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TECHNOLOGICAL CHANGE, AGRICULTURAL DEVELOPMENT AND THE RELEVANCE OF CROP-LIVESTOCK INTERACTION[1]

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ABSTRACT

The connection between technological change and economic growth is generally explained within a framework provided by a macro-economic production function where output depends on labour and capital. The shortcomings of such an approach are critically examined. It is argued that technology is not merely a production phenomena but embraces all aspects of human activity which should be incorporated in a technology-growth model. The contribution of colonization, slavery, migration and discovery of cheap oil and gas to technological change and economic growth in the developed countries should be thoroughly analyzed to explain the actual process of their development. Historical experience of the interaction between crop and livestock sectors in the process of development of these countries also need to be understood for developing appropriate technology in the less developed countries.

INTRODUCTION

Technology is regarded as having a vital role to play in the development of human societies. The gap between the more developed and less developed countries (MDCs and LDCs) is explained in terms of the differences in their technological capabilities. The LDCs in their effort to accelerate their rate of development are placing great emphasis on acquiring improved technology. Such acquisition has been made possible by the assistance of MDCs and international organizations. Many unhappy experiences with these imported technologies have generated a considerable controversy about the desirability of transferring modern technologies to LDCs and the sequence of technological change appropriate for them.

It will be argued in this paper that inadequate and rather mechanistic analyses of the experiences of MDCs has led to the idea of direct transfer of technology as a means of achieving higher growth rates in LDCs. An important aspect, generally ignored in studies on technological change and agricultural development, is the role of interaction

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between crop and livestock in the development process. Crop and livestock are often treated as independent fields of study but it will be argued that such treatment leads to the separation of some common elements of technology in an arbitrary way and directs technological change in LDCs to undesirable directions. Throughout this paper no distinction is made between technique and technology.

EXPERIENCE OF MORE DEVELOPED COUNTRIES

The connection between technological change and economic growth is generally explained within a framework provided by a macro-economic production function where output depends on labour and capital. Technology is defined by a given mixture of labour and capital; the actual mixture of labour and capital used depends on their relative prices; a shift in the production function brought about by a change in the relative prices of labour and capital is viewed as representing technological change. A simplified graphical presentation of the model is given in Figure 1. Each product curve depicts the state of technical possibilities at a given point in time, the tangential straight lines represent relative prices of labour and capital; points A, B and C represent technology actually employed at different points in time; ABC depicts the technology-growth path. The nature of the depicted change in technology is “labout-saving”. Thought in terms of contemporaneous economics, points A and c represent technologies used by LDCs and MDCs respectively.

Empirical analyses of the contribution of technological change to growth are inconclusive or indeterminate partly because different mathematical variants of the model have been used depending on differing views on technical change, *viz*, neutral vs non-neutral, endogenous vs exogenous, embodied vs disembodied. The difficulty of separating the development of technical possibilities from the expansion of technical knowledge, which are not only to some extent interdependent but also hardly, if at all, directly observable, makes it almost impossible to deduce algebraically the effect of technical change (for a critical review, see Heertje 1977, pp. 173-206). Apart from this abstract conceptual difficulty, other deficiencies of the model lie in the assumptions and definitions used.

Sources of Growth

In the model, labour productivity is assumed as the indicator of growth and labour saving technological change is assumed as the sole source of growth. In a macro frame-work, total production may depend on many factors other than capital-labour substitution such as changes in the scale of production, relative prices of output and input, the quality of labour and management, living and working conditions, endowment of resources including labour and capital, social, political and economic institutions. The contribution of such great events as colonization, slavery, migration and the discovery of cheap oil and gas to technological change and economic growth needed to be included in any model explaining the process of growth.[3]

For example, the form of capital employed in crop production in selected countries differs according to the relative endowment of land and labour (Table 1). Labour productivity is positively related to the level of labour-saving mechanization while land productivity is positively related to the level of land augmenting (bio-chemical) capital. At a later stage countries adopting land augmenting capital also adopted labour-saving mechanization but labour productivity increased marginally because neither the scale of mechanization nor the scale of farming increased significantly (Hemmi and Atsumi 1981).

