Farm and Factory: A Comparison of the Skill Requirements for the Transfer of Technology

By Peter Kilby*

Among the disparate ingredients of technical advance in agriculture and industry, labour skill is perhaps the only dimension in which the mechanics of development in these two sectors are comparable. In this paper, the organization of traditional production in the pure subsistence economy is described, and then we consider the changes in organization and skill requirements that occur as development proceeds, first for manufacture and then for agriculture, bringing into focus oft-cited but usually undefined cultural factors which mould role behaviour of employees. Implicit in the analysis is a three-fold partitioning of human work performance into specific technical skills, internal organizational activities of control and co-ordination and activities related to external market transactions.

I

Traditional agriculture and traditional manufacturing have much in common. In each instance the basic productive unit is the family. Capital equipment is limited to simple human and animal powered implements with few or no moving parts. Work is sequential with no division of labour for individual commodities, the individual producer carrying the product through every stage of production. This lack of specialization means that there are no significant co-ordinating activities. Similarly, because factors of production are not hired and output is not sold, there are no market-oriented entrepreneurial activities. Production techniques rest upon a fairly confined range of physical principles and skills are simple. Technological knowledge and work competencies are transmitted by observation and learning-by-doing.

There are also important differences between agriculture and manufacturing, differences that apply to traditional production and which are responsible for dissimilar rates of absorption of the advanced technologies. Manufacturing is dominated by processes, equipment and power contrived by the human participants. All the inputs and the physical principles governing the transformation are manipulable by man. Agriculture, on the other hand, is a co-operative venture between man and nature. Its sequences are given and production depends upon soil, sunlight and rainfall. Thus the inalterable character of the process of biological growth, however it may be augmented, provides a continuity of farm organization and work patterns between the most primitive and the most advanced farming methods which is absent in manufacturing. The specific difference

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between farming and craft production in the traditional economy is that the precise seasonal requirements of agriculture impose a pattern on the timing of work and organic growth provides a rough standardization of product. Neither of these built-in controls is present in primitive manufacture. In producing the pot, the hoe and the sandal, raw material inputs, product specification and product quality are variable.

Let us consider how the organization of manufacturing changes as more productive technologies are introduced. The controlling principle is specialization. As the productive process becomes more complex, i.e. as it is broken down into a larger and larger number of specialized operations, the unit of production moves from the family to the workshop to the factory. Division of labour makes possible the introduction of machinery whose power, speed, precision and tirelessness greatly multiplies the productivity of human effort; and so the stock and diversity of capital equipment increases. This movement toward specialization within the productive unit has its external counterpart in the abandonment of self-sufficiency for market dependence. With the larger scale of production output must be marketed and factor inputs must be purchased.

These structural alterations concomitant with the adoption of more productive technologies radically transform the nature of work and the skills required. The labourer no longer works with his family or villagers, but among strangers in a larger impersonal setting. As a performer of only a few of the many operations that constitute the production process he no longer has control over the rate of work and cannot identify or take pride-of-craftsmanship with the finished product. Expensive equipment must be handled with care, work operations must be precise and performed at a certain pace; within these constraints the individual's freedom is further limited by the direction of his supervisor. New technical and analytical skills must be learned, typically entailing formal education as well as practical training.

Moreover, as manufacturing moves from traditional to complex technology, internal co-ordination must be provided by a 'visible hand'. The shift from sequential to simultaneous productive operations creates the necessity for a wide range of co-ordinating, supervising and controlling functions that had no place in the earlier technology. The appearance of task specialization requires that the work of all groups and individuals within groups be synchronized in time and controlled for standardization, quality, material wastage and rate of throughput. These co-ordinating activities, in conjunction with the appropriate patterning of human relations, integrate the differentiated technical operations to form a single co-operative organization.

Finally, the shift from traditional to larger scale modern technologies entails the change from internally supplied factor services and demand to reliance upon markets. Market-oriented management functions must now be performed to sell the product and selectively purchase a wide range of capital equipment, raw material and labour service inputs. There are labour relations, customer relations, supplier relations and public bureaucracy relations to be managed. The financing of circulating and fixed capital must be secured and maintained.

The movement to more productive technologies brings, of course, many changes other than those connected with labour skills. As previously noted individual production units grow in scale, employing a larger capital stock
and more capital per employee. Superior technology means that both capital cost and labour cost per unit of output fall, although capital costs typically fall less. The rising capital–labour ratio occurs because of the nature of the more productive techniques available for transfer from the capital-rich economies, and because of the tendency to substitute capital for labour as non-market pressures lift wage rates faster than interest rates in the recipient labour surplus countries.

As division of labour proceeds within the firm under the influence of newer techniques, those processes that are subject to increasing returns are taken over by specialist companies which, by obtaining a scale of output that permits full cost minimization, can then sell this input to a number of producers cheaper than they can supply it to themselves [Stigler, 1951, pp. 185–93]. In addition to specialist firms making standardized components or providing wholesaling, purchasing or maintenance services, the producer network is further expanded by supervised subcontracting with smaller workshops that realize lower costs by virtue of fewer overheads and less well paid labour. Thus the proportion of value added in gross output falls and new vertically-linked firms emerge as the input–output matrix expands. This pattern of rising productivity, the shedding of functions and increased reliance upon purchased inputs holds for agriculture no less than for industry. Economic growth continues until scarcity of inputs, limitation of final demand or the exhaustion of economies of specialization bring the process to a halt.

