5 January 1996

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AND LABOR MARKET INEQUALITY

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Revised Jan. 5, 1996

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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," where standardized inputs are processed to yield standardized outputs, and where different functional tasks (e.g. administration, production, marketing, design) are 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 pervasive organizational structure is now in retreat. Charlie Chaplin at the conveyor belt, in the movie *Modern Times,* is no longer the prototype worker. 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 skill-specific occupation, creates demands for new combinations of skills, and thereby leads to new patterns of wage inequality.

The restructuring process is characterized by a number of complementary features.[1] *First,* the organizational structure of firms is becoming flatter: the new structure is built around teams that report to the central management, with few if any intermediaries. *Second,* production processes are being transformed: the application of computer technology, flexible tools, and programmable, multi-task equipment reduces returns to scale and permits greater production flexibility. *Third,* the flow of information within firms has been revolutionized: the introduction of computerized data systems permits more

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[1] See, for example, Hammer and Champy (1993), Lindbeck and Snower (1995a) ,Milgrom and Roberts (1990), and Wikstrom and Norman (1994).

individualized treatment of 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 engage in multi-tasking and work rotation. These various aspects distinguish the traditional, Tayloristic organizations from what we shall call "holistic" organizations.[2]

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, customer service, product design) that a given employee can exploit. Furthermore, the growing amounts of all-round knowledge that has been disseminated through the education systems over the past few decades 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 developments for the reorganization of work, the move towards multi-tasking and the consequent break-down of occupational barriers, the transformation of job opportunities, and the implications for inequality in the labor market.

I. The Reorganization of Work

In standard microeconomic theory, the production function is a black box in which a vector of inputs is transformed into a vector of outputs, and the allocation of tasks among workers is not specified explicitly.[3] To examine the effect of the restructuring process on

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[2]It is interesting to note that a number of these features have been characteristic of many Japanese organizations for some time.

[3]There is, however, an emerging literature on the principal-agent problems associated with multi-tasking (e.g. Holmstrom and Milgrom (1991)).

labor market inequality, however, we need to look into this black box. When different workers in a Tayloristic organization perform different tasks, the distribution of wages across workers clearly 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, clearly, is that the distribution of task productivities no longer coincides with the distribution 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 are employed at two tasks 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) is

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

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 workers) is

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

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. For all τ_{ij} where the return to specialization dominates, the productivity function $e_{ij} = e_{ij}(\tau_{ij})$ is monotonically

increasing; and for all τ_{ij} where the informational task complementarity dominates, the function is decreasing.[4]

Let the firm's labor cost be $c = w_1 n_1 + w_2 n_2$, where w_j is the real hourly wage for type-j labor.[5] Then firm's decision problem is to maximize $\pi = q - c$, with respect to n_j and τ_{jj}, subject to $\tau_{jj} + \tau_{ij} = 1, \quad i \neq j$ and the predetermined wages w_j. Given that the solution lies in the range $n_j > 0, \ 0 < \tau_{jj} \leq 1$, the Kuhn-Tucker conditions for profit maximization are

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

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_{jj} (so that $0 < \tau^*_{jj} < 1$ for $j = 1,2$, where τ^*_{jj} is the profit-maximizing τ_{jj}), 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 depicts profit in terms of the time allocation (τ_{jj}) of a particular worker, taking account of the constraint $\tau_{1j} + \tau_{2j} = 1$ and holding the time allocation of the other type of worker at its profit-maximizing level. If a firm's profit opportunities are given by the curve π^1, then it will choose a Tayloristic organization of work, since the profit maximum is achieved when $\tau^T_{jj} = 1$. If another firm's profit opportunities are given by the curve π^2, then that firm will choose a holistic organization, since profits are maximized when $0 < \tau^H_{jj} < 1$. The latter profit curve is depicted as hump-shaped,[6] which occurs when the marginal return to specialization dominates the informational task complementarity at low values of τ_{jj}, but the informational task complementarity dominates at high τ_{jj}.