Table 1 Resource endowment, form of capital employed and cereal productivity in selected countries

Country	Land	Labour	Capital form employed	Cereal output	
				Per hectare	Per worker
Australia	Abundant	Scarce	High mechanization Low fertilizer	Very low	Medium
Canada	Abundant	Scarce	High mechanization Medium fertilizer	Low	High
USA	Abudant	Scarce	Very high mechanization Medium fertilizer	Medium	Very high
UK, France, W. Germany	Moderate	Scarce	High mechanization High fertilizer	Medium	High
Japan	Scarce	Abundant	Very high fertilizer Labour intensive irrigation Improved seeds	Very high	Low medium
R. Korea, Egypt	Scarce	Abundant	High fertilizer Labour intensive irrigation Improved seeds	High	Low

Note: Approximate present cereal output per hectare in kg: Australia 1,370; Canada 2,275; USA, UK, France, Germany 3,500; Japan 5,400; Korea, Egypt 4,200.

Source: Adapted from Stout *et al*. 1979; Khan and Lee 1981; Herdt 1981; FAO 1976.

This recent picture does not explain fully the historical process of growth in these countries. Like Japan, early prosperity of West Europe also depended on labour intensive technology but its organization took a different form. The economic development of

[3] McInerney (1978, p. 2) defined technology as a matrix of characteristics, structures and processes inextricably entwined with the system of human activity, and a change in technology as some alteration in this complex.

West European countries, particularly Britain, was based on three inter-related pillars: early development of domestic agriculture, slave trade and plunder of colonies, most important being India. A triangle formed by the movement of Britaish goods to Africa, African labour (slave) to Britain, provided not only a path of perpetual motion but a system of self generating, snowballing expansion of the British economy for a long time. The main basis of this expansion was slave trade and slave based agriculture overseas.

> … In one sense, slavery is analogous more to a premature discovery of power, pre-dating the steam engine and the tractor, than an accreation of extra supplies of labour as conceived by the professional economist. For one thing, there was an inexhaustible power supply; in the early stages it only had to be fetched, and it continued to be on tap until abolition one hundred and fifty years later; and such welfare as it got was provided simply to maintain the machine in working order, and as far as was profitable, prolong its life. Certainly its chief economic effect, in the West Indies and America, was to facilitate the application of large scale methods to agriculture, a development which otherwise postulates mechanization…. (Yet) the British to this day hate to be reminded how much of their one-time imperial greatness and their present relative prosperity, was built on the slave trade…. Although there are plenty of books on the abolition of the slave trade, there are very few indeed which even recognize the vast and decisive contribution it made to economic development. We are prepared to take for our primacy in abolishing the trade when it became an economic hindrance and embarrassment; and for self-righteous efforts to prevent any other from gaining an unfair advantage over us by carrying on with it (Dunman 1975, pp. 32-4).

Like slavery, the contribution of colonies to the economic development of Western Europe is either ignored or given a cursory treatment in the standard economic histories. For example, an elaborate description on the construction of railways in British India might be easily found but it is rarely mentioned what prosperity those railway lines brought for the British economy. It is rarely recognized that the prosperity of the British textile industry, one of the first beneficiaries of industrial revolution, was made possible by the destruction of Indian textile and by turning the Indian craftsmen back to the land where they still are.

The role of emigration in economic development of Western Europe is also ignored or denied in standard economic history. Some writers claim that in the long run, rural-urban migration was more important than emigration (see for example, Grigg 1980; Bose-rup 1981). But facts provided by them prove it otherwise. Medieval Europe was overpopulated. The rate of urbanization was not high enough to absorb natural rural increment in population. Opportunities for emigration were wlso absent. When North America and Oceania provided this opportunity, emigration, particularly large scale exodus in the nineteenth and early twentieth centuries, became a major factor in moderating the problems of underdevelopment and population pressure in European countries. Thus, taking place in a short period of demographic history, emigration had a pull effect on rural-urban migration. No such 'safety valve' exist for the third world countries today.

Causes of Technical Change

The model under discussion assumes that labour-saving technical change takes place because of changes in the relative prices of labour and capital. As labour becomes expensive because of expanding non-agricultural employment opportunities, capital is substituted for labour.

Earlier discussions revealed that technical change may not necessarily be labour-saving; at a certain stage it may be labour-using as well as land augmenting as in Japan, Korea and the southern provinces of China including Taiwan where the supply of land was limited but land price was not an important factor in the choice of technology. Land augmenting technical change may also accompany labour-saving technical change in a land abundant yet high land price situation as observed recently in the USA (Table 2). Two important features revealed in Table 2 are : (1) Farm wages and machinery prices increased nearly at the same rate but capital intensity (power and machinery relative to labour) increased at a much higher rate that can be explained by changes in their relative prices. (2) The price of real estate increased at a higher rate than the price of fertilizer, so fertilizer per unit of land increased at a faster rate than that of their relative prices.