Returning to the matter at hand, we are now ready to inquire into the changes in skills called for by technical advance in farming methods. The tripartite classification employed for industrial production works equally well in agriculture. Taking the last first, market-oriented managerial functions also come into play as the farmstead begins to market its output.

Clarence Danhof’s description of this transition in mid-nineteenth-century American has universal application:

Since [under subsistence conditions] the products to be secured and the quantities of each were selected as needed within the household, little serious consideration of relative costs was necessary: the importance attached by the family to the commodity determined the effort to be given to it. The varieties of crops and animals raised were common to the area, as were the techniques applied. Under market conditions, the answers to the questions ‘what’, ‘how much’, ‘what variety’, ‘which methods’ were more difficult. Decisions were made with less assurance because they were dependent upon the farmer’s interpretation of a variety of factors relating to the market of which he characteristically had only imperfect knowledge. The decisions made also required more or less continuous review, since conditions changed. The farmer’s problems were further complicated by a set of questions having little significance to the subsistence homestead: how, when and on what terms would the products be sold? [Danhof, 1969, pp. 130–31].

Beyond the decisions on output and marketing, the market-oriented farmer now has to make decisions about purchased inputs, hiring labour and obtaining credit. As in the case of industrial production, these market-oriented managerial functions intensify with the scale of production, but they do not change as new technologies are introduced.
It is in the realm of specific technical skills and organizational requirements that agricultural production diverges from manufacturing. As noted earlier, the unchanging character of nature's contribution to the process of plant growth establishes a basic continuity in work operations and organizational structure which is not present in industry. The central productive operations of ploughing, harrowing, planting, applying water and nutrients, weeding, harvesting and threshing are present in the most advanced as well as in the most primitive technology.

This is not to suggest that modernization does not bring many adaptations to farming technique. New tools and mechanical power are introduced as well as overhead capital in the form of irrigation facilities and farm buildings; a wide variety of intermediate inputs—selected seeds, various types of chemical fertilizers, pesticides, weedicides—are also part of the advanced technology. Greater precision is required in work operations: depth and spacing of plantings, kinds and amounts of chemical inputs, water control, the quality of animal care, and the timing of every phase of farm production. Finally, the modern farmer must have at his personal command a much wider range of technical knowledge concerning the properties of the new inputs and their interaction with each other and the natural environment.

While the modernization of agriculture shares these common features with the modernization of industry—the increased use of capital, of purchased inputs, of technical knowledge, of precision in operations—there are alterations in which farming does not share. First, the locus of modern farming remains unchanged and the family labouring unit continues as an important if not central institution in the organization of production. Second, the skills required in farming are not transformed as radically as in the case of manufacturing; moreover, advanced farming techniques can be mastered with far less formal education than the higher skilled jobs in industry. Third, because the operations in farming remain consecutive even with the highest degree of mechanization, intra-commodity specialization does not occur, thereby precluding the need for the greater part of the co-ordinating, controlling and supervising functions which are so critical in manufacturing.

It is in these three aspects that the shift from traditional to advanced technology represents less of a discontinuity for agriculture than for industry. Thus the learning of new skills and organizational capabilities is a far more difficult process in manufacturing. In the past it has frequently been assumed that it is more difficult to transform agricultural practices than it is to efficiently operate modern industrial plants. The basis for this belief was, on one hand, the large number, inherent conservatism and enforced risk-averting behaviour of small peasant farmers, and on the other hand, the inapplicability of temperate agricultural technologies to the multitude of unique tropical and subtropical environments of the low-income countries. Experience has failed to verify the proposition. The greater success during the past four years with adapting farm practices to the requirements of the new high-yielding plant varieties in Asia, as compared to the progress towards achieving competitive industrial development during the past four decades, can be interpreted as giving some support to our argument. In sum, the differential skill content of commodities provides an alternative way of explaining why farming activities are carried out with greater relative efficiency than modern
manufacturing activities and why the comparative advantage of late developing countries tends to be in primary products rather than simple manufactures, even where the latter are more labour intensive.

II

In terms of facilitating the transfer of technology, what are the policy implications with respect to human competencies? In the area of specific technical skills, the creation of competencies does not appear to be as difficult a problem as was once thought. Particularly interesting is the emerging realization that formal technical training plays a quantitatively minor role and that experience and on-the-job training are the main vehicles for implanting new skills [Anderson and Bowman, 1965, part II; Horowitz et al., 1966; Strassman, 1968; Kilby, 1969 and Maton, 1969]. Similarly, studies reporting on individual enterprises in developing economies reveal that their performance and growth are seldom bound by the supply or quality of market-oriented managerial activities—apparently a result of long-standing traditions of exchange relationships and consensus engineering in these semi-traditional societies.

