind" (1990a, 224). He also says that "The Chinese experience is a powerful counterexample to the Boserup-Simon theory that population pressure leads to technological progress."[1] So the topic certainly must be addressed here, though I argue that it is a nonproblem for present purposes.

It was noted earlier that in accord with the simplest supposition about population size, China was indeed a technological leader, apparently by a wide margin, until perhaps 1400. China also led economically. Differences in education explain much of the huge difference between the West and the East at present, but educational differences probably do not explain what happened starting five centuries ago. At that time printing had barely begun to be practiced, and formal education was too sparse in both continents for any difference to explain the activities that produced the inventions and adoptions of innovations that occurred.

The response to the China-Europe question offered here is that the question cannot be answered scientifically, at least at present. There are three major elements in that response: (1) There indeed were structural differences in the *political-institutional systems,* as mentioned earlier, but the standard analysis based on those differences does not constitute a satisfactory answer to the question at hand. (2) Both Asia and Europe

were *parts of the same larger system,* and hence the question of why they differed is not a question that matters for this book; the question addressed here is why Sudden Modern Progress began *anywhere in the world* in 1750–1800. (3) An answer to the question set forth previously *cannot be given scientifically* because there is only one pair of entities to be compared, and not a larger sample, without any evidential saving grace—that is, there is an econometric problem. The rest of this section will expand on these three elements.

Structural Differences in the Political-Social Systems

In Europe there occurred concurrently, along with population growth, a nexus of interconnections between loosening of feudal ties, growth of cities, increases in personal economic freedom, political freedom, greater openness of societies, competition among the various European states, economic advance, popular government, and general economic advance. Hume ([1977] 1987), McNeill (1963), Jones (1981), and others have suggested that over several centuries the relative looseness and changeableness of social and economic life in Europe, compared to that in China and India, helps account for the emergence of modern growth in the West rather than in the East. Change implies economic disequilibria that (as Schultz [1975] reminds us) imply exploitable opportunities that then lead to augmented effort. (Such disequilibria also cause the production of new knowledge, it would seem.)[2]

More specifically, the extent to which individuals are free to pursue economic opportunity and the extent to which there is protection for the property that they purchase and create for both production and consumption, together with the presence of diversity and competition at all levels, seem to make an enormous difference in the propensity of people to develop and innovate. Clough (1951, 10) discussed the importance for the "development of civilization" of

> a social and political organization which will permit individuals to realize their total potential as contributors to civilization. What is implied here is that in a system where social taboos or political restrictions prevent large segments of a culture's population from engaging in types of activity which add most to civilization, the culture cannot attain the highest degree of civilization of which it is capable. Thus the caste system in India, restrictions on choice of occupation in medieval Europe, and the anti-Semitic laws of Nazi Germany curtailed the civilizing process.

This factor seems to be the best explanation of Europe forging ahead in comparison to the recent centuries' histories of India and China.[3]

As Jones puts it, "[T]he Qing economy, impressively expansible though it proved, failed to move from *extensive to intensive* growth because its political structure did not establish a legal basis for sufficient new economic activity outside agriculture" (1981, 20). That observation, together with the mobility and political competition in Europe, and the closure of China, seems convincing explanation for the European miracle and the lack of a comparable Chinese miracle. This is the way Hume put the same idea sometime before 1777:

> Here then are the advantages of free states. Though a republic should be barbarous, it necessarily, by an infallible operation, gives rise to LAW, even before mankind have made any considerable advances in the other sciences. From law arises security: From security curiosity: And from curiosity knowledge. . . .
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> GREECE was a cluster of little principalities, which soon became republics; and being united both by their near neighbourhood, and by the ties of the same language and interest, they entered into the closest intercourse of commerce and learning. . . .
>
> EUROPE is at present a copy at large, of what GREECE was formerly a pattern in miniature. . . .
>
> IN CHINA, there seems to be a pretty considerable stock of politeness and science, which, in the course of so many centuries, might naturally be expected to ripen into something more perfect and finished, than what has yet arisen from them. But CHINA is one vast empire, speaking one language, governed by one law, and sympathizing in the same manners. The authority of any teacher, such as CONFUCIUS, was propagated easily from one corner of the empire to the other. None had courage to resist the torrent of popular opinion. And posterity was not bold enough to dispute what had been universally received by their ancestors. This seems to be one natural reason, why the sciences have made so slow a progress in that mighty empire.
>
> If we consider the face of the globe, EUROPE, of all the four parts of the world, is the most broken by seas, rivers, and mountains; and GREECE of all countries of EUROPE. Hence these regions were naturally divided into several distinct governments. And hence the sciences arose in GREECE; and EUROPE has been hitherto the most constant habitation of them. . . .
>
> The next observation, which I shall make on this head, is, That nothing is more favourable to the rise of politeness and learning, than a number of neighbouring and independent states, connected together by commerce and policy. The emulation, which naturally arises among those neighbouring states, is an obvious source of improvement: But what I would chiefly insist on is the stop, which such limited territories gives both to power and to authority ([1777] 1987, 118, 120–3, 427–8).

