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Much of the history of economic enterprise has involved reaping the benefits from specialization of labor by dividing increasingly fragmented tasks among different employees - as vividly described already by Adam Smith in his *Wealth of Nations*. This development was greatly facilitated through the rise of "Tayloristic organizations,"[1] where standardized, specialized inputs were processed to yield standardized outputs, and where different functional tasks (e.g. administration, production, marketting, design) were performed in different departments, coordinated through a hierarchy of managers. These organizations - common in both the manufacturing and service sectors - testified to the importance of specialization of work, in production as well as organization.

This status quo is in the process of crumbling. With hindsight, the wave of change began well over a decade ago; it has accelerated in recent years, and may be expected to gather even more pace over the next decade. The organization of many firms in both the manufacturing and service sectors is being progressively restructured. This process calls into question the need for extreme specialization by occupation, creates demands for new combinations of skills, and thereby leads to new organizations of work and new patterns of wage inequality.

The restructuring process is characterized by a number of complementary features.[2] *First*, the organizational structure of firms is becoming flatter: the new structure is built around customer-oriented teams involving work rotation across a number of different tasks (rather than the traditional, task-centered departments), and these teams report to the central management, with few if any intermediaries. *Second*, production processes are being transformed: the application of computer technology and flexible tools in the manufacturing and service sectors permits employees to perform multiple tasks; in manufacturing, the introduction of programmable, multi-task equipment reduces returns to scale in production and permits greater production flexibility, smaller batch sizes, shorter production cycles, smaller delivery lags, smaller inventories, and quicker product development. *Third*, the flow of information within firms has been revolutionized: the introduction of computerized data systems permits more individualized treatment of

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[1] See Taylor (1911).
[2] See, for example, Hammer and Champy (1993), Milgrom and Roberts (1990), and Wikstrom and Norman (1994). Lindbeck and Snower (1995a) summarize various facets of the restructuring process in some detail and provide references to the relevant literature.

employees and customers, facilitates the decentralization of decision making, and enables employees to perform multiple tasks and exploit complementarities among them. *Fourth,* firms offer broader product lines in smaller quantities, responding more readily to customers' requirements: customer participation in product design is growing and there is greater emphasis on product quality and ancillary services. And *fifth,* the nature of work is changing: occupational boundaries are breaking down as workers are given multiple responsibilities, ranging over diverse tasks.[3] These various aspects distinguish the traditional, Tayloristic organizations from the new breed, which we shall call "holistic" organizations.

Recent technological advances and improvements in physical and human capital have undoubtedly played a central role in driving the process whereby Tayloristic organizations restructure into holistic ones. The increasing use of computers to transmit information within firms and the rising versatility and programmability of equipment have increased the complementarities across tasks (e.g. production, marketing, design) that a given employee can exploit. Furthermore, the growing amounts of all-round knowledge disseminated through the education systems has made young people increasingly capable of performing multiple tasks. This accumulation of human capital has also changed people's preferences away from the monotonous, single-purpose Tayloristic jobs to the frequently more varied and stimulating holistic ones.

In what follows, we examine the consequences of these development for the reorganization of work, the break-down of occupational barriers, the transformation of job opportunities, and the implications for inequality in the labor market.

1. The Reorganization of Work

In standard microeconomic theory it is generally assumed that different types of labor perform different tasks in the production process, and in this sense the theory mirrors a Tayloristic organization of work. But to examine the effect of the restructuring process on labor market inequality, we need to take a more discriminating approach.

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[3] It is interesting to note that a number of these features - particularly the production flexibility, small inventories, short delivery times, quick product development, widespread application of computer technology, and a blurring of occupational boundaries - have been characteristic of many Japanese organizations for some time.

When different workers in a Tayloristic organization perform different tasks, the distribution of wages across workers obviously depends on the distribution of productivities across tasks. But when the organization of work is restructured along holistic lines, so that individual workers are assigned multiple tasks, the link between the distribution of wages and the distribution of task productivities is broken. The reason is that the distribution of task productivities no longer coincides with the distribution of of productivities across people.