Observe that when the organization of work is Tayloristic, the production functions (1a) and (1b) are identical, since $\tau_{12} = \tau_{21} = 0$. Then it is clearly unnecessary to distinguish

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[4]The productivity function is of course an static simplification of what in practice is a dynamic learning process.

[5]Since we will assume that the firm unilaterally determines the assignment of tasks to workers, it makes no difference whether each worker is paid a single wage (as above) or a different wage of each task.

[6]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_{jj}'s in the figure) is irrelevant to our analysis.

between production functions in task space and people space. But under 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 three major improvements in physical and human capital: (i) advances in information technology that increase informational task complementarities, (ii) advances in production technologies that increase the technological complementarities given by the magnitudes of the cross-partial derivatives f_{12} and f_{21}, and (iii) advances 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. These changes all raise profit per worker and, if they are large enough, they reduce the fraction τ_{jj} at which profit per worker is maximized. Reinterpreting Figure 1 in time-series terms (rather than in cross-section terms, as above), these advances raise the profit curve and shift its maximum to the left, so that the corner point solution $\tau_{jj}^{T} = 1$ turns into an internal solution $0 < \tau_{jj}^{H} < 1$. The reason for the latter effect is that the opportunity cost of a rise in τ_{jj} is the corresponding fall in the fraction of time spent at the other task (τ_{ij}, $i \neq j$), and the above advances in physical and human capital all raise this opportunity cost. As result, in Figure 1, the π^1 curve is gradually transformed into the π^2 curve. Thus, if the above changes are sufficiently large, Tayloristic organizations are induced to restructure along holistic lines.

II. 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 this restructuring occurs, inequality in wages and job opportunities will come to depend less on workers' productivities at specific task-specific occupations and more on their degree of versatility across tasks.

To explore this theme in a simple way, let the production function of each firm take the form:

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

For simplicity, we assume that each Tayloristic firm offers n^T jobs,[7] with (n^T/2) of them at task 1 and (n^T/2) at task 2, and that workers have the same productivity at both tasks: $e_{11}(1) = e_{22}(1)$. Then each Tayloristic firm's production function may be written as $q = e_{11}(1)(n^T/2) + e_{22}(1)(n^T/2) = e_{11}(1)n^T$. Let the wage be the outcome of a Nash bargaining process[8] between each employer and employee, in which the employee receives a proportion μ (where $0 < \mu < 1$) of the relevant surplus:

$$w_T = \mu e_{11}(1) \tag{4a}$$

leaving each Tayloristic organization with a profit of

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

The holistic firm is assumed to employ fewer people than the Tayloristic one: $n^H < n^T$. (Lindbeck and Snower (1995a) derive this difference from the observation that Tayloristic organizations characteristically have larger fixed costs of operation and thus larger returns to scale than holistic organizations.) Assuming that the two types of workers have symmetric productivities (so that $e_{11}(\tau_{11}) = e_{22}(\tau_{22})$ and $e_{21}(1-\tau_{11}) = e_{12}(1-\tau_{22})$ for $0 < \tau_{11} = \tau_{22} < 1$), it then suffices to focus just on the type-1 worker, since the type-2 worker must have the same productivity and wage in equilibrium. Thus the production function of the holistic organizations may be expressed as $q = e_{11} \cdot \tau_{11}^H \cdot n^H + e_{21} \cdot (1-\tau_{11}^H) \cdot n^H$ for $0 < \tau_{11}^H < 1$. 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

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

To fix ideas, consider an initial equilibrium in which $e_{11}(1)n^T > \left(e_{11} \cdot \tau_{11}^H + e_{21} \cdot (1-\tau_{11}^H)\right)n^H$, so that all workers are employed in Tayloristic organizations. Let the labor force be a constant L and let there be L/n^T Tayloristic organizations, so that there is full employment. There is no labor market inequality in this initial equilibrium, since all workers are assumed to have equal productivities. In practice, of course, productivities

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[7]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.