Table 2. Indices of quantities and prices of selected inputs in United States Agriculture, 1960-75 (1960=100)

Year	Labour	Power and machinery	Power and machinery relative to labour	Real estate	Fertilizer & lime	Fertilizer relative to real estate
…………………indices of quantities……………………						
1960	100	100	100	100	100	100
1965	75	97	129	101	154	152
1970	62	102	164	99	221	223
1973	59	104	176	96	267	278
1974	57	108	189	95	277	291
1975	58	107	184	96	276	288
…………………indices of prices……………………						
	a	b			c	
1960	100	100	100	100	100	100
1965	116	112	103	126	100	126
1970	174	141	123	172	97	177
1973	212	174	122	221	116	191
1974	231	201	115	275	197	140
1975	255	233	109	315	239	132

a. price of machinery excluding power
b. wage relative to price of machinery
c. real estate price relative to price of fertilizer

Source: Pasour and Bullock 1977.

This variety of situations cannot be adequately explained by a model which incorporates only labour-saving technical change brought about by changes in their relative prices. In reality, both labour-saving and land-augmenting technical changes were influenced equally, if not more, by cheap energy as any other factor.

Energy was not even mentioned as a discrete factor of production in classical economic theories of growth. It is only since the oil price crisis of 1975 that serious attention has been given to energy as a factor alongside of capital and labour. Energy price is still blamed for many ills of the Western economies during the last decade. Detailed analyses, however, show that the period of most rapidly rising energy prices also was a period of comparably rapid but less widely publicized increases in the prices of many other inputs. In the course of these analyses, some authors came to recognize that the capital stock for agriculture and other basic industries in the Western economies were built during a period when current and expected prices of energy were low relative to other productive factors (Carter and Youde 1974, p. 881; for other references see, Lokeretz 1977).

Relative prices of coal, oil and electricity to wages show consistently decreasing trends over a long period (Figures 2, 3, 4; reproduced from Simon 1981). It means, the quantity of these items bought with an hour's wage has steadily increased, no matter what their current prices were. Even during the years of the 'energy crisis', consumer price of oil increased due to production and distribution cartels, but the overall index of energy prices weighted by their values and deflated by the consumer price index felt steadily by over 25 percent between 1950 and 1973, then went up slightly. On the other hand, cost of production and transportation of oil did not rise at all during 1950-1973 (Simon 1981, p. 112).

The commercial energy required annually to operate farm machinery is about twice the requirement for its manufacture; the energy required to operate irrigation equipment is about five times that required for its manufacture (FAO 1976). Petroleum is the main ingredient for nitrogenous fertilizer which is by far the most important chemical fertilizer both in terms of the amount of plant nutrient applied to the world's agriculture and in terms of the requirements of energy for its production and distribution. The price of natural gas is so low that much of this resource is still wasted. For example, 62 percent of natural gas produced by OPEC countries in 1972 was flared and this amount would be sufficient to produce about five times the nitrogen fertilizer consumption projected for developing countries in 1980 (UNWFC 1974, p. 45). In the late 1960s one dollar's worth of petroleum was equivalent in energy terms to 3,800 hours of human labour (FAO 1976) or "two human 'energy slaves' working for about a year" (Leach 1975). This explains why agriculture in the MDC's, both labour-saving and land augmenting types, became highly energy intensive during the last two decades. The situation in the USA has been partly illustrated in Table 2.

Current high energy prices bear different implications for more developed and less developed countries. In MDCs, the impact of oil price increases has been found to be insignificant and future increases also are expected to have a similar impact. In LDC_s

growth rates are highly sensitive to oil price increases. The reasons for such differences are these: (1) In MDCs energy costs account for a very small share of GNP. In the United States it is now around 2 percent; it was less than 3 percent fifty years ago. Thus, MDCs can absorb fairly sharp energy price increases without much difficulty. In LDCs energy costs account for a much larger proportion of GNP. Some countries dependent mostly on imported energy are facing serious balance of payment problems. Those importing with current cash have had to increase indebtedness. The maneuverability of these LDCs is very small indeed. (2) In MDCs, the possibilities of substitution between different sources of energy are much greater compared to LDCs. Even if some LDCs may have the necessary energy source, they may not have the capability to harness it. In MDCs, high prices may lead to replacement of both energy and capital by labour in the short-run, but capital is expected to replace energy in the long-run, as more thermally efficient and expensive machines are developed. In LDCs, labour rather than capital is expected to be substituted in both short and long-run. This means that LDCs have to develop their own technologies in the future because MDCs are not likely to develop energy conserving technologies of a labour intensive type 'appropriate' for LDCs (Dunkerley et al. 1981).