To distinguish clearly between these distributions, it is convenient to express the firm's production function in two alternative ways, one in terms of tasks and the other in terms of people. For simplicity, suppose that the firm has a production function in which two types of labor ($j = 1,2$) are employed at two tasks ($i = 1,2$) to produce a homogeneous output. Let n_j be the number of type-j workers that the organization employs, let τ_{ij} be the fraction of worker j's available time devoted to task i, where $\tau_{1j} + \tau_{2j} = 1$; and let e_{ij} be the productivity of the type-j worker at task i (per unit of time). Then $e_{i1}\tau_{i1}n_1 + e_{i2}\tau_{i2}n_2$ is the amount of labor services devoted to task i, and the *production function in task space* (i.e. in terms of activity level by task i) is

$$q = f\left[\left(e_{11}\tau_{11}n_1 + e_{12}\tau_{12}n_2\right),\left(e_{21}\tau_{21}n_1 + e_{22}\tau_{22}n_2\right)\right] \qquad (1a)$$

where $f_1, f_2 > 0$ and $f_{11}, f_{22} < 0$ (positive, diminishing returns to the two activities). Furthermore, $(e_{1j}\tau_{1j} + e_{2j}\tau_{2j})n_j$ is the amount of labor services performed by the type-j workers, and the *production function in people space* (i.e. in terms of labor input j) is

$$q = g\left[\left(e_{11}\tau_{11} + e_{21}\tau_{21}\right)n_1,\left(e_{12}\tau_{12} + e_{22}\tau_{22}\right)n_2\right] \qquad (1b)$$

$g_1, g_2 > 0$ and $g_{11}, g_{22} < 0$ (positive, diminishing returns to labor).

Suppose that type-1 workers have a comparative advantage at task 1 and type-2 workers have a comparative advantage at task 2, so that $(e_{11}/e_{21}) > (e_{12}/e_{22})$. Moreover, assume that the productivity of worker j at task i depends on his exposure to the task: $e_{ij} = e_{ij}(\tau_{ij})$. In Lindbeck and Snower (1995a), this relation is rationalized as a tradeoff between (i) the "return to specialization" whereby a worker's productivity at a task rises with the fraction of the available working time spent at that task, and (ii) an "informational task complementarity" whereby the worker's productivity at a task depends positively on the information and skill gained from the time spent at another task.

Let the firm's labor cost be $c = \left(w_{11}\tau_{11} + w_{21}(1-\tau_{11})\right)n_1 + \left(w_{12}(1-\tau_{22}) + w_{22}\tau_{22}\right)n_2$, where w_{ij} is the real hourly wage for type-j labor at task i. Then firm's decision problem is to maximize $\pi = q - c$, with respect to n_j and τ_{ij}, subject to $\tau_{1j} + \tau_{2j} = 1$. Given that the solution lies in the range $n_j > 0$, $0 < \tau_{ij} \leq 1$, the first-order conditions for profit maximization are

$$(\partial\pi / \partial n_j) = 0 \text{ and } (\partial\pi / \partial\tau_{ij}) \geq 0, \ (\partial\pi / \partial\tau_{ij})(1-\tau_{ij}) \geq 0 \qquad (2)$$

The first condition of (2) determines the number of people employed and is quite standard. The second describes the choice of work organization by determining the allocation of each worker's time across tasks. If the profit maximization problem has an interior optimum with respect to τ_{ij} (so that $0 < \tau_{ij}^* < 1$ for $i,j = 1,2$, where τ_{ij}^* is the profit-maximizing τ_{ij}), then the firm chooses a holistic organization of work. But if the profit maximum is attained at a corner point $\tau_{11}^* = 1$ and $\tau_{22}^* = 1$, the Tayloristic organization is chosen.

Figure 1 illustrates the real labor cost (c) and real revenue (q) in terms of the time allocation (τ_{ij}) of a particular worker, taking account of the constraint $\tau_{1j} + \tau_{2j} = 1$ and holding the time allocation of the other worker at its profit-maximizing level. The revenue is depicted by two alternative curves, q^T and q^H. For revenue curve q^T, maximum profit is achieved at point T, where $\tau_{ij}^T = 1$, so that the organization is Tayloristic; while for revenue curve q^H, profits are maximized[4] at point H, where $0 < \tau_{ij}^H < 1$, so that the organization is holistic. The latter curve is depicted as hump-shaped,[5] indicating that when τ_{ij} is low, the marginal return to specialization dominates the informational task complementarity, and when τ_{ij} is high, the informational task complementarity dominates.