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

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.

The ongoing advances in physical and human capital, described in Section I, 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 raise the holistic profit (5b) relative to the Tayloristic profit (5a). We assume that Tayloristic organizations differ in terms of their costs of restructuring into holistic ones. Ordering all Tayloristic organizations in terms of these costs, from the highest to the lowest restructuring cost, we let the marginal organization's restructuring cost (ρ) in terms of the number of Tayloristic organizations (M^T) be $\rho = \rho(M^T)$, $\rho' < 0$. Thus the profit of the marginal restructured organization is

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

Starting from the initial equilibrium in which $M_T = L/n^T$, it is clear that once the cumulative advance 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. We assume that the labor force L contains L^v versatile workers (capable of performing both tasks, as in Section I) and L^n non-versatile ones (i.e. capable of performing only one task), where L^v, $L^n > 0$, $L^v + L^n = L$. Then the equilibrium condition for the restructuring process is that Tayloristic organizations proceed to restructure into holistic ones until either (a) the stock of versatile workers is exhausted or (b) 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 $e_{11}(\tau_{11}^{H})+e_{21}(1-\tau_{11}^{H})$ rises relative to $e_{11}(1)$, the number of Tayloristic organizations (M^T) falls and the number of holistic ones rises accordingly.

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. Then, even if holistic firms enter the labor market, the non-versatile workers who have been layed off will be unable to avail themselves of the new job opportunities. Thus the labor market comes to be segmented into three sectors: an expanding holistic sector where wages are rising, a contracting Tayloristic sector with wages are relatively stagnant, and an expanding pool of the jobless.

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^o line. The restructuring process then progressively enlarges the holistic group and the jobless group at the expense of the Tayloristic group, moving the Lorenz curve[9] from LC_0 to LC_1 and further to LC_2. (The figure assumes that the holistic wage (w^H) exceeds the Tayloristic wage (w^T) and that the unemployed receive no wage income.) Thus the people at the lower end of the wage distribution capture a progressively smaller share of total wage income, whereas those in the upper end capture a larger share.

Of course, this rising inequality in wages and job opportunities is mitigated through an increased supply of versatile workers (through the services of the education system). The greater this supply, the more high-wage jobs and the less unemployment will be created.

We do not think that these conclusions 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 are often more versatile than people in the low-wage occupations,[10] and this feature tends to magnify the extent to which the restructuring process generates wage disparities.

III. 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 increased versatility of work, 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

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[9]It can be shown that the ratio of the slopes of the two downward-sloping segments of LC_1 is equal to the ratio of the corresponding slopes of LC_2; thus the two Lorenz curve cross.

[10]Of course there are many exceptions of highly paid specialists who are not versatile.

wage differentials, decline in the importance of centralized bargaining 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.

The analysis above 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.

Our analysis also has striking implications for wage formation, and particularly for the role of wage incentives for promoting the reorganization of work. Although the analysis above has ignored this role by assuming that firms determine workers' tasks unilaterally, Lindbeck and Snower (1995b) show how the increasing importance of wage incentives to promote efficiency in multi-tasking undermines centralized bargaining. 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, then rewarding people in accordance with marginal products in task space need not be grossly inefficient, particularly if workers within a particular occupation have similar productivities. But when work is restructured along holistic lines, this practice 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 set wages in accordance with marginal products in people space and therefore to offer different workers different wages for the same task. But this is precisely the practice that centralized wage bargaining inhibits. In this way, the restructuring process

raises the efficiency costs of centralized bargaining and thus gives employers and employees growing incentives to choose decentralized bargaining arrangements instead. This, however, may be expected to increase wage dispersion in countries where centralized bargaining has compressed the distribution of wages.

Furthermore, 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. And finally, 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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Footnotes