Technological Change and Mechanization

By assuming labour saving technological change as the main source of growth measured by labour productivity, the distinction between technological change and mechanization has been obscured. This obscurity probably led to the adoption of such arbitrary criteria as 'farm power ladder' and 'minimum power levels' for comparing technological achievements in crop production between more and less developed countries (see for example, WFP 1967, p. 87; Giles 1967a, p. 192; Giles 1967b, p.22; Weil 1970, p. 234). Such comparisons culminated in the transfer of modern farm machinery to LDCs where they proved to be largely inappropriate.

Following many unhappy experiences with modern farm machinery, a new concept variously called selective machanizaion, appropriate technology, intermediate technology, labour intensive technology, has emerged. It is a technology of which the LDCs are thought to be in need but does not exist in reality because MDCs do not produce/use it any more or they never produced/used it in the past. This alternative approach has also failed to serve a significantly useful purpose largely because of the failure to appreciate fully that mechanization is only one component of the process of technological change and that mechanization in MDCs has passed through processes of transition between hand tools, animal drawn equipment and engine power, and through processes of improvement within each of the above categories (Green 1971).

In the technical sense, each mechanization process (transition or improvement) aimed at increasing agricultural production through the release of labour constraints and/or performing tasks with improved timeliness too hard for manual power. In the economic sense, the mechanization process aimed at realizing optimum returns to all resources having socio-economic costs in the context of the totality of social objectives which were different among different societies and nations (Stout and Downing 1974, pp.

1-2; Green 1976, p. 25). Consequently, there is no natural sequence or uniform evolutionary process of mechanization which the LDCs could now follow as a blueprint or rule. Appropriate technology evolved in each society as an indigenous phenomena manifesting outcome of the interaction of a multitude of forces within and outside the society. Therefore, direct transfer of material or machinery is now likely to be very helpful in finding appropriate technology in the LDCs[4].

It should also be added that technical development in general was in the hands of practical men, the carpenters and smiths of villages, until about 1800. In the case of agriculture, the reign of the practical men continued until the introduction of internal combustion engines at the turn of this century. These essential characteristics of the process of mechanization are lost in a purely quantitative treatment of technical development in terms of production and factors of production (Heertje 1977, p. 62-78; Nishimura 1980).

Technological Change and Inter-sectoral Linkages

The model under review is based on the assumption of a fully employed labour market; labour displaced by capital is re-employed immediately within the economy. Empirical production functions are often fitted to different sectors and sub-sectors, *viz*, agriculture and industry, crop and livestock, assuming that the macro-economy is equal to the sum total of its various parts. In reality, the macro economy is equal to the sum of its parts and the interactions among them and the dynamic process of growth involve relative changes in the component parts brought about by interactions. The sectoral production functions are incapable of accounting for these interaction effects, however, so over-or under-estimate the effects of technological change depending on the nature of change and the flow of its effects. For example, mechanization of agriculture may leave total agricultural production unaffected, release labour for industrial production, thus increasing total production. Such a change involves a movement along an isoproduct curve of an agricultural production function, while in the aggregate function for the macro-economy the entire function shifts, representing technological change. These interaction effects can be better handled within the framework of the input-output model.

The economic development of the advanced countries has been accompanied by a general decline of the agricultural sector and a corresponding expansion of the non-agricultural sectors. Within agriculture, crop and livestock subsectors have also undergone relative changes. The agriculture-non-agriculture interplay has been well recognized in the economic growth models but due attention has not been given to the changing relationship between crop and livestock, even though the interaction between agriculture and industry has a comparatively short history in relation to the interaction

[4] A survey of firms manufacturing intermediate technology in the United States, US aid organizations, government agencies and private organizations in a number of LDCs revealed that (a) US firms were interested in any form of technology transfer that was profitable, (b) US aid organizations were likely to contract out projects to large well known firms generally not producing intermediate technology, (c) intermediate technology was more effective if produced in LDCs (Swannack-Nunn 1978, pp. 119-24).

between crop and livestock. For many LDCs, crop-livestock interaction deserves more attention in the process of devising appropriate development strategy and technology.