Arguments against the Humian Explanation

The Humian explanation cannot be considered a complete answer and a stopping point to the discussion, for some of the following reasons.

The Failed Record of Explanations of the Rises and Falls of Nations

It is sobering to reflect on the long history of now-rejected informed opinions about the success and failure of countries: Protestant work ethic; Anglo-Saxon and European race; natural resources (or the lack of them); temperature and climate; north-south location; cultural explanations by the bushel; and on and on. This record of failures should warn us against any monocausal explanation.

Other Possible Explanations

One might also adduce such other possible explanations as the diffusion of printing in Europe. This might have occurred because of the importance of the written Bible in Christianity and/or the character system of writing. But whatever the reason, Western-style printing (including newspapers, which are very important for a modern economic society) did not arrive in Japan and China until the middle of the nineteenth century;[4] the interrelated absence of Western printing and of literacy could by themselves have exerted a huge drag on the development of China.

Concerning "the availability of journals" and other printed media, which surely are a crucial element in development: DeVries (1976) tells us that "London's first daily newspaper, the *Daily Courant,* was established in 1702; by 1709 eighteen dailies appeared in the city. For Europe as a whole newspaper sales have been estimated at 7 million copies per year by 1753" (189). These observations should be compared to the lack of any newspapers at all in China for another century and half, as noted earlier in this chapter.

One might also mention such other possible explanatory factors as the probable absence of the Arabic number system in China (the abacus

continued to be used there even though it had disappeared before the eighteenth century in Europe [Dantzig 1954, 35]); higher life expectancy in Europe than in India and China, where well into the twentieth century the death rate was higher than that in Europe perhaps as early as 1600; and the greater possibility of migration within Europe than in India and China.[5] None of these factors can be shown to be decisive, alone or in combination with one or more other factors.

Was an Appropriate System "Inevitable" in China and India?

The reader might ask whether the very existence of a counterproductive legal-political structure (such as that of China) is consistent with the argument here that such phenomena are endogenous. But endogeneity does not imply immediate response; if history is clear on any one point it is that an appropriate political-economic system does not appear immediately when circumstances change. It is hope enough that even a rough approximation of such a system will appear sometime short of the very long run.

Should Poverty Not Have Induced Progress?

Elsewhere (Simon 1987a) I have systematically developed the hypothesis that the combination of a person's wealth and opportunities affects a person's exertion of effort, which may seem to contradict the thrust of this essay. Ceteris paribus, the less wealth a person has, the greater the person's drive to take advantage of economic opportunities. The millions of villagers in India and China certainly have had plenty of poverty to stimulate them. But they have lacked opportunities because of the static and immobile nature of their village life. In contrast, villagers in Western Europe apparently had more mobility, fewer constraints, and more exposure to crosscurrents of all kinds. Hence they were more easily able to loosen their rural ties and join in the changes that led to Sudden Modern Progress.

Multicausality

Mokyr comments that "The problem seems so huge that it is tempting to resort to some exogenous but relatively simple theory to explain a massive societal behavior change" (1990a, 226). He examines many such simple explanations that have been proposed and finds them all wanting. He implicitly endorses an entire complex of causes, as does Kuznets. Kuznets does suggest that the "epochal innovation" of a scientific attitude may have been crucial.

> [M]odern economic growth, as observable for a substantial number of currently developed countries, could best be viewed as a process based on an epochal innovation—a complex of additions to useful knowledge which raises sharply the stock of technological and social knowledge in the world, and which when exploited is the source of the high rate of aggregate increase and of the high rate of structural shifts that characterize modern economies. Whether this basic source is best described as the increasing application of science to problems of economic production and organization—with the stimulus coming from the exogenous growth of science, basic and applied—or whether the emphasis should be on changes in men's views and social institutions which, at one and the same time, stimulate the growth of science and of its useful applications is an important question, but it need not concern us here. Whatever the source, the increase in the stock of useful knowledge and the extension of its application are of the essence in modern economic growth; and the rate and locus of the increase in knowledge markedly affect the rate and structure of economic growth. (1966, 286)

The process may be understood, I think, in light of a contemporary analogy: the difficult and relatively unproductive professional lives led by economists and other researchers who work in universities in poor countries. This analogy is developed at length at the end of this chapter.

