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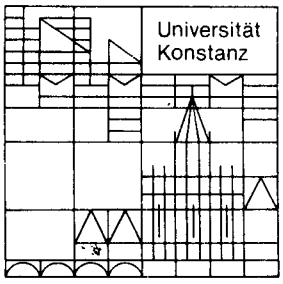

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Capitalism and the Factory System

Diskussionsbeiträge

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Serie A — Nr. 184

CAPITALISM AND THE FACTORY SYSTEM

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Serie A - Nr. 184

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Serie A: Volkswirtschaftliche Beiträge

Serie B: Finanzwissenschaftliche Arbeitspapiere

Serie C: Betriebswirtschaftliche Beiträge

Introduction

Economic theorizing utilizes, on the one hand, mathematical techniques and, on the other, thought experiments, parables, or stories. Progress may stagnate for various reasons. Sometimes we are held back for lack of the technique needed to turn our stories into the raw material for effective scientific work. At other times, we are short of good stories to inject meaning into, and perhaps even draw a moral from, our models. One can strive for intellectual coherence in economics either by attempting to fit all aspects of the subject into one overarching mathematical structure or by trying to weave its best stories into one grand epic.

This paper attempts to revive an old parable, Adam Smith's theory of manufacturing production, which has been shunted aside and neglected because it has not fitted into the formal structure of either neo-classical or neo-Ricardian theory. The paper attempts to persuade not by formal demonstrations at this stage but by suggesting that the parable can illuminate many and diverse problems and thus become the red thread in a theoretical tapestry of almost epic proportions.

The subject may be approached from either a theoretical or a historical angle. On the theoretical starting-point it is possible to be brief because it is surely unnecessary to rehearse the familiar litany of complaints about the neoclassical constant returns production function. The one point about it that is germane here is that it does not describe production as a process, i. e., as an ordered sequence of operations. It is more like a recipe for bouillabaisse where all the ingredients are dumped in a pot, (K, L), heated up, f(.), and the output, X, is ready. This abstraction from the sequencing of tasks, it will be suggested, is largely responsible for the well-known fact that neoclassical production theory gives us no clue to how production is actually organized. Specifically, it does not help us explain (1) why, since the industrial revolution, manufacturing is normally conducted in factories with a sizeable workforce concentrated to one workplace, or (2) why factories relatively seldom house more than one firm, or (3) why manufacturing firms are "capitalistic" in the sense that capital hires labor rather than vice versa.

Revolutions: Agricultural and Industrial

The story of the industrial revolution has often been told around the theme of technical invention and innovation in spinning and weaving, in steel-making and power generation, in freight transportation, and so on. Similarly, the agricultural revolution that preceded it sometimes seems just a long catalogue of new crops, new rotations, new ways to drain or fertilize land, new techniques of selective breeding, etc.

If one looks at the two revolutions, instead from the standpoint, not of technological history, but of a "New Institutional" history, the agricultural revolution becomes primarily the story of enclosures and the industrial one the story of the coming of the factory system and, eventually, of the joint stock corporation.

It is customary in standard treatments of 18th century English economic history to hail both these organizational developments as obvious "progress". Carl Dahlman[1)] has pointed out that the juxtaposition of the two poses something of a paradox, for one process seems to be almost the reverse of the other. The reorganization of agriculture, known as the "enclosure movement", was a move away from the collective "team" working of village land. Each family ended up working their own farm. Correspondingly, it required the "unscrambling" of joint ownership rights in land held in common (and of obligations owned to the collective). In the somewhat later reorganization of manufacturing we have the reverse. The coming of the factory was a move towards collectively organized modes of production. It replaced the "family firm" craftshop and the putting-out system. The craftshop run by a master craftsman with a couple of journeymen and apprentices and with family helpers had been the dominant type of manufacturing business since the early Middle Ages. Under the putting-out system, an entrepreneur "put out" materials for processing at piece rates by workers who usually worked at home. The factory pulled the workforce in under one roof. Later on, the limited liability manufacturing corporation arose to pool individual titles to physical capital in the joint stock arrangement.

Thus the Dahlman paradox: What is progress in manufacturing is backwardness in agriculture and vice versa! The open field system and enclosures is admirably analyzed in Dahlman's book. The present inquiry concerns the Factory System.

The Factory System

Contemporaries tended, of course, to marvel at the new inventions and to be deeply impressed by the (very visible) role of fixed capital in the new factories. The most prominant features of the factories were (a) the size of the workforce in one and the same workplace, and (b) the new machinery. The impulse is to explain (a) by (b), that is, to take for granted that the novel spinning-frames, weaving looms, steam engines, etc., make the explanation for factory organization of the work almost too obvious to require explicit comment.

Some histories of the industrial revolution do take the line that the new machinery explains the factories. It is pointed out, for example, that the early steam-engines, with their low thermal efficiency, were very large, stationary ones; if one wanted to utilize steam-power, therefore, one had to pull a sizeable labor force in under one roof and run the various machines of the factory by belt-transmission from a single source. The answer suggested in this sort of illustration is that the new technologies introduced obvious economies of scale (e. g., in power generation), that led quite "naturally" to large scale factory production.