At present, crop and livestock production in the MDCs are highly specialized and mechanized; a large volume of cereal is fed to livestock for producing meat and milk. In South and East Asia cattle are raised mainly on crop byproducts for draft purposes; milk has little value in East Asia, while meat has practically no value in South Asia. In Africa and parts of Asia, shifting cultivation and pastoral culture, two of the oldest agricultural practices developed, are still widely used. The richest third of the world's population now occupies over one half of the world's arable land and pasture land, nearly one half of the world's cattle, produces over one half of the world's cereal and pulses, 80 percent of beef and veal and 90 percent of milk (Table 3). From a comparison of the relative shares of resources and output, it would appear that the LDCs were not only less endowed with resources, but also were less efficient in both crop and livestock production, and least efficient in livestock productions.

Table 3. Distribution of world agricultural resources and output

Region/group	Population	GNP	Arble land	Pasture land	Cereal output	Cattle heads	Beef/veal output	Milk output
………………………percent………………………………								
Europe	18.7	41.9	25.5	15.5	31.4	20.3	38.6	65.3
N. America	8.6	31.7	18.5	11.8	18.6	16.0	30.0	17.1
S. America	5.3	3.6	6.1	12.9	4.5	17.8	14.1	5.4
Oceania	0.5	1.5	3.2	15.6	1.3	3.6	4.1	3.3
Africa	10.2	2.4	14.3	26.4	5.3	12.9	5.4	2.6
Asia	56.6	18.9	32.4	17.8	38.9	29.4	7.7	6.4
Poorest1/3	33.3	3.4	27.3	17.4	18.4	31.2	5.3	4.3
Middle 1/3	33.3	9.7	20.9	26.0	25.8	21.7	14.2	6.0
Richest 1/3	33.3	86.9	51.8	56.6	55.8	47.0	80.5	89.7
World	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Notes: Thirds of world population divided on the basis of GNP per caput; Cereal includes pulses; milk output excludes buffalo milk; and cattle also excludes buffalo.

Source: Crotty 1980, p.6.

Two thousand years ago, the world's crop and livestock resources had a strikingly different distribution. At that time little or no crop was grown in Western Europe; there were no domesticated grazing animals and hardly any crop production in the entire American hemisphere, in Australia and New Zealand, and in the tropical forests of Africa and Asia. Crop growing was concentrated in tropical and semitropical river valleys such as Egypt's Nile, Mesopotamia's Tigris-Euphrates, India's Indus-Ganges, South-East Asia's Irrawady-Mekong, China's Yangtze-Yellow river. Part of Japan, Java and Mezzo-America are also ancient crop growing locations. Outside this environmental belt, crop growing in Mediterranean littoral (Greece and Southern Italy) was a remarkable exception. While Asian crop growers were a few centuries old in using animal energy for crop production, the Graeco-Roman crop growing empire was expanding on the basis of slave based production methods. It appears that the relationship of man to crop and livestock has changed very little in Asia to this day while the collapse of the Graeco-Roman empire in the fifth century after over extending into pastoral North-Western Europe-paved the way for a course leading to the world we see today (Crotty 1980).

The history of human civilization is marked with man's changing relationship with plants and animals. Methods of crop and livestock exploitation evolved through ages, in varied and complex ways, to suit specific environments, to meet varying needs of the societies. Institutions and customs governing the exploitation of these resources also evolved to serve specific needs of the society. For example, beef eating was banned, making it a religious taboo by the Hindus in India when saving of draft animal became crucial for expanding crop production to less fertile areas. Centuries later, the Christian church in Europe prohibited meat eating during Lent on economic considerations, i.e. to dissuade peasants from slaughtering and eating their oxen during springtime when they were most needed for draft power. At an opportune moment this partial ban was lifted, but in India it still remains a taboo.

As well as adapting animals and plants to his needs, man also adapted himself to the plants he grew and the animals he domesticated. Pastoralist man acquired the characteristic of adult lactose tolerance, not considered normal for species of the order mammalia including man. Intercourse with pastoralist societies diffused this characteristic among South Asians but East Asians, having remained beyond the reach of pastoralists, retained the normal characteristics of adult lactose intolerance.