Indeed, there is some reason to think that the entire intellectual infrastructure was much more fruitful in Europe than in China, as evidenced by the vibrant atmosphere in the major cities of Europe in the 1600s. Why, then, should one not think that ingenious Chinese individuals were hampered by more of the ordinary difficulties of lack of development than Europeans were around the 1600s?

And though China and Europe may (or may not) have started off with equally propitious situations for agents of progress to operate in, an unpredictable shock such as the death of a benign ruler and the onset of a disastrous regime, or a war and invasion, or a climatic shift could have set off a cumulative process wherein the circumstances were progressively more different for prospective agents of progress.

The Ecumene of Asia and Europe

The emergence of the ecumene encompassing both Asia and Europe was mentioned earlier. This concept suggests that the question of why the entities within the ecumene differed—as if they were separate,

disconnected entities—is not the proper question for this essay; rather, the key question here is why Sudden Modern Progress began *somewhere* about 1750 or 1800.[6] Though he focuses on the differences between Europe and Asia, Jones notes that "European economic history is a special case of the economic history of all Eurasia" (1981, 3). He adds that attempting to analyze why the two continents differed is not profitable in this context.

Additional evidence that it is reasonable to consider the continental entities part of the same system for the purposes of the present analysis is that early advances in Asia (such as printing, paper, and gunpowder) fed into later developments in Europe and therefore should get part of the credit for the overall development. And a complicated interrelatedness, referred to earlier, was the trade-based division of labor between India and Great Britain; an increase in the standard of living of the latter led to a decrease in the standard of living of the former.

Trade in textiles and cotton between India and Great Britain was so great that because of the decline in Indian textile production, Indian urban income fell sharply, cities shrank, and the level of urbanization fell. Hard as it is to believe, income in Indian cities at the turn of the twentieth century is said to have been only half or a quarter of what it was in the second half of the sixteenth century (Bairoch 1988, 401). And the (proportional) deurbanization at that time was not restored until 1930. This suggests a division-of-labor process between urban and agricultural areas similar to that which spontaneously occurred between the U.S. South and North in the nineteenth century and to that which was forced on Indonesia by the Dutch after 1830.[7] (We should note, however, that there also was deurbanization in China over much the same period, and Bairoch says that the decline was "in no way imputable to colonization," which casts some doubt on his trade explanation of India's decline.)

One may think of the overall process as follows: The total population in Eurasia taken as a whole (plus the state of technology) became great enough to support one or more successful forays into SMP. As with multiple research-and-development teams working on the same problem, one does not expect all of them to succeed or even that the biggest one with the highest potential will succeed. In hindsight one might offer the informed opinion (as in the "Structural Differences in the Political-Social Systems" section of this chapter) that team China did not make it because of too strong a structure of authority (perhaps induced by a high density of population, together with pride), compelling inwardness, no international trade, and no colonies. Similarly, one can speculate that India failed for many of the same reasons, though perhaps also because of the caste structure rather than because of excessive central authority.

Additionally, Woodruff (1973) makes a good argument for the importance of trade and imported treasures in the rise of the West after 1700. China and India lacked this element.

China certainly had at least reached the status of being a candidate for success half a millennium ago, as Jones makes clear. Its standard of living rivaled that of Europe as of 1500 (see fig. 71). Perhaps a complete change in the form of its government could have made a difference, as perhaps Hume thought. For perspective, could one imagine that low-population-density Africa or South America was a candidate at that time—let alone North America or Australia?

As with a drug company being large and strong enough to afford a set of three research teams that includes one that is eventually successful, we can say that by two or three centuries ago, the ecumene of Eurasia had became capable of producing three "laboratories," one of which succeeded—and only that was necessary for Sudden Modern Progress to become a fact.

In explaining the slowness or nondevelopment of horology in China, Landes again and again mentions the absence in earlier times of sufficient human talent.