Observe that when the organization of work is Tayloristic, the production functions (1a) and (1b) are identical[6] since $\tau_{12} = \tau_{21} = 0$. This explains why the standard microeconomic theory of production, based on holistic organization, finds it unnecessary to distinguish between production functions in task space and people space. But under

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[4] In other words, at point H the slope of the revenue curve q^H is equal to the slope of the cost curve c.
[5] Since maximum profit for a holistic organization is achieved when there are diminishing returns to τ_{ij}, any range of increasing returns (such as those at low τ_{ij}'s in the figure) is irrelevant to our analysis.
[6] (This explains why the standard microeconomic theory of production, based on holistic organization, finds it unnecessary to distinguish between production functions in task space and people space.)

holistic organization, the two production functions are distinct, since the productivity of a particular task can no longer be identified with the productivity of a worker.

In this context it is easy to see how the process of restructuring Tayloristic organizations into holistic ones can be driven by the technological advances that increase complementarities among tasks and by the improvements in human capital that make workers more versatile across tasks: (i) Advances in information technology that increase the informational task complementarities imply that worker j's productivity at, say, task 1 rises more slowly with τ_{1j} (since the rise in τ_{1j} comes at the expense of a fall in the time τ_{2j} spent at the *informationally* complementary task). (ii) Advances in production technologies that increase the cross-partial derivatives f_{12} and f_{21} (which may be called "technological task complementarities") also make worker j's productivity (e_{1j}) at task 1 rise more slowly with τ_{1j} (since the increase in τ_{1j} reduces the time τ_{2j} spent at the *technologically* complementary task). (iii) Improvements in human capital that make workers more versatile (reducing workers' comparative advantages, so that e_{11}/e_{21} falls and e_{12}/e_{22} rises) have the same qualitative effect on productivity. In terms of Figure 1 these changes all raise the level of the revenue curve and reduce its second derivative, so that the q^T curve approaches the q^H curve. Clearly, if these changes are sufficiently large, Tayloristic organizations gain the incentive to restructure along holistic lines.[7]

2. Labor Market Inequality

The analysis above can shed light on how the restructuring process affects labor market inequality. Our theme is that this process creates increasing demand for versatility and thereby "re-segments" the labor market. We argue that where the above restructuring occurs, the degree of labor market inequality will come to depend less on workers' productivities at specific occupations and more on their degree of versatility across tasks.

To explore this theme in the simplest possible way, it is convenient to assume that in the labor force L, there are L^V workers who are versatile (i.e. capable of performing both tasks, as in Section 2) and L^n workers who are not (i.e. capable of performing only one

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[7]Note that the complementarities and versatility underlying multi-tasking by workers are analogous to the public inputs underlying economies of scope for firms. (See Baumol, Panzer, and Willig (1982).)

task), where L^v, $L^n > 0$, $L^v + L^n = L$. Let the production function of each firm take the simple form:

$$q = \sum_i \sum_j e_{ij} \tau_{ij} n_j \ , \quad i,j = 1,2 \tag{3}$$

To fix ideas, consider an initial equilibrium in which all workers are employed by Tayloristic organizations. Specifically, suppose that there are L/n^T Tayloristic organizations, each offering n^T jobs, [8] with $(n^T/2)$ of them at task 1 and $(n^T/2)$ of them at task 2.