After the demise of Graeco-Roman Empire, oxen instead of slaves were used for crop production in Europe. In the middle ages, oxen were replaced by horse, a more powerful animal. Slavery was reintroduced in North America by European colonizers more than a thousand years after its demise in Europe. Defeated European pastoralists were turned into slaves by Roman crop growers. Defeated African pastoralists were turned into slaves by colonial crop growers in North America where slaves were later released by horses. Asian crop growers still depend on cattle, buffalo, mules and asses which they started using probably three thousand years ago. In Europe, North America and Australia, crop and livestock competed for land, so transition from horse to engine power released land for extra crop/livestock production. In Asia, man competed with each other for land and the competition has increased over time (Crotty 1980).

Inadequate understanding and appreciation of the circumstances and events leading to such diverse methods of crop and livestock exploitation and their dramatic changes led to the transfer of inappropriate technology in both crop and livestock production such as the tractor, exotic breeds and feed mills. A simple technology-growth model is inadequate for studying the process:

> …The process of first accumulation that transformed the European pastoralist into crop grower must necessarily have been much slower and gradual. An explosion of change, by contrast, now affects pastoralism. The human population dependent on grazing animals is now doubling in each generation in extensive area; it has increased by as much in 25 years as it previously grew in the 12 millenia since

> man domesticated grazing livestock. Complex, delicate relationships between man and his grazing animals, that evolved through millennia, are strained or shattered by this explosion of change…. The changes being experienced are essentially sociological, political and economic in nature, though having also a technological dimension. Their study is the proper domain of the social sciences; but social scientists are ill-equipped to study them. Urban born, based and biased social scientists know little about the countryside, less about farming, less still about grazing livestock. Further, the vast majority of social scientists hail from Europe, where modern livestock technology and institutions evolved along with capitalism, or from those parts of the new world – North America, Australia and New Zealand – where indigenous societies were obliterated to make way for the new capitalist one, and have therefore little opportunity to observe the conflicts created in traditional societies by the imposition of capitalist pastoral technologies and institutions (Crotty 1980, pp. 194-5).

The statement is applicable to the phenomenon of technology transfer in general and reinforces the earlier argument that appropriate technology can and should emerge only as an indigenous force.

CONCLUSIONS

For a long time technology and technical development used to be taken as given data in economic theory. It is now increasingly realized that technology and technical development ultimately represent the outcome of human activities, preferences and decisions, so can be influenced by economic and social policy for achieving rapid rates of economic development. However, it is still not adequately recognized that technological change is not merely a production phenomenon but embraces all aspects of human activity. A multidisciplinary approach is therefore necessary for the study of technology and technical change. The current system of professionalism in which recognition goes to the outstanding in specialization, is a positive deterrent to the use of a multidisciplinary approach. Lack of a methodology or framework for unifying various disciplines also impedes its adoption. Thus, formalization of a methodology or analytical framework needs urgent attention.

Treatment of technology within the narrow bounds of production and factors of production, and inadequate analysis of the experiences of the more developed countries often led to the equation of technological change with mechanization and to the belief that transfer of modern farm machinery to LDCs might be helpful in their pursuit for rapid development. A detailed and longer term analysis of the experiences of MDCs taking a broader view of technology would reveal that appropriate technology emerged in each society as an indigenous force. Therefore, LDCs should give more attention to scaling up their own technologies rather than importing modern technology which has proved to be largely inappropriate in almost all fields of activity. MDCs and international organizations should also pay more attention to helping LDCs in their pursuit of generating own technologies rather than financing the transfer of modern technology.

Economic growth models have been generally built on the assumption of two production sectors, *viz*., agriculture and industry. Due attention has not been given to the role of interaction between crop and livestock within agriculture. Moreover, crop and livestock are often treated as separate fields of study thus separating common elements of technology in an arbitrary way. Consequently, inappropriate technologies are adopted in both the fields such as tractor in crop production and exotic breeds and feed mills in livestock production. In many LDCs, more attention needs to be given to crop-livestock interaction in the process of devising appropriate development strategy and technology.