> Needham . . . remarks that from Chang Heng (78–142), astronomer royal, mathematician, and engineer, the first in Chinese history to build a water-driven armillary sphere, to Matteo Ricci, the Jesuit missionary of the sixteenth century who first brought mechanical timepieces to China—that is, over a span of fifteen hundred years—only a half-dozen, perhaps only four, astronomer-clockmakers kept the great tradition alive in China or, more accurately, revived it at intervals. Needham presents this fact as something of a wondrous economy: "It is well worth noting how few men it took to span all the centuries of clockwork drive mechanisms." He might have written that nothing better illustrates the constraints on experiment and the impediments to diffusion of knowledge in this domain than the paucity of successful practitioners over time. (Landes 1983, 35)

This accords with the general remark by Jewkes, Sawyers, and Stillerman, cited earlier in connection with contemporary science in note 7 of chapter 1, that there "are always too few minds of the highest calibre and there is a limit to the help that can be afforded them in their original thinking" (Jewkes, Sawyers, and Stillerman 1958, 162). Reinforcing this

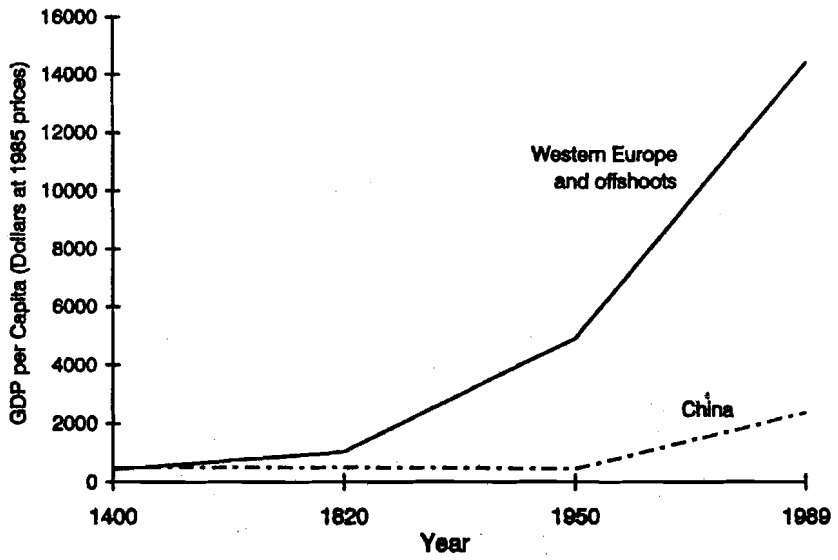

Fig. 71. Comparative performance of Western Europe (and its offshoots) and China, 1400–1989. (From Maddison 1991, 10.)

point in discussing the search for a clock that would solve the longitude problem, Landes says that in the 1600s "Spain simply did not have the pool of knowledge and talent to solve the problem" (1983, 112).

China obviously had enough human beings at the time of which Needham and Landes write, by comparison with the raw talent pool of Europe. But it did not have enough *trained* persons working in *congenial settings.* A larger total population would have been likely, ceteris paribus, to have increased that pool, as also was the case in Spain. But again, let us put this problem aside by focusing on the Eurasian ecumene as the relevant unit and on the sudden leap a few hundred years ago as the key event, rather than trying to explain the details of the past couple of hundred years.

The Dominating Econometric Problem

One might say: If China had for exogenous reasons come to have a different set of political institutions than it actually did in (say) 1300, it might have entered into intensive growth and thereby speeded up the entire progress of humanity. But can one be *reasonably sure* that even if it had had the "optimum" institutions, China would have moved to a faster path and to intensive growth? Even if the structural analysis in the earlier part of this chapter is correct, there still must be much uncertainty. That is, an answer to the question set forth in this section cannot be given scientifically because there is a sample of only one pair of entities to be compared. In other words, the intellectual roadblock is placed there by sound econometrics and statistical inference rather than by the absence of penetrating historical analysis.

It would seem nearly impossible to explain a single such comparison with any surety because of the tiny difference in growth rates between the successful and the unsuccessful examples. The difficulty is illustrated by the large number of major outliers in any cross-sectional regression analysis of growth; this shows that even a proven important variable—such as economic freedom, nowadays—fails to be dominant in many cases; indeed, it fails in enough cases that correlation coefficients are not high.

Who can claim to offer a conclusive explanation of why southern Italy has done so much worse economically than has northern Italy? Or why French Canada has done worse than English Canada? Yet in those cases the political-legal structures were the same for both regions within the countries, which ought to make the comparison easier than the China-Europe situation.

This is the nub of the econometric problem: When the difference in the dependent variable is large, and there is only one big difference in independent variables, one can sometimes draw a solid conclusion. One could fairly decide that the Communism-capitalism structural difference explains postwar differences in economic growth between East and West Germany, even if we did not have corroborating evidence for North and South Korea, and for Taiwan and mainland China, because the prior conditions were much the same for each pair in the comparisons and because the growth-rate differences were very large.

In contrast, the yearly growth-rate differences between China and Europe were small. Yes, they cumulate to a lot. But the yearly differences in the period we are talking of surely were not independent of each other; rather, they depended upon past achievements—the cumulativeness emphasized by Kuznets.