For expositional simplicity, we assume that the two types of workers have the same productivity: $e_{11}(1) = e_{22}(1)$. Then each firm's production function may be written as $q = e_{11}(1)(n^T/2) + e_{22}(1)(n^T/2) = e_{11}(1)n^T$. Furthermore, we assume that the wage is the outcome of a Nash bargaining process[9] between each employer and employee, in which the employee receives a proportion μ (where $0 < \mu < 1$) of the relevant surplus:

$$w_T = \mu e_{11} \tag{4a}$$

(since $\tau_{11}=1$) leaving each Tayloristic organization with a profit of

$$\pi^T = (1-\mu)e_{11}(1)n^T \tag{5a}$$

In this initial equilibrium, there is no labor market inequality, clearly due to the assumption that the workers have equal productivities. In practice, of course, productivities differ across task-specific occupations, and thus the wages at Tayloristic firms will differ correspondingly. This does not mean, however, that our analysis (based on equal productivities) will necessarily overstate the degree to which restructuring generates inequality between versatile and non-versatile workers; on the contrary, as we shall see, the analysis may well understate it.

Starting from the initial equilibrium above, we now consider how the restructuring process can be driven by the changes in physical and human capital described in the previous section. Suppose that each holistic organization employs n^H workers, who must all be versatile. We assume, plausibly, that a holistic organization employs fewer people than a Tayloristic one: $n^H < n^T$. (Lindbeck and Snower (1995a) derive this difference from

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[8] Fixing the number of workers in this way is a harmless simplification, since we focus on the organization of work which is characterized by each worker's allocation of time across tasks, not on the number of workers employed by the firm. The underlying assumption is that each organization has fixed capital-labor coefficients and a given capital stock, so that exactly two jobs are available.

[9] For simplicity, let the fall-back positions of the firm and the workers be zero so that the Nash product is $w^\mu (q-w)^{1-\mu}$.

the observation that Tayloristic organizations characteristically have larger fixed costs of operation and thus larger returns to scale than holistic organizations.) Assume that the two types of versatile workers have symmetric productivities - so that the productivity functions $e_{11}(\tau_{11})$ and $e_{22}(\tau_{22})$ are identical for $0 < \tau_{11}, \tau_{22} < 1$, as are the productivity functions $e_{21}(1- \tau_{11})$ and $e_{12}(1-\tau_{22})$. Then the production function of each holistic organization is $q = e_{11} \cdot \tau_{11}^H \cdot n^H + e_{21} \cdot (1-\tau_{11}^H) \cdot n^H = e_{22} \cdot \tau_{22}^H \cdot n^H + e_{12} \cdot (1-\tau_{22}^H) \cdot n^H$, for $0 < \tau_{11}^H, \tau_{22}^H < 1$. The resulting wage is

$$w^H = \mu\left(e_{11} \cdot \tau_{11}^H + e_{21} \cdot (1-\tau_{11}^H)\right) \tag{4b}$$

and the associated profit of each holistic organization is

$$\pi^H = (1-\mu)\left(e_{11} \cdot \tau_{11}^H + e_{21} \cdot (1-\tau_{11}^H)\right) n^H \tag{5b}$$

Suppose that Tayloristic organizations differ in terms of their potential costs of restructuring into holistic ones. Ordering the organizations in terms of these costs, from highest to lowest, we may express the marginal organization's cost of restructuring (ρ) in terms of the number of Tayloristic organizations (M^T): $\rho = \rho(M^T)$, $\rho' < 0$. Thus the profit of the marginal restructured organization is

$$\pi^{TH} = \pi^H - \rho(M^T) \tag{5c}$$

The ongoing changes in physical and human capital, described in Section 2, raise the productivity per worker at holistic organizations $\left(e_{11}(\tau_{11}^H) + e_{21}(1-\tau_{11}^H)\right)$ relative to the productivity at Tayloristic ones $e_{11}(1)$ and, as result, they also raise the holistic profit (5b) relative to the Tayloristic profit (5a). Consequently, the profit (5c) from restructuring must also rise relative to the Tayloristic profit (5a). Starting from the initial Tayloristic equilibrium in which $M_T = L/n^T$, it is clear that once the cumulative change in physical and human capital is large enough to raise the profit (5c) from restructuring above the profit (5a) from remaining Tayloristic, the restructuring process begins. The equilibrium condition for the restructuring process is that Tayloristic organizations proceed to restructure along holistic lines until the profit (π^{TH}) from restructuring is equal to the profit (π^T) from remaining Tayloristic, i.e. by (5a) and (5c),

$$(1-\mu)\left(e_{11}(\tau_{11}^H) + e_{21}(1-\tau_{11}^H)\right)n^H - \rho(M^T) = (1-\mu)e_{11}(1)n^T \tag{6}$$

This equation shows that as $e_{11}(\tau_{11}^H) + e_{12}(1-\tau_{11}^H)$ rises relative to $e_{11}(1)$, the number of Tayloristic organizations (M^T) falls and the number of holistic ones rises correspondingly.