Economies of scale due to indivisible physical capital were obviously one aspect of the story. But they do not make the whole story. Some 150 years later, small scale electrical motors removed the basis for the particular type of scale-economy just adduced - but did not, of course, thereby undermine the factory system. (At the same time the economies of scale in generating electricity were even more formidable than in steam power). We might also check some centuries earlier. The fourteenth century Arsenal of Venice

was one of the wonders of the world for the size of the labor-force concentrated in it. Yet, the organization of shipbuilding in the Arsenal was not that of a single firm; instead, numerous craftsman, owning their own tools, each with a few journeymen and apprentices operated within the Arsenal and cooperated via exchange transactions in the building and outfitting of ships. In short, the famous Arsenal was not a factory and not a firm[2].

There are other examples of large workforces in one location before the industrial revolution. Large woolen manufacturing workshops existed in England since at least the beginning of the 16th century. Their size would not have been dictated by machine technology[3]. While medieval mining was in general organized as partnerships of independent miners, by the sixteenth century, deeper mineshafts with dangerous ventilation and drainage problems raised the capital requirements in mining beyond the means of artisan miners. The mines became capitalist firms. Alum, bricks, brass, and glass, are 17th century examples of technology dictating production in sizeable establishments[4]. In these instances, the workplaces were factories and were firms.

The putting out system was also replaced by the factory system. It exemplifies capitalist control of production often without capitalist ownership of the means of production[5]. The organization could be large but the workplaces were, of course, small.

It is not all that obvious, therefore, what role should be assigned to indivisible machinery in explaining the emergence of the factory as the dominant form of manufacturing enterprise. Some questions remain. Why, for example, did not the steam engine simply lead many independent masters to locate in the same workplace (and, perhaps, pay rent for the right to attach their new-fangled machines to the overhead, steam-powered shaft)?[6]

The Classical Theory of the Division of Labor

There is one contemporary observer whom economists might be particularly inclined to pay attention to, namely, Adam Smith. The

Wealth of Nations is, of course, a bit early (1776) for the mechanized, steampowered, relatively fixed-capital-intensive Factory System to have become established as the wave of the future. Even so, it is worth remembering that Smith did not dwell much on machinery as one of the "Causes of Wealth". Instead, of course, he made the "division of Labour" his grand theme. In fact, he treats the role of machinery as important but as secondary and subsidiary to "increasing division of labor" in his account of economic progress:[7)]

> "... every body must be sensible how labor is facilitated and abridged by the application of proper machinery. It is unnecessary to give any example. I shall only observe, therefore, that the invention of all those machines by which labour is so much facilitated and abridged, seems to have been originally owing to the division of labour ..."

The Classical theory of the division of labor was greatly advanced by Karl Marx in Das Kapital[8)]. In his day, of course, the factory system was the wave of the present. Marx made the use of machinery the criterion of "modern industry", which he associates with factories. At the same time, however, he emphatically agrees with Smith that mechanization follows from the division of labor. In Marx's historical schema, capitalism is subdivided into a manufacturing period ("from the middle of the 16th to the last third of the 18th century")[9)] and the subsequent modern industrial epoch. Manufacturing, in Marxist terminology, results from applying the principles of the division of labor to as yet unmechanized industry.

In Smith's famous pin-making illustration of the benefits of the division of labor two modes of organizing production are contrasted. Prejudging matters a little, let us call them "crafts production" and "factory production" respectively[10)].

In Crafts production, each craftman sequentially performs all the operations necessary to make a pin. In Factory production, each worker specializes in one of these operations so that "the important business of making a pin is, in this manner, divided into about eighteen distinct operations which, in some manufactories, are all performed by distinct hands ..."[11)].

Suppose, for illustration, that we have five craftsman producing a product that requires five successive operations. These must be undertaken in temporal sequence running from left to right in Figure 1:

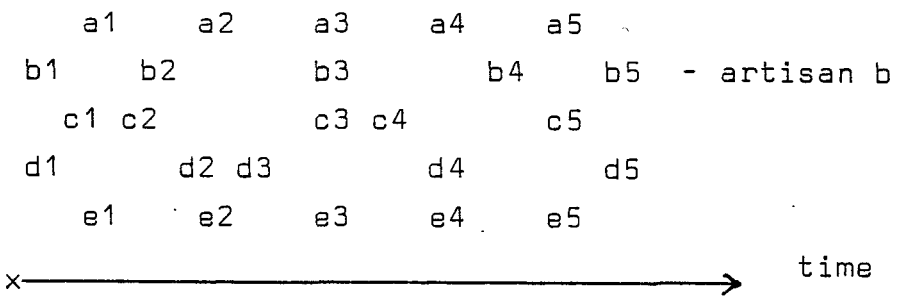

Figure 1: Crafts Production

Here each artisan is working at his own pace and the individuals differ in (absolute and comparative) skill across the different operations.