> [A]ggregate growth benefited from the easily *cumulative* character of modern tested knowledge. Handicraft skills embodied in mortal human beings cannot be accumulated as easily as modern technological knowledge embodied in quantitative formulations and innovations based on overtly measurable and testable characteristics of natural and social processes. It is the very overtness and easy embodiment of

> tested knowledge and of its scientific base in a variety of durable forms independent of the personal skills of human beings that make both for its easy communicability and worldwide availability, and for the steadily cumulative results. (Kuznets 1966, 290)

The model of cumulative stochastic growth is strengthened by the saga of the intertwined development of mechanical power and machine tools in Europe starting in the eighteenth century, as told by Usher and in chapter 3. The process comprises one advance following another after the latter was made possible by the former. For example, the saga of the cylinders in the steam engine is familiar. At first the gap between piston and cylinder walls was a loose enough fit that a smaller finger could be inserted, and rags were used to make it tighter. Then boring machines were improved, themselves driven by steam. And other improved tools were produced that contributed to the process.

Another example: There are differences in economic growth rates among U.S. states. But would one feel confident in explaining a Massachusetts-Indiana differential? One would feel more confident if several New England states moved together and moved differently than several Midwestern states—unless there were common regional elements; tax differences are somewhat independent from state to state and might offer a satisfactory explanation.

Similarly, the cumulative differences in population growth in the nineteenth century between the UK and France were large, but the yearly differences were small. And who would now claim to be able to explain those trend differences with surety? True, many have offered explanations, such as the inheritance system. But would you consider any such explanation to be more than an informed opinion? There are so many differences between the two countries that one might adduce, and the rate differences are so small—even the completed-family fertility differences are not huge—that doubt must continue. If one were to array 100 countries, one might test one's hypothesis about the France-UK difference, but even then there surely would be many exceptions and a low (multiple) correlation coefficient.

One has better basis for a before-after comparison of the same country—say, the birthrate in East Germany before and after the fall of the Berlin Wall—because so much else was the same (language, culture, etc.). It also helps when the event is sudden. But a China-Europe comparison does not have these favorable characteristics.

An analogy: Black squirrels seem to be displacing brown squirrels in my part of the world. But I doubt that any ecologist would bet much on any explanation of the phenomenon. In contrast, the total squirrel population seems to vary over the years, and the number of squirrels killed on the streets seems to rise and fall. That variation over time might be reasonably explicable in terms of changes in the food supply, breeding patterns, and so on.

Still another reason for seeing the entire matter as chancy rather than determined is the small numbers of persons involved, as noted in the preceding quotation from Landes. Nowhere does chance operate with a more fickle hand than in the adoption of inventions where adoption decisions are confined to a few persons—as often is the case. Was it not possible that Savery could have failed to find an adopter for his steam engine and that the entire course of invention following from that adoption could have not taken place?[8]

Despite the healthy scientific tendency to focus on statistical aggregations of microevents—see the epigraphs by Petty and Kuznets at the beginning of the preface to this essay—I will now reverse course and remind us that there always is the possibility that one of Jonathan Hughes's "vital few" can make a crucial difference, even for entities as large as a subcontinent. Might not a Chinese emperor who decided to close China—then, out of inertia, was followed in this policy by his successors, backed by those who acted from their own interests—have made a decisive decision whose consequences then cumulated?

Analogy to sports results may help bring out the econometric problem at hand. Preliminary work with Manouchehr Mokhtari on the outcomes of Olympics games from 1956 to 1984 finds that total population and the level of average income explain much of the ranking of countries in medals counts. Nevertheless, there are some far-out outliers—for example, India, which has scored far below its statistically expected results as well as far below China and even below many smaller poor countries; and East Germany, which scored far above its statistically expected results. If the only data that were available were for India, China, and a few other poor countries, it would not be possible to arrive at a sound conclusion about the roles of population size and the standard of living. And the role of political system might therefore receive disproportionate weight.

Here is another sports analogy. The countries competing in the Olympics may be presumed to be very different in many ways. This might well produce large discrepancies between actual and statistically expected performance. The performances among high school basketball teams in a given U.S. state—say, Indiana—may be expected to be more regular. And indeed, schools with larger student bodies usually beat schools with smaller student bodies, so much so that the winning of the championship by a smallest-category school was sufficient occasion for a Hollywood

movie. But apparent anomalies do happen, and if one did not have available a large pool of such schools as context, those anomalies would be mysterious and challenging to the imagination, as in the case of the small school just mentioned. There are other cases where one school wins against another of the same size and character for many years in a row. Is it the coach that matters? Is it just the workings of chance? These are among the true mysteries of a world filled with variability.

