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## Restructuring production and work

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## RESTRUCTURING PRODUCTION AND WORK

*by Assar Lindbeck and Dennis J. Snower*

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**Abstract:** The paper analyzes the contemporary organizational restructuring of production and work and derives some salient implications for the labor market. The analysis focuses on the switch from occupational specialization at “Tayloristic” organizations to multi-tasking at “holistic” organizations. The restructuring process is shown to create demands for new combinations of skills and thereby “resegment” the labor market, raising the wages and job opportunities of some workers relative to others.

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## 1. Introduction

The past decade or two has witnessed a constellation of far-reaching changes in production technologies, physical and human capital, and ideas about how to organize firms. This has resulted in a fundamental restructuring of production and work in advanced industrialized countries. The restructuring process has received a lot of attention in the media and in the business management and sociology literatures but, with relatively few exceptions, has gone virtually unnoticed in economics thus far.<sup>1</sup> What is particularly striking about this process is how much of it depends on a breakdown of the traditional occupational barriers.<sup>2</sup>

The traditional organizations required their employees to have highly specialized skills, appropriate for standardized production processes. Sales people needed interpersonal skills, production workers required narrow manual skills, administrative personnel needed organizational and accounting skills, product designers needed creativity, and managers required prudence and judgment. It is on account of this specialization that employees could be divided into narrow occupations and the traditional distinctions between skilled and unskilled workers could be made. In this environment, relatively little attention was given to people's capacity to acquire multiple skills; if a person happens to have more than one occupational aptitude, he generally had to decide which particular one to use and let the rest lie fallow.

In the new types of firms emerging nowadays this separation of roles is breaking down. Workers are often given responsibilities spanning production, administration, training, customer relations, and even the development of products and production

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<sup>1</sup> Examples of studies where this process is described, and sometimes also recommended, are Womack, Jones and Roos (1991), Hammer and Champy (1993), Pfeiffer (1994), Wikström and Norman (1994). For a penetrating analysis emphasizing the complementarities of different functions in the restructured firms, see Milgrom and Roberts (1990). Their focus of attention differs markedly from ours, however, in that they concentrate on changes in production technology (in terms of the rate of product improvements, processing and delivery time, setup costs, and the like) while we emphasize changes in the nature of work (multi-tasking in particular) and the consequences for labor market activity. See also Appelbaum and Bott (1994), Kremer and Mishkin (1995), Mitchell, Lewin and Lowler III (1990), Levine and Tyson (1990) and Piore and Sabel (1984).

<sup>2</sup>The business literature is replete with case studies of work being reorganized, so that people no longer staff functional departments but rather rotate among multiple tasks in customer-oriented teams. A few examples are ABB, the producer of heavy capital goods, Bell Atlantic, the IBM Credit Corporation, Motorola, and the airline SAS.

processes. The new, smaller, customer-oriented teams require versatility, cognitive and social competence, as well as judgment. Employees involved in producing a product are increasingly required to deal with customers, organize their production and marketing structure, and provide ideas for product design. In addition, employees become involved in managerial tasks, including the evaluation and supervision of their peers, the training of new recruits, the organization of input supplies, the forming of customer relations, and the choice of financial and accounting procedures. What matters is not only the competence in a particular activity of production, organization, development, and marketing, but rather all-round knowledge, potential to acquire multiple skills, and ability to learn how the experience gained from one skill enhances another skill, which facilitates work rotation.

In what follows, the traditional producer organizations will be called “Tayloristic organizations”, whereas the new, integrated ones will be called “holistic organizations”. Needless to say, we do not wish to imply that the restructuring process is uniform throughout the economies of the world; it is certainly not true that all Tayloristic organizations have ever greater incentives to turn into holistic ones with the passage of time. Thus far the restructuring has taken place predominantly in the advanced industrialized market countries, and here the development has been uneven across the various manufacturing and service sectors. The upshot appears to have been a greater diversity of organizations, with the overall employment opportunities at the holistic ones growing relative to those at the Tayloristic ones. As the holistic organizations in these countries proliferate, production activities requiring Tayloristic organizations are often split off or contracted out to other firms in the same country or to firms in other countries where the prevailing human and physical capital is as yet unsuited to versatility across tasks and flexible production.