Suppose, next, that we simply rearrange the work in some given workshop as indicated in Figure 2:

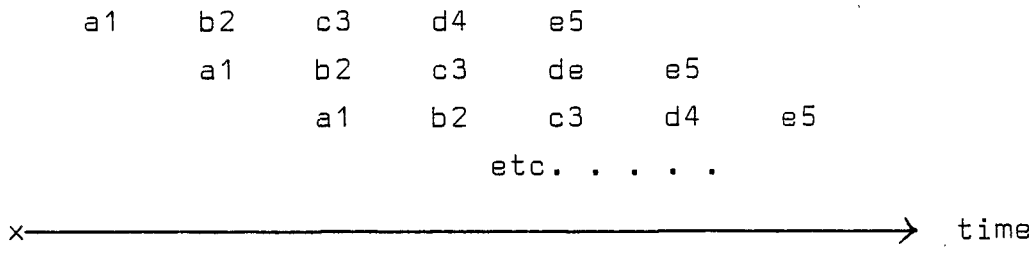

Figure 2: Factory Production

People that previously worked in parallel now work in series. Worker b now performs only operation 2 but does so on all units of output produced by the team. The individual now has to work at the pace of the team. Note, however, that we do not change the engineering descriptions of the operations performed, we do not change the tools used, and we do not change the people involved. But Smith and Marx both would tell us to expect a large increase in productivity.

The sequencing of operations is not captured by the usual production function representation of productive activities; nor is the degree to which individual agents specialize. A production function simply relates a vector of inputs to one or more outputs without specifying the method by which tasks involved are coordinated. Thus Smith's division of labor - the core of his theory of production - slips through modern production theory as a ghostly technological change coefficient or as an equally ill-understood economies of scale property of the function[12].

The economies achieved by switching from crafts to factory production arise from increased division of labor. In the above example, labor was entirely "undivided" to begin with, so that the conversion takes us from individual production to team production. There are three aspects to this that deserve comment. First, the specialization of labor in team production will require standardization of product. Under crafts production, in contrast, the skills and care of individual artisans will be reflected in non-standard output. Second, serial production requires coordination of activities in the sense of the time-phasing of the inputs of individual workers. Third, the labor of individual workers become complementary inputs. If one workstation on an assembly line is unmanned, total product goes to zero.

So far we have supposed that the number of workers and the tools are unchanged and that the only change arises from their improved coordination. But it is obvious that the conversion from crafts to factory production will present opportunities to economize on inputs.

The switch is capital-saving. This is an aspect easily missed. The reorganization of production undertaken to increase the division of labor will very often also create opportunities for mechanizing some stage of the process. Hence what we tend to observe is that an increase in fixed capital takes place at the same time. The impression we are left with is that productivity increases are normally due to more capital intensive technology being adopted[13]. But the pin-making illustration is a counterexample.

In crafts-production, each artisan would be equipped with a full complement of pin-making tools. Suppose, for simplicity, that there is a different tool for each of the five stages in the series. Then, four out of five tools are always idle when artisans work in parallel under crafts-production[14]. In factory production, only one complement of tools is needed, not five[15].

It is possible that the more decisive capital-saving incentive may be the opportunity to economize on goods-in-process inventories. Suppose that, under crafts production, considerable time (and concentration) is lost in switching from one task to the next. A master craftsman with a thick enough market to allow him to produce in batches would then perform operation 1 x times, before moving on the operation 2, etc. If his "dexterity" (as the Classical writers used to say) at each task were equal to that of the specialized factory worker, the factory's competitive edge would lie mainly in its lower working capital requirements. Economizing on goods-in-process is likely to have been particularly important in the evolutionary struggle between the factory and the putting-out system.

The switch to factory production will also save on human capital. No worker need possess all the skills required to make a pin from beginning to end. Under crafts production, each individual has to spend years of apprenticeship before becoming a "master pinmaker". In factory production, the skills needed to perform one of the operations can be quickly picked up. The increased productivity resulting from specialization on simple, narrowly defined tasks was the advantage arising from increased division of labor most emphasized by the Classical economists. The decreased investment in human capital was, correspondingly, the disadvantage that most concerned them.

Horizontal and Vertical Division of Labor

There are two dimensions along which the division of labor may be varied. Adam Smith drew examples from both (without however

making the dinstinction clear). The manufacture of pins illustrates what we will call vertical division of labor. Recall his observation that "in so desert a country as the Highlands of Scotland, every farmer must be butcher, baker and brewer for his own family." When the growth of the market turns slaughtering, baking, and brewing into specialized occupations, we have examples of horizontal division of labor.