This process generates two types of labor market inequality. First, the holistic wage w_H (in (4b)) rises relative to the Tayloristic wage w_T (in (4a)), and thus the versatile workers in holistic organizations earn progressively more relative to the others. Second, as the Tayloristic firms restructure, they shed jobs, leaving some workers unemployed. As result, the labor market comes to be segmented into three sectors: an expanding holistic sector where wages are rising, a contracting Tayloristic sector where wages are relatively stagnant, and an expanding pool of unemployment.

The resulting rise in inequality is pictured in Figure 2. In the initial, Tayloristic equilibrium all workers are employed at the same Tayloristic wage, and thus the corresponding Lorenz curve is LC_0, coinciding with the 45° line. The restructuring process then progressively enlarges the holistic group and the unemployed group at the expense of the Tayloristic group.[10] In the figure, this development is pictured by the movement from LC_0 to LC_1 and further to LC_2.

Of course, this rising inequality in wages and job opportunities can be mitigated through entry of new firms into the holistic sector. The more the above changes in physical and human capital encourage entry relative to restructuring, the more high-wage jobs and the less unemployment will be created.

Finally, we do not think the conclusions above concerning inequality are overstated on account of our simplifying assumption that productivities are uniform across the Tayloristic sector. In practice, people in the high-wage occupations may often be more versatile than people in the low-wage occupations, and this feature tends to magnify the extent to which the restructuring process generates wage disparities.

3. Concluding Remarks

The theory outlined here can be seen as a potential first step towards providing a new understanding of a constellation of seemingly disparate phenomena: the downsizing of middle management, the widening dispersion of wages within occupational, educational, and job tenure groups in the US and the UK, accompanied by a narrowing of the male-female wage differentials, decline in the importance of centralized bargaining

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[10] The figure assumes that the holistic wage exceeds the Tayloristic wage and that the unemployed receive no wage income.

relative to firm-level bargaining in many European countries, the growing importance of broad-based education in improving people's job opportunities, the reorganization of firms from task-oriented departments to customer-oriented teams, and the break-down of occupational barriers. Our approach to these phenomena may be summarized as follows.

Our analysis suggests how the growing versatility of workers and the increasing complementarities among tasks induce firms to switch from organizations where workers specialize by occupation to ones where they rotate among multiple tasks. This inevitably entails a blurring of occupational lines. In the restructuring process, decision-making within firms is decentralized, permitting the emergence of customer-oriented teams which are inherently responsive to the changing customer needs. The decentralization also leads to cost saving through shedding of middle management positions.[11]

Our analysis also has striking implications concerning the future of centralized bargaining. In Europe and elsewhere centralized bargaining is often used to compress the distribution of wages. We contend[12] that this strategy may be expected to become less effective with the passage of time and that employers and employees may be expected to face growing incentives to choose decentralized bargaining arrangements instead. The reason is straightforward. A usual objective of centralized bargaining is "equal pay for equal work", and this it invariably imposes some uniformity of wages across workers for given tasks. When the organization of work is Tayloristic, with different occupational tasks performed by different workers, such uniformity need not be grossly inefficient, particularly if workers within a particular occupation have similar productivities. But when work is restructured along holistic lines, this uniformity can become very inefficient indeed, for when different employees perform different sets of complementary tasks, there is no reason to believe that the marginal product of one employee's time at a particular task should be similar to the marginal product of another employee's time at that task. For instance, there is no reason that time spent with customers should affect the productivity of a product designer in the same way as it affects the productivity of a production worker. Thus holistic firms have an incentive to offer different workers different wages for the same task. But this is precisely the practice that centralized wage bargaining

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[11]Japanese firms have been in the vanguard of many of these developments, helping them exploit many of the recent advances in computer technologies and increased versatility of capital equipment.
[12]See Lindbeck and Snower (1995b) for a detailed analysis.

inhibits. In this way, the restructuring process raises the efficiency costs of centralized bargaining.