In the sectors where restructuring has occurred, it is easy to see why multi-tasking and work rotation is central to the entire process. On the technological front, the salient feature of the restructuring process has been the introduction of computer technology and programmable, multi-task equipment in the manufacturing and service sectors; the resulting improvements in production flexibility and information flows have permitted a dramatic expansion in the number of tasks employees are able to perform. On the business management front, the structure of control and responsibility

within firms has become flatter, as middle management is downsized and relatively small customer-oriented teams replace the functional departments (e.g. the production, marketing, design, finance, and administration departments) that characterized the large, traditional firms. Whereas the traditional departments were divided by tasks, the new teams require employees to straddle occupational lines and engage in multi-tasking. With regard to the organization of production, the emphasis is increasingly on shrinking the scale of production runs, reducing order-backlogs, shortening the production cycles, reducing inventories through “just-in-time” production techniques, and creating more opportunities for interaction between design, production, and marketing of products. These developments also encourage firms to seek employees with abilities spanning multiple tasks. Finally, on the marketing front, firms are becoming increasingly responsive to customers’ needs, not only by offering broader product lines, but also providing a wider range of ancillary services (information, advice, repairs, etc.) and permitting increasing customer participation in product design. Here again multi-tasking is essential.<sup>3</sup>

For these reasons, the paper focuses on the role of multi-tasking in the restructuring process. Section 2 analyzes the determinants of a firm’s decision to shift from the traditional organization of work, based on extreme specialization of work and returns to scale, to a new organization requiring greater versatility.<sup>4</sup> On this basis, Section 3 presents a simple model of wage and employment determination in holistic and Tayloristic organizations. Section 4 describes the labor market equilibrium, given the number of holistic and Tayloristic organizations. Section 5 allows the number of organizations to vary and examines the equilibrium in the market for organizations. Section 6 depicts the restructuring process, whereby Tayloristic organizations turn into holistic ones and new holistic organizations enter the economy, and it shows how this process is responsible for the resegmentation of the labor market. Section 7 concludes.

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<sup>3</sup>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.

<sup>4</sup>We also examine workers’ incentives to shift between Tayloristic and holistic sectors. The issue of how individual firms give their employees incentives to engage in multi-tasking lies beyond the scope of this paper; it is addressed in Lindbeck and Snower (1995c).

## 2. *Specialization versus Multi-Tasking*

In deciding whether workers are to specialize or perform multiple tasks,<sup>5</sup> employers face a tradeoff between two sets of returns: (i) “returns from specialization” whereby a worker’s productivity at a particular task increases with his exposure to that task, and (ii) “returns from task complementarities” whereby his activity at one task raises his productivity at another task.

The former are well-known and straightforward. In the short run, the more a worker devotes himself to one task, without being diverted by other activities, the more productive he will be at that task (although the returns may generally be expected to diminish and might eventually even turn negative). Over the long run, the more experience a worker acquires at a task, the more adept he becomes at it, on account of learning by doing (see Arrow (1962)).

The returns from task complementarities have received much less attention thus far; it may be divided into what we will call “technological” and “informational” task complementarities. The *technological task complementarities* are captured by the cross-partial derivatives of the production function: just as labor and capital may be complementary in the production process, so different occupational types of labor may be complementary as well. To take a trivial example, the productivity of managers is enhanced by the services of their secretaries, and the managers do not themselves have to perform secretarial tasks for this complementarity to arise.

The *informational task complementarities* arise when a worker can use the information and skills he acquires at one task to improve his performance at another task. These complementarities give more leverage to the technological task complementarities. For example, when a worker is involved in sales, he gains information about customer preferences that can be put to use when he is engaged in production or the provision of ancillary services to the customers, or even in research and development. Furthermore, when a worker is involved in production, he gains information about technological processes that can be useful when he contributes to product design. In the same vein, information gained in product development, production and marketing can be useful in making hiring and training decisions; and

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<sup>5</sup>Note that the gains from multi-tasking exploited by the worker are analogous to the economies of scope exploited by the firm. See Baumol, Panzer, and Willig (1982).

information gained in product repairing can help improve the customer services ancilliary to the product.

Clearly, both the returns to specialization and the informational task complementarities manifest themselves only with the passage of time. Since our analysis, for simplicity, covers only a single time period, the length of this period must be taken as sufficiently long for these returns to be able to manifest themselves.

The following model examines (a) how the decision to organize work, along Tayloristic lines or holistic lines, depends on the returns from specialization relative to the returns from task complementarities and (b) how recent advances in technologies and in physical and human capital provide incentives for organizational change.