It is in the domain of internal co-ordination and control that the formation of human competencies has proved most difficult. As suggested in section II, such activities are relatively unimportant in agriculture. In manufacturing, persistent shortcomings in these capabilities have been a principal cause of under-utilization of factory capacity and limited adoption of technological improvements. These organizational inefficiencies in conjunction with excessively protected domestic markets have resulted in high-cost, non-competitive industrial production. That, among the three skill categories, organizing capacities should constitute the bottleneck may be attributed to (a) this category's lack of antecedents in traditional technology and, as a result of the latter, (b) the presence of incongruent cultural factors conditioning individual behaviour.

We have already detailed the relative absence of internal organizational requirements in traditional production. Most of the impeding social structural factors can be traced to role behaviour associated with vertically-organized status systems. Take the case of supervision. By foregoing the right to remain aloof from the practical details of a subordinate's task, by treating social inferiors as equals, by sharing authority with a person of lower status through co-operative effort—by doing these things a supervisor is engaging in socially degrading activity which undermines his social worth, both in his own eyes and those of his charges, to the extent that they both adhere to traditional norms. Superiors cannot acknowledge error nor delegate responsibility without diminishing their authority. Normative role expectations by all participants stress compliance over performance.

The recent survey of management problems in developing economies carried out by the United Nations Research Institute for Social Development would seem to lend support to the importance of such social structural factors:

The management system found in both public and private enterprises was very often characterized by problems associated with a high degree of centralization of authority in the office of top management and lack of delegation which created difficulties in the way of adoption of
modern management methods. The principle reasons for this lack of
delegation of authority were transfer to the enterprise of the traditional
authority system, patriarchal roles, respect for age and superiors; lack
of confidence of the top managers in the competence of their subordi-
nates; lack of trust in subordinates and suspiciousness of outsiders.

A second and related major problem was the fact managerial
decisions were often made without adequate consultations with
subordinates and without sufficient flow of information form relevant
departments within the firm.

A third problem centred in achievement orientation. Both in public
and private firms, there was reported to be a concern for achievement
on the part of managerial personnel, but for individual achievement
rather than company achievement [UNRISD, 1969, p. 51].

The analysis offered here does not yield any novel policy prescriptions.
The writer has eslewhere presented his opinions on the appropriate
organization of technical education, devices for supervisory and manage-
ment training, provision of industrial engineering consulting services,
tax incentives related to capacity utilization, the encourgement of sub-
contracting between foreign and indigenous firms and emphasis on high
carry-over 'intermediate foreign investment' (e.g. Lebanese, Greek,
suggest is that the learning of specific and managerial skills provides an
additional reason for pursuing the kinds of unimodal, anti-dualistic,
competitive market-oriented development policies recommended by Bruce
Johnston [1966], Hla Myint [1970] and Little, Scitovsky and Scott [1970].

The existence of a bimodal size distribution of producers is nearly
universal in manufacturing and holds true for farming in much of Latin
America and Asia. The contrasting attributes of the two modes are
familiar: large versus small scale, advanced versus primitive technology,
capital-intensive versus labour-intensive, high-wage versus low-wage,
and so on. It is now quite clear that this dualism does not arise simply
'from the nature of things' but rather is to a large extent the unrecognized
result of a diverse collection of government policies. These policies lead
to various forms of rationing which have the effect of providing capital,
import requirements, technically-trained labour and public services to the
large-scale sector on far more favourable terms than these same inputs
are available to producers in the rest of the economy. In the case of
manufacturing, the large-scale units not infrequently have the additional
advantage of selling in monopolistic product markets.

The removal of policy distortion, beyond its repercussions upon the
manifold aspects of resource allocation, will both accelerate the transfer of
technology to small-scale producers and create improved conditions for
skill acquisition, particularly for the activities of co-ordination, super-
intendence and control where there is 'no adequate simulation substitute
for learning by participation' [Bowman, 1965, p. 102]. On the supply side,
increased competition and higher priced imported materials force large-
scale producers to break out of their enclavity to seek inputs from low-cost
ancillaries and indigenous specialist firms; new design and quality control
capabilities are transmitted in this process. On the marketing side, the
small firm's easier access to scarce inputs permits it to more closely imitate
the product specifications of the large-scale producer (especially in food
processing, furniture and light engineering); both specific skills and internal organization develop as a result. Not only does an expanding, integrated network of producers involve a large number of individuals in the learning process and promote the adoption of scores of modest innovations, the forcing-house of competition among the technology leaders is likely to induce choice of techniques that are more consistent with factor prices, skill endowment and other constraints of the local environment.

NOTES

1. Robert Solo, for example, emphasized the latter factors: 'This may account for the seemingly paradoxical emphasis on industrial development by predominantly agricultural low-productivity societies; since the ineradicable differences in the natural parameters of agriculture (and also the very deep differences in the social circumstances of agriculture) in low-productivity vis-à-vis high-productivity societies probably makes it more difficult to adapt advanced agricultural technologies than to adapt advanced industrial technologies for assimilation' [Solo, 1966, p. 94].

2. A considerable body of evidence on this subject is summarized in Kilby [1971].

3. See Kilby [1971] for quantitative data on the extent of organizational slack in a wide variety of industries in some fifteen countries.

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