The distinction is seldom drawn in the literature. This may be in part because these authors, who see the advantages of division of labor as deriving primarly from the concentration of time, experience, and ingenuity on part of individuals on a narrower range of tasks, are looking simply for all the differentiations of functions that the expansion of markets will allow. Charles Babbage improved on Smith's statement of the division of labor by making clear how functional differentiation brings comparative advantage into play also inside the individual firm: [16]

> That the master manufacturer, by dividing the work to be executed into different processes, each requiring different degress of skill or force, can purchase exactly that precise quantity of both which is necessary for each process; whereas, if the whole work were executed by one workman, that person must possess sufficient skill to perform the most difficult, and sufficient strength to execute the most laborious, of the operations into which the art is divided.

But there are reasons for making the proposed distiction. An increase in the vertical division of labor requires less skilled labor at the various stages of the manufacturing process. Increased horizontal division of labor does not in general carry this implication and is perhaps more likely to mean an increase in human-capital per worker. Furthermore, increased horizontal division is a question simply of minimum economical scale, whereas vertical division of labor results from an increasing returns to scale technology.

This implication of pin-making technology may be another reason why the dinstinction is most often fudged, particularly in the neoclassical literature. Stigler, in his famous article on the subject, notes the dilemma bequeathed by classical to neoclassical theory: [17]

> Either the division of labor is limited by the extent of the market, and, characteristically, industries are monopolized; or industries are characteristically competitive, and the theorem is false or of little significance. Neither alternative is inviting.

Marx saw the significance of the distinction very clearly. The consequences of expansion of the market for a branch of manufacturing, he pointed out, would depend upon the technology. He distinguished two "fundamental forms", namely, "heterogenous manufacture" and "serial manufacture". The latter, of course, is exemplified by Smithian pin-making and offers opportunities for vertical division of labor. As an example of the former, Marx used watch manufacturing. All the parts of a watch may be separately manufactured for final assembly. This "makes it ... a matter of chance whether the detail labourers are brought toghether in one workshop or not". Heterogenous manufacture may be carried out under the putting-out system, therefore.[18)]

Social Consequences

The competitive impetus to exploit the economies afforded by "vertical" division of labor would seem to explain, therefore, many of the social consequences of the 19th century factory system that have been the object of so much adverse sociological commentary:[19)]

> (i) When labor is subdivided vertically, less skill is required, less versatility as producer as acquired by the individual worker. The use of child labor at some workstations often becomes feasible.
>
> (ii) No normal prospect of promotion or improvement in social status is to be expected; the unskilled workman does not become a master of his guild by sticking to his job for many years.
>
> (iii) More discipline is required and of a sort that most people will find irksome and that most rural emigrants would have to be taught; you cannot "work at your own place", you have to be on time; random absenteeism must be subject to relatively severe sanctions.

(iiii) "Alienation from the product": no worker can take personal pride in the output or its quality.

Considerations of this sort do not give one grounds for blundering into the much controverted subject of the development of standards of living during the Industrial Revolution in Britain. The point to be made is simply that a subset of those conditions in industry that were criticized by contemporary observers can be seen as resulting from the utilization of the "vertical" division of labor technology.

The Extent of the Market

In our simple five-man example, a doubling of output under crafts production will require a doubling of all inputs. Under factory production, some economies of scale will normally be present. In factory production, "the division of labor depends on the extent of the market" - and so, therefore, do the scale economies that can be realized. These will be of two kinds.

(1) Parallel series scale economies:

Suppose, in the example, that one of the workers (worker d at work-station 4, let's say) is idle half the time after conversion to factory production. Then double the output can be had with nine workers, and the flow of work would be organized as in Figure 3.

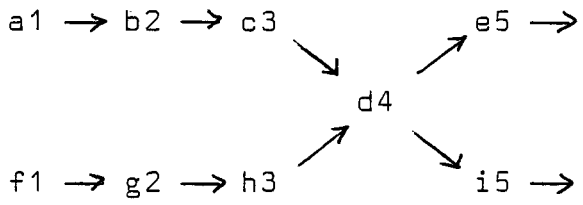

Figure 3

This is the source of increasing returns emphasized by Georgescu-Roegen as almost universally present in manufacturing - but not, as all the Classical economists agreed, in agriculture. Even on the sophisticated assembly lines of a large-scale factory there

is almost bound to be some "factor" ("fund" in Georgescu-Roegen's terminology) whose input-stream is not perfectly continous. Babbage's "master manufacturer" cannot always divide the work so as to "purchase exactly that precise quantity" of the services of the factor that is technically required to produce his output. A machine that is idle half the time cannot be replaced by half a machine employed all of the time. But it may be possible to double its utilization rate if, say, the machine can be shared between two parallel assembly lines and the firm can sell twice the output.

These "parallel series scale economies" are probably never totally exhausted. In our five-stage example, it might be found, for instance, that worker b is busy only 80 % of the time in which case a quintupling of output can be had with only a quadrupling of stage 2 workers. And so on. But it is clear that, if we keep the number of serial stages constant, these economies of parallel replication become less and less significant as output is increased. It can in fact be shown that this is a case of assymptotically constant returns (although a non-monotonic approach to the assymptote).

