Book Reviews

The Economics of Technical Advance

Induced Innovation. Technology, Institutions, and Development. HANS P. BINSWANGER and VERNON W. RUTTAN with nine others. Johns Hopkins University Press, Baltimore, 1978. xvi, 424 pp., illus. $22.50.

In 1932 Oxford's J. R. Hicks, a 1972 recipient of the Nobel Prize in Economics, introduced a matrix classification of technical advances. The rows of the matrix represent "autonomous" technical advances and "induced" technical advances. The first category refers to those technical advances that, although they may have important economic consequences, are not economically motivated. The second refers to economically motivated ones, especially responsive to relative costs of factors of production such as labor and capital. The columns of the matrix represent "labor-saving," "capital-saving," and "neutral" technical advances. A technical advance falls into the first, second, or third of these categories according to whether it increases, decreases, or leaves unchanged the optimal capital-labor ratio for the production of a particular item at fixed prices of labor and capital. It is important to note here that these definitions refer to the effects on labor and capital of a technical advance only in connection with the production of a particular item and not with its total consequences. Thus a technical advance involving substitution of automated equipment for labor would be classified as labor-saving even if it finally resulted in a larger total number of jobs because of expanded production of the automated equipment.

Hicks went on to say that autonomous technical advances are on balance neutral in their effect on the relative employment of labor and capital. This was not to say that every autonomous advance is neutral but that overall, over a sufficient period of time, the ones biased in one direction are matched by others biased in the opposite direction. Induced technical advances, on the other hand, are not neutral according to Hicks but are biased against the relatively more expensive factor of production. Thus, the relatively high cost of a factor of production causes its users not only to seek out methods of production from among those currently available that economize on it but also to develop new methods of production that economize on it further. This is the induced technical advance hypothesis.

Hicks went beyond the formulation of the hypothesis by opining that induced technical change tends overall to be laborsaving. Moreover, this tendency has a self-perpetuating quality because technical advances, of any variety, further reduce the price of manufactured goods and therefore machines relative to the cost of labor. This spiraling effect against labor can be offset by the growth in real income accompanying technical advance provided aggregate demand does not taper off.

The conjecture that technical advance has on the whole been laborsaving appears plausible. In virtually all lines of work new mechanical or electronic devices enable the worker of today to do far more than his or her predecessor of 20, 50, or 100 years ago. The work week has declined dramatically during the past hundred years, and there is greater awareness of laborsaving technical advances than of capital-saving or neutral ones. Yet to provide firmer support for the conjecture than these casual observations it is necessary to establish the validity of the induced technical advance hypothesis. And this difficult task is what the authors of this book address. It may be a bit surprising that a hypothesis of such importance has not been subjected to extensive testing in the past 48 years. In part this has been because of a lack of suitable data, in part because of economists' preoccupation with subjects either deemed of more immediate importance or more fashionable, and in part because of the formidable conceptual difficulties involved. In any event this book reports on tests of this hypothesis in connection with agricultural factors of production.

There are four conceptual difficulties encountered in attempting to test the induced technical advance hypothesis. First is the question whether technical advance is controllable. Can a desired technical advance be made to order provided enough money is devoted to it? Despite the recognized role of serendipity in the process of invention and despite failure to find a cure for cancer after the devotion of considerable amounts of money to the effort, the answer is a qualified yes. The optimism is based on purposeful achievements such as the Manhattan Project, the Apollo Project, heart transplants, and test tube babies plus more prosaic evidence of a strong positive correlation between the amount of money devoted to R & D activity and the development of new products or processes. The authors of this book argue that applied research is controllable but that basic research is not. More on this later.

The second difficulty arises in distinguishing between a response to a relatively high-cost factor of production by selection of a method of production that economizes on it and a response involving an entirely new method of production. In technical economic jargon the difficulty is in distinguishing between movements along an isoquant and shifts in the isoquant. The source of the difficulty is that in either case the optimal factor ratio changes in the direction of less use of the more expensive factor. The authors have a rather clever way around this problem. They reason that if the observed change in a factor ratio were simply the result of a new selection from the existing production technology, it would imply the existence of a certain ease of substitution of factors of production in the production of a given item. A measurement of this ease of substitution that was low would demonstrate that the observed change in the optimal factor ratio could not have been achieved within the set of current production technologies and must therefore have resulted from a change in the technology. The ease of substitution measure employed is the elasticity of substitution, a concept also introduced by Hicks. The elasticity of substitution is defined as the percent change in the optimal factor ratio divided by the percent change in the relative prices of the two factors. The authors assume that the elasticity of substitution is constant. This means that it is as easy to substitute, say, capital for labor when the capital-labor ratio is relatively high as it is when it is relatively low. Moreover, it implies that the elasticity of substitution is itself unchanged through technical advance. The conclusions reported by the authors depend on these strong assumptions. This is intended not as a criticism of the authors—these are assumptions commonly made in the course of testing economic hypotheses—but to call attention to the crudeness of our measurement techniques.