Finally, insofar as women tend to specialize less in terms of skills than men, our analysis offers a new explanation for the narrowing male-female wage differentials and nonemployment differentials. Insofar as people within given occupational, educational, and job tenure groups differ substantially in terms of their versatility as well as the social and cognitive skills necessary for success in holistic organizations, our analysis also offers a new explanation for the widening wage dispersion within these occupational, educational, and job tenure groups.

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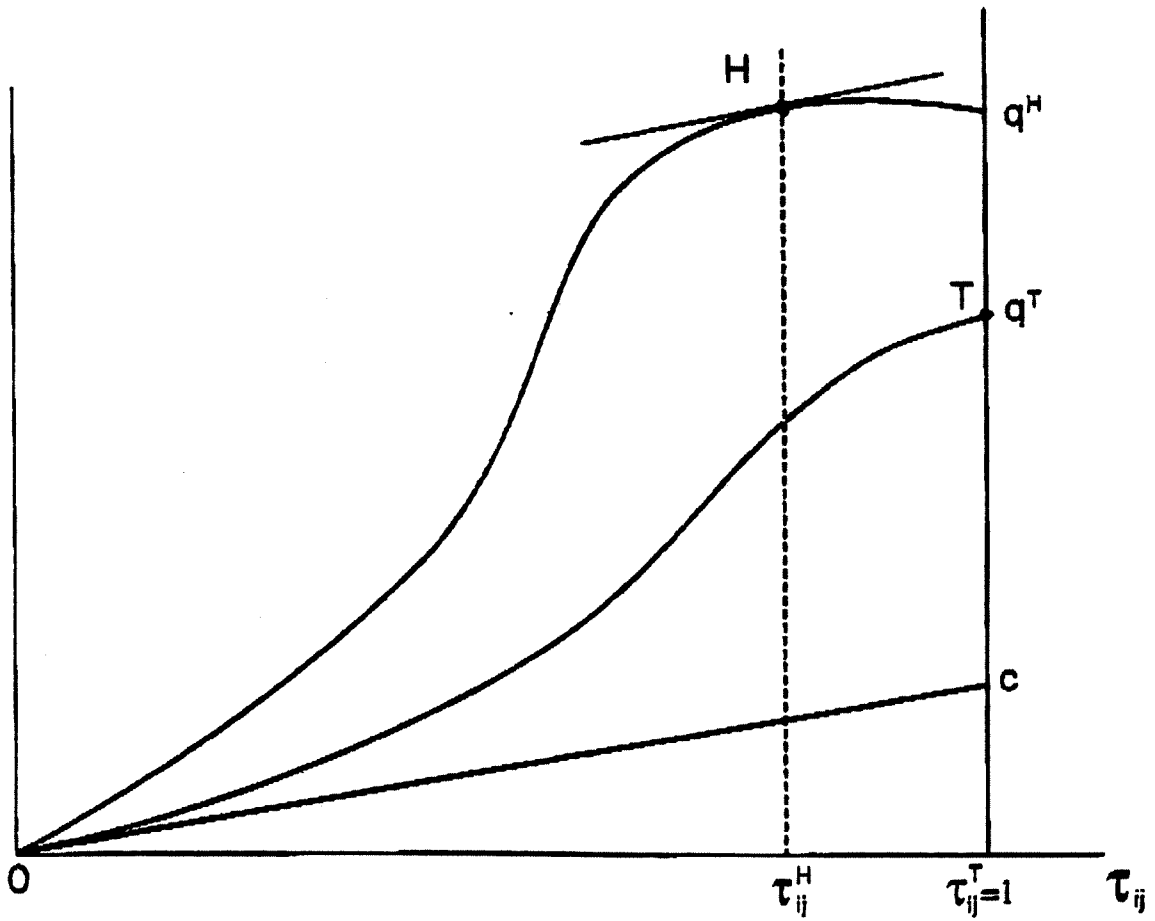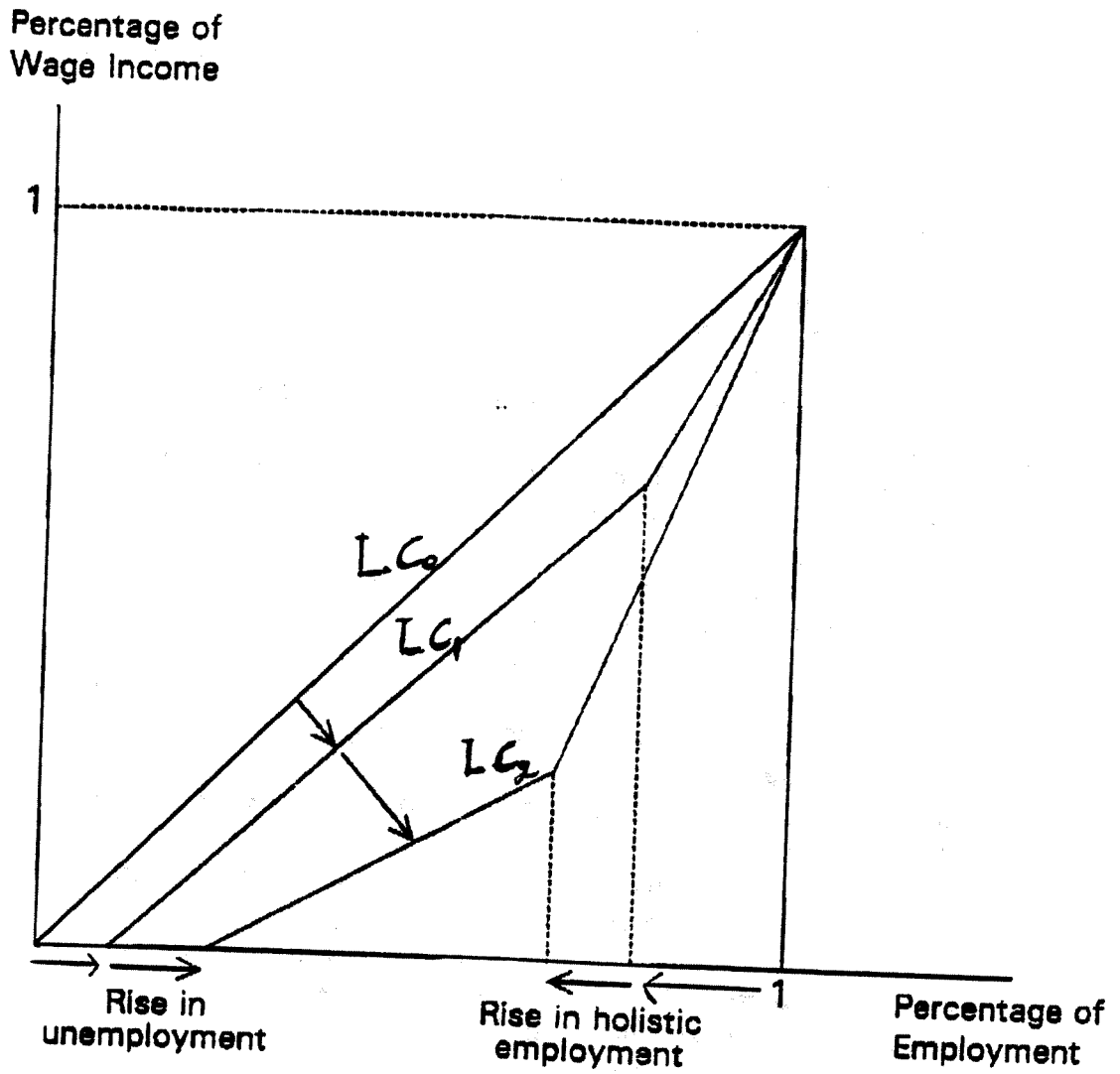Wikström, Solveig and Richard Norman (1994) *Knowledge and Value*, Routledge, London.

FIGURE 1: The Optimal Organization of Work

FIGURE 2:   The Effect on Inequality