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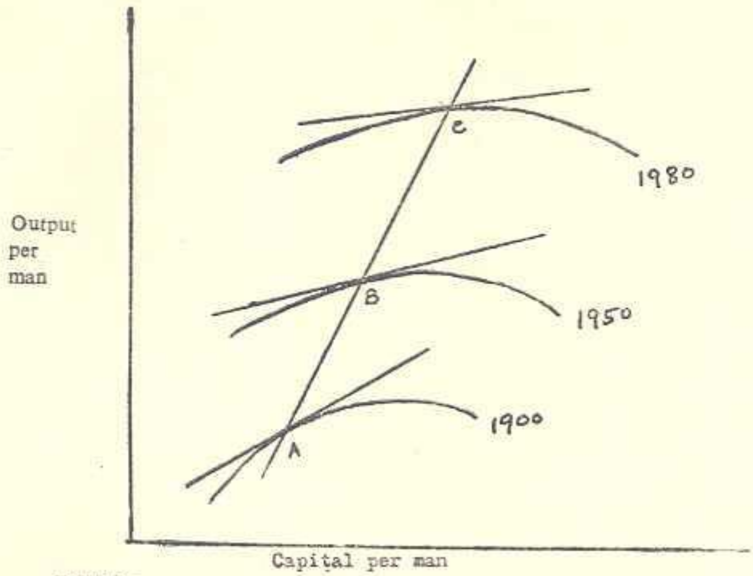

FIGURE 1 Relationshih between technical change and economic growth

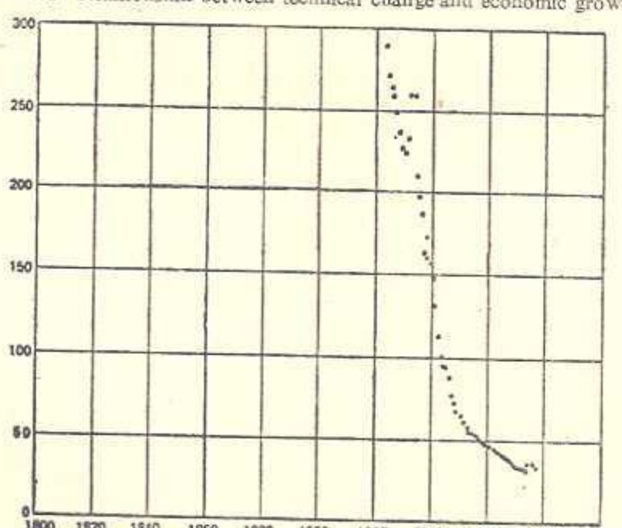

FIGURE 2 The Price of Electricity Relative to Wages

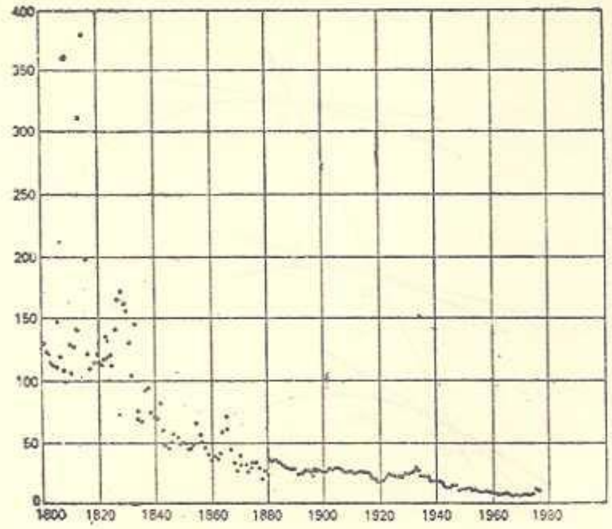

FIGURE 3 The Price of Coal to Wages

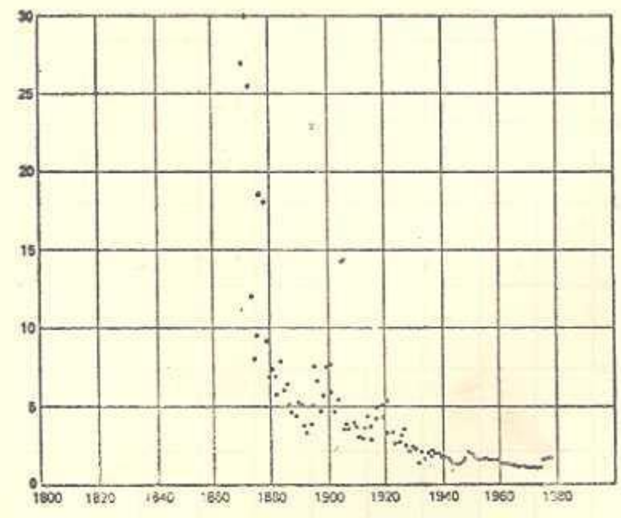

FIGURE 4 The Price of Oil Relative to Wages