2) Longer series scale economies:

Smith, Marx, and Mill, however, were thinking more of another source of economies of scale, namely, increased vertical division of labor. As the extent of the market grew, opportunities would arise, they thought, for further efficient subdivision of the production process into a greater number of serial tasks. This vertical differentiation would not only be efficient in itself but, as it proceeds, it opens up new possibilities for exploiting scale economies of the Georgescu-Roegen kind.

Mechanization and Division of Labor as a "Discovery Procedure"

As one proceeds with the analysis of this Classical Division of Labor theory, it increasingly escapes the analytical categories of static neoclassical production theory. The Classical theory becomes a theory of an evolutionary process, rather than a theory of the rational choice between known alternatives.

Recall that Smith and Marx both insisted that the New Division of Labor preceeded the mechanization of industry. They also thought there was a causal link and they thought it rather obvious what this link was. As you subdivide the process of production, vertically, into a greater and greater number of simpler and simpler tasks, some of these tasks become so simple that a machine could do them. The mental task of analyzing the production process so as to carry through the division of labor leads to the discovery of these opportunities for mechanization. Once you get the hang of the division of labor, you will discover how to mechanize industry.

With mechanization, the sources of economies of scale are ever again renewed - by the same argument as before.

Differentiation of function: Capital and Labor

The process leads to increasing functional differentiation of both capital equipment and labor. But in one respect the consequences are quite different - and it turns out to be a socially important respect.

Although the tasks that become mechanized tend to be quite simple, completely standardized tasks, the machines will very often be extremely specialized to doing just this one task in the production of just one product. This means that they may have no alternative employment. This differentiation of equipment was illustrated by Marx: a generation ago, he said, there were 7 different hammers in the market; in his days, they made over 80 different hammers for specialized tasks in Birminghan.[20)]

In the same process of vertical subdivision of the process, however, labor gets increasingly unskilled. This will have both socio-cultural and more strictly economic consequences.

Adam Smith gradually became so convinced that the division of labor tended to produce an unskilled, illiterate, brutalized proletariat that in the end his Wealth of Nations contained "Two Views"[21)] of the division of labor. In the early chapters, it is The Source

of the Wealth of Nations. Towards the end of the book, it is the ruination of the laboring classes. This outlook Marx took over.

From the more narrowly economic standpoint, the machines are functionally specialized, but the workers are not. This has implications for the competitive position of capital and of labor, respectively, in the market.

American and Japanese Traditions in Production Management

The American tradition in production management has made the most of the "static" advantages of the division of labor: minimal human capital requirements, maximum "dexterity" in performance of individual tasks and minimal time lost in switching between tasks - these are the principles stressed on Henry Ford's assembly lines and in Taylorite time-and-motion studies.

Apparently, Japanese production management violates all of these principles. Each member of a production team is supposed to learn every work-station on the assembly line. Human capital input is maximized rather than minimized. But the "dynamics" of the Smithian evolutionary process are improved. The Japanese teams are better at "discovering" potential improvements in both products and methods.

The Capitalist Firm

Consider next an idyllic thought-experiment of so-called team-production:[22] a number of individuals come together for the purpose of producing a particular commodity. Suppose that, in the "Original State", we need not distinguish these people by wealth, power or status. Some of them will contribute their skilla and labor, others will commit themselves to bring machines to the joint enterprise.

We may assume that they will decide to take advantage of the Smithian economies of vertical division of labor and so set up production in the form of one single, long assembly line. For simplicity, let there be n stages of production, n machines, and n operatives - one per machine. The product could also be produced

by craftsmen using a set of simple hand-tools or in shorter assembly-lines of n/k workers using less specialized machines. But we presume, with Smith and Marx, that by setting up on one long assembly line, the collective effort will produce a larger output with the same resources.

How many firms will there be? Will the typical firm be a "capitalist" one? If so, why?

One can imagine the possibility of n successive firms, each one buying the output of the stage preceding and selling to the stage succeeding. In half of these firms (one might also imagine) the owner of the machine hires the operative and pays him wages, while in the other half the worker rents the machine he is working with. But these imaginings, of course, fit singularly ill with the ways in which we find manufacturing to be organized.

Since the team utilizes the economies of scale due to the division of labor, the enterprise earns a joint rent (a "surplus" if you will). Total sales-proceeds exceed the sum of the earnings that the input would find in alternative employments. The joint rent is a snake in this paradise. For how is it to be divided? In our illustration, all the inputs are assumed to be strictly complementary. If one machine is withdrawn from the assembly line, total output falls to zero. If one worker is missing, the consequence is the same. Marginal productivities will not supply the criteria for the distribution of product.

Let the members of the collective form coalitions amongst themselves and bargain against the rest. How well might the various coalitions do? How stable would we expect them to be?