Of course there also exist cases that are quite explicable—such as a few tiny private high schools that have national-caliber basketball teams year after year. The obvious explanation is that they recruit talented players from far and wide. This is the sort of case to which historians liken the China-Europe comparison, but that comparison seems not at all analogous.

A somewhat more ambiguous case is the small Minnesota town that has produced many Olympic medal winners in speed skating. Is the water better in Minnesota? Is the town just a suburb of a big city? Or is this just chance? Similar questions apply to the Australian dominance of tennis in the decades after World War II and the predominance of major-league baseball players from a single small town in the Dominican Republic.[9]

The point of the sports analogies is that any single comparison of China and Europe is attempting to explain more than can possibly be explained by the evidence—probably even any evidence that can be accumulated in the future.

Kuznets (1966, 462–68), too, suggested a stochastic approach to what he called the "restricted locus" problem: the problem of explaining why the industrial revolution occurred in Great Britain rather than in larger France or Germany and why in Europe and not in China. He first speculated that smallness of political unit may have been an advantage, by which we may assume he meant that a given large entity of land and people (Europe or China) would do better if it proceeded in several separate units rather than a single unit. He then mused that one of the smaller among the separate units might be the "winner" not just because it was small but also for undetermined stochastic reasons. He refers to this argument as "purely formal." "There are many more small countries than large—given the usual skewness in the distribution of politically independent units by size—and hence, other conditions being equal, there is a greater chance that the pioneer will be small rather than large" (467). So ultimately Kuznets suggests that we should not try to explain, or consider explained, the actual causes of Great Britain and Europe being the locuses of the breakthrough. Rather, he says, we should simply consider the matter unexplained, as the present essay suggests.

Interestingly, in the very essay in which Hume offers his discussion of the China-Europe differential—"Of the Rise and Progress of the Arts and Sciences"—he begins with an excellent statement of the econometric problem of too-small samples and statistical variability.

> Nothing requires greater nicety, in our enquiries concerning human affairs, than to distinguish exactly what is owing to chance, and what proceeds from causes; nor is there any subject, in which an author is more liable to deceive himself by false subtilties *[sic]* and refinements. To say, that any event is derived from chance, cuts short all farther enquiry concerning it, and leaves the writer in the same state of ignorance with the rest of mankind. But when the event is supposed to proceed from certain and stable causes, he may then display his ingenuity, in assigning these causes; and as a man of any subtilty *[sic]* can never be at a loss in this particular, he has thereby an opportunity of swelling his volumes, and discovering his profound knowledge, in observing what escapes the vulgar and ignorant.
>
> The distinguishing between chance and causes must depend upon every particular man's sagacity, in considering every particular incident. But, if I were to assign any general rule to help us in applying this distinction, it would be the following, What depends upon a few persons is, in a great measure, to be ascribed to chance, or secret and unknown causes: What arises from a great number, may often be accounted for by determinate and known causes. . . .
>
> For the same reason, it is more easy to account for the rise and progress of commerce in any kingdom, than for that of learning; and a state, which should apply itself to the encouragement of the one, would be more assured of success, than one which should cultivate the other. Avarice, or the desire of gain, is a universal passion, which operates at all times, in all places, and upon all persons: But curiosity, or the love of knowledge, has a very limited influence, and requires youth, leisure, education, genius, and example, to make it govern any person. (Hume [1777] 1987, 111–13)

The econometric problem we face here is related to the concept of path dependence[10] as expressed in the cumulative random growth models of Herbert Simon. If one assumes that two or more entities start out at the same size (or level of wealth), and each is incremented by a random percentage of its size in the prior period, the entities are likely to arrive at very different sizes after any given number of periods. Incrementing by a proportion rather than by an absolute amount expresses the path dependence, in that the size in the previous state influences the

absolute amount of change; a higher state of technology, say, induces a greater change in technology. In such a random fashion, China, India, and Europe could have arrived at very different states of wealth even if there were no "real" nonrandom economic or other force at work.

This sort of random growth model runs counter to the natural human propensity to assume order and causality and consequently to search for an explanation for an observed outcome. But if one lacks a very solid agreed-upon explanation, a random growth model seems the most modest and defensible approach.

Landes (1994) provides additional references to writers who have viewed the China-versus-Europe and Britain-versus-France outcomes as "accidents." He views some as holding this view on ideological grounds, and he himself rejects this view on the grounds of "a golden rule of historical analysis: *big processes call for big causes*" and "all these things have their reasons" (653). But he does not, I think, come to grips with the possibility of a *cumulatively large* random process whose first step may have been a *small* "accident."