### *2a. Analytical Building Blocks*

We capture these elements in a simple way by first presenting a general formulation of the decision problem about how to organize work and then focusing on a simple special case that highlights the basic principles. Beginning with the general problem, consider an organization that produces an output  $q$  through  $i=1,\dots,\sigma$  tasks.<sup>6</sup> We describe the supply technology and the organization's profit in terms of the following analytical building blocks.

*The Output Function:* Let  $\lambda_i, i=1,\dots,\sigma$  be the labor services, in efficiency units, devoted to the various tasks, respectively. The relation between these labor services and the output may be summarized by the "output function":<sup>7</sup>  $q = f(\lambda_1, \dots, \lambda_\sigma)$ , where  $f_i > 0$  and  $f_{ii} < 0$  for  $i = 1, \dots, \sigma$ . The technological task complementarities are depicted by positive cross-partial derivatives  $f_{ij} > 0$  ( $i = 1, \dots, \sigma$  and  $j \neq i$ ); while the informational task complementarities are covered below.

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<sup>6</sup>The tasks need not be restricted to production. They could also cover product development, marketing, or administration. The output may be thought of as a good or service, possibly combined with such auxiliary services as distribution, customer information, and repairs.

<sup>7</sup>We refrain from calling this function a production function since it could equally well cover sales, marketing, and so on.

*The Constituents of the Labor Services:* The labor services  $\lambda_i, i = 1, \dots, \sigma$  depend on the number of the employees providing these services, their labor endowments at the various tasks, and the time they devote to these tasks. Let us divide the employees into  $\mu$  homogeneous groups,  $k=1, \dots, \mu$ . Let each worker in the  $k$ 'th group have the following factor of labor endowments across tasks:  $(e_{1k}, \dots, e_{\sigma k})$ , where  $e_{ik}$  is efficiency units of labor of a type- $k$  worker at task  $i$  per unit of time.

Let  $\tau_{ik}$  be the fraction of each type- $k$  worker's available time devoted to task  $i$ . Normalizing the total available time to unity,  $\sum_i \tau_{ik} = 1$ . Furthermore, let  $n_k$  be the number of type- $k$  workers employed by the organization. Then the total labor services in efficiency units devoted to tasks  $i$  is  $\lambda_i = \sum_k e_{ik} \tau_{ik} n_k$ .

*The Constituents of the Labor Endowments ( $e_{ik}$ ):* The labor endowments, in turn, have two determinants in our model: the "returns to specialization" ( $s_{ik}$  for the type- $k$  worker at task  $i$ ), and the "informational task complementarity" ( $c_{ik}$  for the type- $k$  worker at task  $i$ ):  $e_{ik} = \xi_{ik}(s_{ik}, c_{ik})$ , where  $(\partial \xi_{ik} / \partial s_{ik}), (\partial \xi_{ik} / \partial c_{ik}) > 0$ .

We assume that each worker has positive returns to specialization, i.e. the greater the fraction of his working time devoted to a particular task, the more productive he becomes at that task (i.e. the greater his labor endowment):  $s_{ik} = s_{ik}(\tau_{ik})$ , where  $s'_{ik} > 0$ . Furthermore, we assume that each worker faces positive informational task complementarities, i.e. the greater the fraction of his working time devoted to the tasks  $j \neq i$ , the more information he gains about those tasks and consequently the more productive he becomes at task  $i$ :  $c_{ik} = c_{ik}(\tau_{jk} | j \neq i)$ , where  $c'_{ik} > 0$ .

*The Organization's Decision Problem:* The revenue function may be written as

$$q = f(\underline{\lambda}_i), \text{ where } \underline{\lambda}_i = (\lambda_1, \dots, \lambda_i, \dots, \lambda_\sigma), \quad \lambda_i = \sum_k e_{ik}(\tau_{ik}) \tau_{ik} n_k,$$

$$e_{ik}(\tau_{ik}) = \xi_{ik}(s_{ik}(\tau_{ik}), c_{ik}(\tau_{jk} | j \neq i)). \text{ Thus } q = q(\underline{\tau}_{ik}, \underline{n}_k), \text{ where}$$



$\underline{\tau}_{ik} = (\tau_{1k}, \dots, \tau_{ik}, \dots, \tau_{\sigma k})$ , and  $\underline{n}_k = (n_1, \dots, n_k, \dots, n_\mu)$ . For simplicity, let the organization's profit be expressed as  $\pi(\underline{\tau}_{ik}, \underline{n}_k) = q(\underline{\tau}_{ik}, \underline{n}_k) - \kappa(\underline{n}_k)$ , where  $\kappa(\underline{n}_k)$  are the organization's costs, which we assume to be independent of the workers' allocation of time between tasks.<sup>8</sup>

Then the organization's decision problem is to maximize  $\pi = \pi(\underline{\tau}_{ik}, \underline{n}_k)$  with respect to  $\tau_{ik}$  and  $n_k$ , subject to  $\sum_i \tau_{ik} = 1$  for  $k = 1, \dots, \mu$ .