Consider first how the bargain might go between the machine owner ("capitalist") and the operative ("labor") at one of the work-stations on the presupposition that the total sum going to this work-station has somehow been arrived at. Each can threaten the other to withhold his input so that their joint income will go to zero. But the bargaining situation is not symmetrical. There are plenty of unskilled laborers in the market, but few if any

substitutes for the specialized machine. This might make us suspect a tendency for the capitalist to walk away with the joint rent, leaving the laborer with a wage equal to his alternative earnings. But there is also another asymmetry: the unskilled laborer has many, the specialized machine few alternative employment opportunities. If, therefore, the laborer could threaten to "fire" the machine, his bargaining position would be very strong indeed.

To see why this is not a relevant possibility consider the bargaining situation among the capitalists. Each machine owner can threaten to reduce output and therefore, everyone else's earnings to zero[23] - until a replacement for his machine is found. But, again, the market for very specialized machines will be thin so replacements - and alternative employments - for them are hard to find. Any agreement about the division of earnings amongst the machine owners would be extremely unstable.[24] So unstable, in fact, that some organization of production that avoids the complementarities between the highly specialized inputs of cooperating owners might be preferred - even at the cost of foregoing the advantages of the division of labor. To sink one's capital into these dedicated machines will not appear to be an attractive investment - unless some stable organizational form can be found.

The solution, of course, is not to allow individual capitalists to own and control specific machines. Instead, you form a "firm" and any capitalist who joins has to give up onwership of his machines and accept "shares" in the firm instead. The assembly-line is vertically integrated into one firm.[25] We might find "market-gaps" between firms along the production chain at some stage where a safely thick market exists in the intermediate product issuing from the stage.

The formation of a firm as a solution to the machine-owners' problem has one additional advantage (for them): it creates a cartel of capitalists that bargains as one unit against the workers. The non-unionized worker is not going to come out of that contest with any part of the joint rent (unless, of course,

he has some firm specific capital). As long as unions can be kept illegal, at least, the factory owners will continue to appropriate all the rent.

Unionization will look like labor's best bet in this situation. Workers cannot pool their labor power, as the capitalists pool their physical capital, in a labor-managed firm in order to hire the machines at a rental that would leave the joint rent going to labor. Labor will not be owned and specialized machinery is not for hire. The producer cooperative is a possible compromise form but, on the whole, successful enterprises started as worker partnerships are going to end up owning capital and hiring labor - which is to say, end up as capitalist firms. Unions that do succeed in capturing part of the joint rent, on the other hand, might thereby discourage capital accumulation and the further subdivision of labor.

The labor union is a subject on which economics has a less than secure grasp. In neoclassical economic theory, unions are just another pernicious form of monopoly. The alternative "labor relations" tradition tends to reject economic theory and to draw lessons more friendly to unions from labor history. Perhaps the view of the manufacturing firm presented here might provide ground on which theoretical and historical analysis could finally meet?

Fluctuations and Growth

Our representation of the pin-making technology is so simple as to be little more than a metaphor. It is obviously capable of considerable formal elaboration. But at this point the question is whether there are good reasons to prefer it to that other simplistic metaphor, the neoclassical production function. The Smithian production function may well have advantages in areas other than the ones discussed in this essay. It may be worthwhile, in conclusion, to indicate some of these potential applications.

One of the mainstay stylized facts of applied macroeconomics is that employment in manufacturing fluctuates less than proportionally to output over the business cycle. Most macoreconomic models

assume a neoclassical constant returns to scale technology and most macroeconomists explain the "Okun's Law" phenomenon as reflecting the "hoarding" of labor, in particular of workers with firm-specific skills, during recessions. Firms, this hoarding hypothesis avers, keep workers on during recessions, although they are not needed in production, to make sure their skills are available when business picks up again.

The Smithian increasing returns technology suggests a competing hypothesis. Firms that utilize the scale economies of parallel series (Figure 3) will reduce output by shutting down, say, one assembly line of two. But the workstation that the two lines have in common cannot be left unmanned. Thus, half the workforce cannot be laid off when output is cut in half.[26] By the same token, the laid-off worker cannot by cutting his own wage in the recession get the line started up again. Individuals are not able by marginal wage-cutting to expand the number of production jobs being offered at the factory in recession.[27]

When "the Extent of the Market" determines the Division of Labor, economic growth will bring productivity gains. The growing economy will show increasing division of labor not only within firms but among firms. The economy becomes more complex as it expands. When, in our simple illustration, the work of the five artisans was reorganized into a five-man factory, the production process became more complex in the straighforward sense that the number of people cooperating in making any given unit of output increased. It is this increasingly complex coordination (when it can be maintained!) of larger and larger numbers of specialists that shows up as increasing productivity. It is perhaps over-optimistic to hope that explicit modelling of division-of-labor production would give us an econometric handle on the Solow-Dennison growth residuals. But it could give us a better qualitative understanding of how economic development differs from mere economic growth, which would be worth having.[28] An economist used to thinking of production in terms of the Smithian division of labor model is likely to be more impressed with the dangers of protectionism, for instance, than colleague whose thinking run in neoclassical or neo-Ricardian channels.