The extent of path dependence may be much greater than we suppose at first. In fact, it may cast light on all of human progress and not just the China-Europe comparison. Consider as an example the development of the process of statistical inference. There is nothing in the arithmetical techniques of statistical analysis that in principle could not have been invented much earlier. But the first analyses of census data apparently were done by John Graunt in 1662. Graunt's work was based on the London Bills of Mortality, and the collection of these first vital statistics predictably was done in London, a very large city in a period of unprecedented wealth and growth. The availability of these data then stimulated Graunt to collect new data on his own in the town of Romsey, which he would not have done if he had not wished to compare some such data with the London data. And the first published formal test of a hypothesis seems to have been made by John Arbuthnott in 1718 (concerning the greater probability of a male than a female human birth). Arbuthnott's inference was based upon the existence of 80 years of vital statistics containing data on the sexes of children born, which apparently grew out of the Bills of Mortality, and his work probably was stimulated as well by Graunt's famous study. Arbuthnott's work, together with the work on probability that had been done by Parisian savants such as Pascal (though some of the work was done at Port Royal) and by European mathematicians such as Bernoulli and Gauss, came together in Thomas Bayes's theorem and then moved into the stream of work passing through the beginning of modern statistics by Francis Galton. All this was "organic" growth, and it is nearly unthinkable that the endpoint

of this process should have been suddenly produced all by itself in some other place, especially a rural place or a place where census data had not been collected (such as China through the years). This is so, even though all the necessary mathematical devices were readily available.

There also seem clear links from the developments just described to John Snow's statistical discovery in London in 1854 that cholera was caused by polluted water. Snow had to collect voluminous data on each death. "Snow and his assistant systematically . . . went up and down the streets listing for each household, the age and sex of all residents, the address, and the name of the company that supplied their water" (Gehan and Lemak 1994). Snow's work could in principle have been done earlier, in any place where there had been cholera, requiring as a condition only that there had been water supplies from several wells that differed in whether or not they were polluted.[11] But his work was preceded by Francis Bissett Hawkins's *Elements of Medical Statistics* in 1829, the first, and very remarkable, tract in epidemiology. Though I have not dug into this history (my knowledge of it comes from Gehan and Lemak), it seems plausible that Hawkins linked backward to Graunt and forward to Snow.

Many of the other great discoveries about the prevention of infectious diseases, the main early killers in human history, also took place in the large cities. For example, Semmelweiss discovered the cause of childbed fever in the 1840s in Vienna, then the large capital of the Austro-Hungarian empire (Semmelweiss 1983). The large hospital in which he worked contained many cases for observation; such a hospital could only be found in a large city. And it is not likely that the sort of mortality data Semmelweiss used would have been available in earlier centuries or in smaller places.

According to Mokyr, inventions may not require that the conditions become right for them but rather simply that no one thought of them earlier. He may certainly be correct about *some* inventions. Here is an example that would seem to fit his description: Across the back of the wider part of men's ties is a one-inch strip of material—usually containing the brand name—through which passes the narrower end, to hold it in place unexposed. This innovation first appeared sometime in the 1940s or 1950s and completely replaced tie clips, but it could have been invented decades earlier. I assume that it was diffused soon after the invention. But for such advances as taking a survey of the affected population for data on disease incidence, surely many people were forced to think about the situation at some earlier time, and many must have thought of gathering such information; that idea comes too naturally not to have been thought of by anyone.

Another example of such path dependence in the development of practical concepts: in its discrete form, dynamic programming requires no more than multiplication and can be taught to middle-school students. Why, then, was this most powerful of all decision-making engines first invented by a mid–twentieth-century mathematician, Richard Bellman, culminating in a 1957 publication? This invention might be one of Mokyr's cases of no one thinking of it first, though the conditions for invention were much the same facing many people in the past. But the better explanation[12] may be that this was the first time in history that a group of the persons who would be likely to produce this innovation — mathematicians and operations researchers — was employed by organizations such as the Rand Corporation and was then exposed to the sorts of problems that would evoke such developments as dynamic programming. Hence this discovery may be seen as a result of the demand for better decision making by the military, by government, and by business firms, as well as by the supply of the various concepts that went into the discovery and the supply of trained persons in the United States and in the world who might have produced the discovery. The reader will notice the attention here to the existing stock of knowledge in a society rather than to the culture of the society as it relates to the spirit of discovery and the encouragement of intellectual activity.