The third difficulty in testing the induced innovation hypothesis is related to the second. It is again the problem of distinguishing between choices within the existing production technology and development of new technology. The source of the difficulty this time arises from changes in the level or scale of production. As production expands, a different, more appropriate method of production may be chosen from among the existing ones. The chosen method may, for example, be more capital-intensive than the best method for producing at lower quantities. The shift to the different method of production results in a change in the optimal factor ratios even with relative factor prices fixed. Thus, what may appear to be an induced technical advance is in fact not. In technical terms this difficulty is avoided by assuming that the production function is homothetic. But then this assumption requires some independent justification.

The fourth difficulty is associated with the possibility that the costs of achieving different types of technical advances differ. Although it is reasonable to assume that if all other things are equal a technical advance that economizes on the relatively more expensive factor of production is the more profitable, in reality other things might not be equal. It might in fact be more profitable to economize on the cheaper factor of production because that type of technical advance is easy to come by. Thus, a test of the induced technical advance hypothesis requires that the costs of achieving different technical advances be made comparable.

The authors deal with each of these difficulties to a greater or lesser extent. Their studies of changes in agricultural technologies in the United States, the United Kingdom, France, Germany, Denmark, and Japan between 1880 and 1960 on the whole support the induced innovation hypothesis. They claim that starting with essentially the same technologies in 1880 the United States and Great Britain experienced laborsaving technical advance while the other countries experienced neutral technical advance. There are some anomalies, however. At different periods of time technical advance tended to be laborsaving in Japan, Great Britain, France, and Denmark despite decreases in the price of labor relative to the price of land. A more intensive study of agricultural technology in the United States between 1912 and 1968 indicates, according to the authors, that "the biases of technical change with respect to machinery, labor, and fertilizers have been responsive to changes in relative factor prices." They claim in addition the presence of an external cost bias favoring machine-using technical advances to explain the prevalence of this type of technical advance despite an increase in the price of machines relative to other factors of production.

Beyond the tests of the induced technical advance hypothesis the authors raise several noteworthy points. The first relates to the dilemma confronted by less developed countries seeking to adopt technologies from the more developed countries. Less developed countries typically have a relatively large agricultural sector. This would suggest that adoption of modern agricultural methods might be the most beneficial, at least initially. As productivity in this sector improves, the price of agricultural commodities falls. The demand for agricultural commodities, however, is relatively inelastic and increases less than proportionately, thereby reducing the demand for labor in this sector. Thus, the less developed country adopting this strategy experiences unemployment unless it has a growing industrial sector to absorb the labor released from the agricultural sector. This helps explain the eagerness of less developed countries to industrialize even when they can purchase industrial products from abroad more cheaply than they can produce them domestically. The adoption of modern industrial technologies has its drawbacks, too, because it tends to be heavily capital-intensive whereas labor-intensive methods would be most suitable for the less developed country.

The second point, mentioned earlier, is the authors' contention that the induced technical advance hypothesis relates to applied research and not basic research. The motivations for the latter type of research, they claim, are varied. Yet apart from the difficulty of distinguishing between applied and basic research, the two tend to be highly interactive, and there is the question of what is meant by economic motivation. If by economic motivation it is meant that a research activity requires a commitment of money and is done for a monetary reward then both basic and applied research are so motivated. It's just that the form of payment may be different in the two cases. And we in the universities, the primary source of basic research, know that shifts in government funding of research creates concomitant shifts in the focus of research in both the short and the long run.

This book is the product of many years of work. Some of the chapters have appeared as journal articles. Bringing them together provides a culmination of this work that is larger than the sum of the parts. This book is not the last or conclusive test of the induced technical advance hypothesis. More studies will follow. Each of them, however, will have to take this book into account for its substantive and methodological contributions to the subject.

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Geochemistry

Terrestrial Rare Gases. Proceedings of a seminar, Hakone National Park, Japan, June 1977. E. C. ALEXANDER, JR., and M. OZIMA, Eds. Center for Academic Publications Japan and Japan Scientific Societies Press, Tokyo, 1978 (distributor, Business Center for Academic Societies Japan, Tokyo). xii, 230 pp., illus. $24.50. Advances in Earth and Planetary Sciences 3.

Rare gases are useful in geochemistry and cosmochemistry because their scarcity permits sensitive detection of nuclear processes occurring in nature with rare gas products and their nonreactivity provides a broad array of tracers for studying, almost without chemical complications, physical processes in nature. Starting with Rutherford, who invented uranium-helium dating, which was the first radiometric clock, and continuing to and beyond the banner year 1969, when the store of important samples was vastly enriched by returned lunar rocks and by the Allende meteorite fall, rare gas studies have contributed a surprisingly valuable subchapter in cosmochemistry and radiometric dating. Relatively neglected by comparison has been the use of rare gas isotopes as tracers in the investigation of the evolution of the earth and atmosphere, where nongaseous tracers such as radiogenic lead, strontium, and neodymium have received more of the play. It was this circumstance that prompted Alexander and Ozima to organize a U.S.-Japan seminar on rare gases and to edit the slim, handsome volume that is the proceedings of the seminar.

In 1969, Clarke, Beg, and Craig in the United States detected excess ^{3}He in sea water and Mamyrin, Tolstikhin, Anufriev, and Kamenskii in the Soviet Union detected excess ^{3}He in volcanic gases. A