Conclusion

The theory of the capitalist factory outlined here shares elements with other explanations that have been proposed. It is not to be expected, however, that the proponents of these other theories will be entirely happy with it. The present theory stresses complementarity of inputs as a central problem as does Alchian and Demsetz but it does not at all accept their insistence that the bargain between capital and labor is essentially symmetrical. My story has a great many points in common with Williamson's "Organization of Work" but differs from his in seeing technological rather than transaction cost considerations as central. Like Marglin, finally, I recognize as essential element of power in the capital-labor bargain but, while he would insist that the capitalists' control of production has no technological or efficiency rationale, the efficient technology lies at the root of the capitalists' power in the present theory.[29)]

Footnotes

1) Carl Dahlman, The Open Fields and Beyond, New York, 1980.

2) Cf., Frederic C. Lane, Venice, A Maritime Republic, Baltimore 1973, esp. pp. 162 - 65. Production by small "firms" inside a larger facility remained an important organizational form in manufacturing into this century. A famous example is the Winchester Repeating Arms Company which operated in this manner until the outbreak of World War I. Cf. John Buttrick, "The Inside Contracting System", Journal of Economic History, Summer 1952.

3) Paul Mantoux, The Industrial Revolution in the Eighteenth Century, Rev. edn. New York 1962, pp. 33 - 36. Mantoux was not willing to count the royal manufactories sponsored by Colbert in France as forerunners of the industrial factory system, mainly because they required royal subsidies or patronage for their continued existence.

4) J. U. Nef, "The Progress of Technology and Growth of Large-scale Industry in Great Britain, 1540 - 1640", Economic History Review 1934. Nef also discusses large plants, such as cannon foundries, in various metallurgical branches.

5) That is, the individual weaver might own his own loom, for instance. The jobber would own the working capital (the materials).

6) It was tried, Cf., Karl Marx, Capital, Modern Library ed., New York 1906, p. 503: "In the Coventry silk weaving industry the experiment of 'cottage factories' was tried. In the centre of a square surrounded by rows of cottages, an engine-house was built and the engine connected by shafts with the looms in the cottages. In all cases the power was hired at so much per loom. The rent was payable weekly, whether the looms worked or not. Each cottage held from 2 to 6 looms; some belonged to the weaver, some were bought on credit, some were hired. The struggle between these cottage factories and the factory proper lasted over 12 years. It ended with the complete ruin of the 300 cottage-factories." Marx mentions other examples "in some of the Birmingham trades".

7) Adam Smith, An Inquiry into the Nature and Causes of the Wealth of Nations, (Modern Library edn.), New York 1937, p. 9. Compare also p. 86:

> "The greater their number, the more they naturally divide themselves into different classes and subdivisions of employment. More heads are occupied in inventing the most proper machinery for executing the work of each, and it is, therefore, more likely to be invented."

And, of course, the opening paragraph itself:

> "The greatest improvement in the productive powers of labour, and the greater part of the skill, dexterity, and judgment with which it is any where directed, or applied, seem to have been the effects of the division of labour." (p. 1)

8) Marx, op. cit., Part IV, Chs. XIV and XV, pp. 368 - 556. This is of course, a far more extensive treatment than we find in Smith. It also compares favorably with that of J. S. Mill, who has little of any interest to add to Smith. Cf., John Stuart Mill, Principles of Political Economy, Ashley edn., New York 1964, Book I, Chs. VII and IX:;, pp. 116 - 136.

Mill was also of the opinion that the advantages of division of labor have precedence over "the introduction of processes requiring expensive machinery" among the "causes of large manufactories". Cf., pp. 132, 135.

9) Marx, op. cit., p. 369.

10) Marx's distinction between "manufacturing" and "factory production" is a perfectly good and useful one. It is omitted here so as not to burden the paper with too much terminological baggage.

11) Smith, op. cit., pp. 4 - 5. Everyone recalls his calculation: "Those ten persons, therefore, could make among them upwards of forty-eight thousand pins in a day". Etc. Marx checked on pin-making in his own day (op. cit., p. 502)"...a single needle-machine makes 145,000 in a working day of 11 hours. One woman or one girl superintends four such machines and so produces near 600,000 needles in a day ..." The most recent report is Clifford F. Pratten, "The Manufacture of Pins", Journal of Economic Literature, March 1980: Today, one operative supervising 24 machines, each of which turns out 500 pins per minute, will make about 6 million pins in a day.

12) Professor Georgescu-Roegen especially stresses the failure of neoclassical production theory to illuminate the fundamental difference between manufacturing processes and agricultural production processes where nature dictates the time-phasing of operations. Cf. his "Process Analysis and the Neoclassical Theory of Production", American Journal of Agricultural Economics, May 1972, reprinted (with several other essays germane to our subject) in Nicholas Georgescu-Roegen, Energy and Economic Myths, (Place?), 1976.