Figure 14 (in chap. 1) brought out the nature of path dependence in rail travel. A large proportion of railway track laid before 1920 was in Europe or was built by Europeans. This construction was an outgrowth of European wealth as well as of familiarity with the steam engine in Europe. In the same way, it was no accident that until well into the twentieth century most of the world's oil reserves and production were in the United States, even though there were other areas of the world that were as well endowed with potential production as the United States (see fig. 72).

This discussion of path dependence was intended to show that a random growth model can explain the "European Miracle" even without some dominating explanatory factor being present in Europe rather than in China.

Conclusion

The prudent response to the question of why Europe forged ahead of China is that an answer is beyond the scope of scientific analysis at present. But this does not imply that the question is an enigma. It should

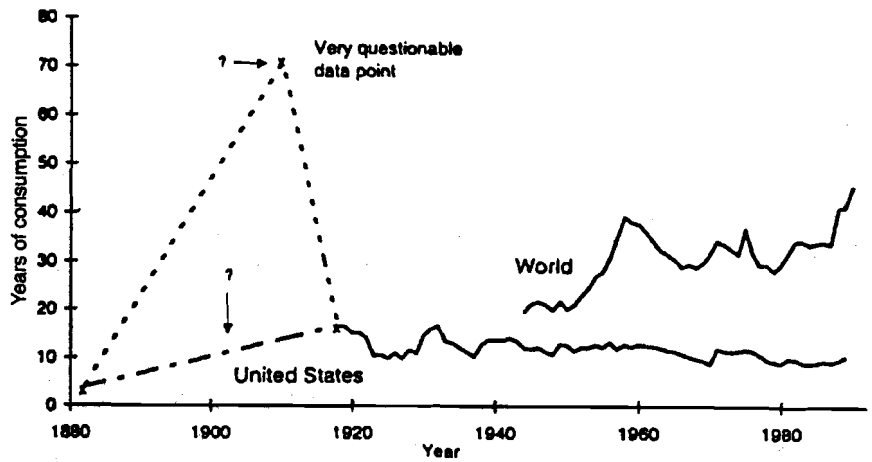

Fig. 72. Crude oil, United States and world known reserves/annual production. (From Simon 1996.)

not be allowed to trouble us any more than the fall of a coin onto its head, or the last-minute victory of one team rather than another.

In order to make more vivid and understandable the difficulty of making new inventions and having them adopted in a country such as China or India circa 1600, consider this contemporary analogy that many readers will understand from their own firsthand and secondhand experiences: the professional lives led by economists and other researchers employed by the universities in poor countries. The data show clearly that these people produce little new science, though the very same people (or people indistinguishable from them) can be very productive when working in universities in developed countries. The causes are many and varied but almost all related, directly or indirectly, to the overall standard of living.

Researchers in a poor country lack modern instruments and have available only primitive tools, perhaps nowadays not having computers (in Israel in 1968 three professors usually shared one desk, meaning that only one could be there at a time); sometimes they are without light and heat for many hours every day or for days and weeks at a time (as in the early and mid–1990s in many former Soviet countries); they lack research funds to hire assistants; war (including military service) and other social disturbances cause work disruption (as in several African countries); graduate students are poorly trained; interested colleagues may

be in short supply; there are no funds to travel abroad and meet colleagues who will bring one up to speed on recent developments and provide mutual reinforcement; the administrators may have little interest in the production of research and do not reward it with status and salary, reducing incentive; recent journals and books may not be held by the university library or, indeed, be found anywhere within the entire country; patent and copyright law may not protect one's intellectual property; inadequate support staff, including lack of English-skilled word-processing and secretarial help; heavy teaching loads; pay may be so low that the researcher must moonlight to eke out a living; and if the product of research is locally oriented, the researcher may find insuperable barriers against having his or her work adopted into practice. An unbelievably strong will is required to overcome these obstacles.

Even with the most well-situated institutions in poor countries—such as foreign companies who invest in building poor-country factories in order to take advantage of what they consider to be a favorable wage situation—the lack of physical and human infrastructure often is enough to defeat these efforts and force firms to pull up stakes and return to producing in the developed country.

A researcher has a much better infrastructure for productive work even at the typical third-level North American university, despite teaching loads much heavier than at first- or second-level universities, than does a researcher even in the elite institutions in poor countries. Yet the heavier teaching loads at those third-level North American universities, together with an intellectual climate and a general culture that are not very congenial, and perhaps even hostile, to high-quality research, constitute enough of a barrier to slow or halt even some dedicated and capable scholars who must work in such places.

Seen this way, through the eyes of individuals who might contribute to progress, the issue does not seem so mysterious or difficult as it is often made out to be.