It turns out, however, that the basic principles governing the organization of work can be derived quite simply in the two-by-two case in which output is produced through two tasks, 1 and 2, performed by two types of labor, 1 and 2. This provides a simple microfoundation for the aggregative analysis in the following section; and thus we will concentrate on this case in what follows. In this context, multi-tasking means that both workers do both of the available tasks (though different workers may do them in different proportions), whereas in the general formulation each worker may of course perform only a few of the existing tasks and different workers will commonly perform different combinations of tasks.

In short, the output function is now simply

$$q = f(\lambda_1, \lambda_2) \tag{1}$$

The two types of workers will be called "type-1 workers," whose skills give them a comparative advantage at task 1, and "type-2 workers," with a comparative advantage at task 2. Simplifying the notation for this special case, let  $e_1$  and  $e_2$  be the labor endowment for each type-1 worker at tasks 1 and 2, respectively; and let  $E_1$  and  $E_2$  be the labor endowment of each type-2 worker at these tasks. The assumption that type-1 workers have a comparative advantage at task 1 (and, obversely, that type-2 workers have a comparative advantage at task 2) may then be expressed as  $(e_1 / e_2) > (E_1 / E_2)$ .

Let  $\tau$  be the fraction of each type-1 worker's available time devoted to task 1, and  $1-\tau$  be the remaining fraction devoted to task 2. Similarly, let  $(1-T)$  and  $T$  be the type-2 worker's distribution of time between tasks 1 and 2, respectively. Furthermore,

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<sup>8</sup>This assumption can be relaxed without substantially affecting our qualitative conclusions. See Lindbeck and Snower (1995b).

let  $n$  and  $N$  be the number of type-1 and type-2 workers employed, respectively. Then the total labor services in efficiency units devoted to tasks 1 and 2 is

$$\begin{aligned}\lambda_1 &= e_1 \cdot \tau \cdot n + E_1 \cdot (1-T) \cdot N \\ \lambda_2 &= e_2 \cdot (1-\tau) \cdot n + E_2 \cdot T \cdot N\end{aligned}\quad (2)$$

We write the labor endowments of the type-1 worker at tasks 1 and 2, respectively, as

$$e_1 = \xi_1(s_1, c_1) \quad \text{and} \quad e_2 = \xi_2(s_2, c_2) \quad (3a)$$

and the corresponding labor endowments of the type-2 worker as

$$E_1 = \Xi_1(S_1, C_1) \quad \text{and} \quad E_2 = \Xi_2(S_2, C_2) \quad (3b)$$

where  $(\partial \xi_j / \partial s_i), (\partial \xi_j / \partial c_i) > 0$ ,  $(\partial \Xi_j / \partial S_i), (\partial \Xi_j / \partial C_i) > 0$ , for  $i, j=1, 2$ . The returns to specialization for each type-1 worker,

$$s_1 = s_1(\tau) \quad \text{and} \quad s_2 = s_2(1-\tau) \quad (4a)$$

where  $s_1', s_2' > 0$ ; and similarly for each type-2 worker,

$$S_1 = S_1(1-T) \quad \text{and} \quad S_2 = S_2(T) \quad (4b)$$

where  $S_1', S_2' > 0$ . Analogously, the informational task complementarity for each type-1 worker is

$$c_1 = c_1(1-\tau) \quad \text{and} \quad c_2 = c_2(\tau) \quad (5a)$$

where  $c_1', c_2' > 0$ ; and similarly for each type-2 worker,

$$C_1 = C_1(T) \quad \text{and} \quad C_2 = C_2(1-T) \quad (5b)$$

where  $C_1', C_2' > 0$ .