13) Events will sometimes challenge that impression. Swedish economists will recall the "Horndal effect" (so named by Erik Lundberg). Horndal was a steelmill considered outdated by its controlling corporation which intended to concentrate production in its more modern plants. Investment in Horndal was therefore stopped altogether. The expectation, of course, was that in a couple of years the mill would not cover variable costs. To the consternation of observers, however, the rate of productivity growth in Horndal kept pace with that of the rest of the industry for many years. Cf. E. Lundberg, "The Profitability of Investment", Economic Journal 1959, pp. 663 - 664.

14) It was in fact normal for each craftsman (guild member) to own the tools he was using.

15) Cf., John Rae, Statement of some New Principles on the Subject of Political Economy, p. 164, as quoted by Mill, op. cit., p. 129.

16) Charles Babbage, On the Economy of Machinery and Manufactures, Third edn., London: Charles Knight, 1833, pp. 175 - 176. Babbage found that priority for this statement of the advantages of division of labor belonged to Gioja, Nuovo Prospetto delle Science Economiche, Milan 1915.

17) George Stigler, "The Division of Labor is Limited by the Extent of the Market", Journal of Political Economy, June 1951, as reprinted in his The Organization of Industry, Homewood, Ill., 1968, p. 129.

18) Marx, op. cit., pp. 375 ff.

19) Cf., esp., E. P. Thompson, "Time, Work-Discipline, and Industrial Revolution", Past & Present, December 1967.

20) Marx, op. cit..

21) Cf., E. G. West, "Adam Smith's Two Views on the Division of Labour", Economica, Feb. 1964, and Nathan Rosenberg, "Adam Smith on the Division of Labour: Two views or One?" Economica, May 1965.

22) Inspired by Armen Alchian and Harold Demsetz, "Production, Information Costs, and Economic Organization", American Economic Review, Dec. 1972.

23) In the literature on vertical integration, this is familiar as the post-contractual "opportunistic behavior" of Williamson or the "hold-up" problem of Klein, Crawford, and Alchian. Cf., O. E. Williamson, Markets and Hierarchies: Analysis and Antitrust Implications, New York: The Free Press, 1975, and B. Klein, R. G. Crawford and A. A. Alchian, "Vertical Integration, Appropriable Rents, and the Competitive Contracting Process", Journal of Law and Economics, Oct. 1978. Also David J. Teece, Some Efficiency Properties of the Modern Corporation, mimeo, Stanford 1982.

24) Technically speaking, the core is empty since every distribution can be blocked. (It does not seem helpful to insist that the empty core is a "transactions cost" problem). I am especially indebted to Dan Friedman for clarifying the structure of the bargaining situation for me.

25) That the integration should be vertical does not seem to be necessary in general. In Dahlman"s theory of the open field system, op. cit., avoidance of the "hold-up" problem is the explanation for why the scattering of strips was maintained over the centuries. With his arable strips scattered, the individual farmer cannot, in some dispute over communal distribution issues, threaten to withdraw (and thereby to reduce the benefits of scale economies to the village as a whole).

26) Marshall's cost curves, which have managed to survive (at least in undergraduate teaching) in uneasy co-existence with neo-Walrasian theory, has a rather natural "fit" to the Smithian technology. The main reason, of course, is that with neo-classical production theory we cannot be sure that there are any "firms" to talk about, whereas with the Smithian we have no doubts. The long-run decreasing cost which Marshall tended to presume follows directly from the increasing returns properties of this technology. The short-run U-shaped average cost schedule gets its downward-sloping segment by the same argument as used in connection with Okun's Law and its upward-sloping segment, quite conventionally, from the diminishing marginal product of variable factors when fixed factors are kept fixed.

Pricing in the markets supplied by these firms, however, should be analyzed in Hicksian, rather than Marshallian terms. We should expect them to be "fix-price" rather than "flex-price" markets.

27) I very much agree, therefore, with Martin Weitzman that the prevalence of these increasing return technologies must be taken into account if one is to understand the situation of manufacturing workers in a recession. Unemployment theory, Weitzman argues, must as a first logical requirement explain why unemployed factor units do not set up in production on their own. In the Smithian division of labor case the answer is straightforward: the manufacturing worker does not have the skills and knowledge required to make the product as an artisan.

Cf., M. L. Weitzman, "Increasing Returns and the Foundation of Unemployment Theory", Economic Journal, Dec. 1982.

28) Erik Dahmen's conception of "development blocks" in growing economies all of whose component sectors have to be completed before any one of them becomes economically viable is another example of an important idea which has not found a home in neoclassical theory but which could be explicated on the basis of Smithian theory. Cf., Erik Dahmen, Entrepreneurial Activity in Swedish Industry, 1919 - 1939, Homewood, Ill.: Irwin.

29) Alchian & Demsetz, op. cit., O. E. Williamson, "The Organization of Work", Journal of Economic Behavior and Organization, 1980, and S. A. Marglin, "What Do Bosses Do?", Review of Radical Political Economics, Summer 1974.