For expositional simplicity, but without substantive loss of generality, we assume that the comparative advantages of the type-1 and type-2 workers at the two tasks are symmetric. Specifically, for any positive real numbers  $x$ ,  $0 \leq x \leq 1$ , we require  $s_1(x) = S_2(x)$ ,  $s_2(x) = S_1(x)$ ,  $c_1(x) = C_2(x)$ , and  $c_2(x) = C_1(x)$ , so that the returns to specialization of type-1 worker at task 1 are identical to the returns to specialization of type-2 worker at task 2, and similarly for the type-1 worker at task 2 and the type-2 worker at task 1. In addition, we assume that the labor services  $\lambda_1$  and  $\lambda_2$  enter the output function symmetrically, i.e. for any positive number  $z$ , we require that  $f(z, \lambda_2) = f(\lambda_1, z)$  for  $\lambda_1 = \lambda_2$ .

Finally, we assume, plausibly, that

$$\begin{aligned}\frac{\partial \lambda_1}{\partial \tau} &= \left( \frac{\partial \xi_1}{\partial s_1} \frac{\partial s_1}{\partial \tau} - \frac{\partial \xi_1}{\partial c_1} \frac{\partial c_1}{\partial \tau} \right) \tau n + e_1 n > 0 \\ \frac{\partial \lambda_2}{\partial (1-\tau)} &= \left( \frac{\partial \xi_2}{\partial s_2} \frac{\partial s_2}{\partial (1-\tau)} - \frac{\partial \xi_2}{\partial c_2} \frac{\partial c_2}{\partial (1-\tau)} \right) (1-\tau) n + e_2 n > 0\end{aligned}\quad (6)$$

i.e. any increase in the time spent at a particular task raises the labor services (in efficiency units) devoted to this task. Similarly,  $(\partial \lambda_1 / \partial (1-T)), (\partial \lambda_2 / \partial T) > 0$ .

*Profit:* The organization's profit is

$$\pi(\tau, T, n, N) = q(\tau, T, n, N) - \kappa(n, N) \quad (7)$$

On account of the symmetry assumptions above,  $\pi(\tau, x, n, N) = \pi(x, T, n, N)$  when  $\tau = T$  and  $n = N$ , i.e. the organization will distribute the type-1 and type-2 workers' time symmetrically across the two tasks when equal number of these workers are employed. Thus it is sufficient to examine the organization's profit-maximizing decision with respect to  $\tau$  alone, focusing our analysis entirely on the type-1 workers.

Under these assumptions, we now proceed to examine the determinants of the Tayloristic versus holistic organization of work.

### *2b. The Tayloristic versus Holistic Organization of Work*

Under the Tayloristic organization of work, type-1 workers specialize in task 1:  $\tau=1$ ; whereas under the holistic work organization, the worker performs both tasks,<sup>9</sup> so that  $0 < \tau < 1$ . (Similarly, for type-2 workers,  $T=1$  under Tayloristic organization and  $0 < T < 1$  under holistic organization; but, as noted, the analysis below need only focus on type-1 workers.) Thus, given that the firm maximizes its profit,<sup>10</sup> its choice of work organization depends wholly on the following conditions:

*Given the profit function  $\pi = \pi(\tau, T, n, N)$ , the profit-maximizing organization of work is holistic ( $0 < \tau^* < 1$ ) whenever the following condition is fulfilled:*

<sup>9</sup>Unless the worker is perfectly versatile, the two tasks will not however be performed at equal levels.

<sup>10</sup>We assume that  $(\partial \pi / \partial \tau)$  is monotonic in  $\tau$ , thereby excluding the possibility of multiple interior optima.

$$\begin{aligned} \frac{\partial \pi}{\partial \tau} &= 0 \text{ in the domain } 0 < \tau < 1, \text{ and} \\ \frac{\partial^2 \pi}{\partial \tau^2} &< 0 \text{ in the neighborhood of } \frac{\partial \pi}{\partial \tau} = 0 \end{aligned}$$

and the profit-maximizing organization of work is Tayloristic ( $\tau=1$ ) whenever this condition is violated.

The intuition is straightforward and powerful: Since workers specialize by task in a Tayloristic organization, the profit-maximizing allocation of time across tasks will lie at a corner point. However, since workers in a holistic organization do not specialize in this way, the profit-maximizing allocation of time must lie in the interior of the feasible set.

To show in a particularly simple way how the profit-maximizing organization of work depends on the returns to specialization and the technological and informational task complementarities, we make some simplifying assumptions. Let

$$e_i = \xi_i(s_i, c_i) = s_i \cdot c_i, \quad i = 1, 2 \quad (8)$$

Now define the elasticity of the returns to specialization with respect to the fraction of time the type-1 worker devotes to the two tasks as

$$\eta_1^s = \frac{s_1'}{s_1} \tau, \quad \eta_2^s = \frac{s_2'}{s_2} (1 - \tau) \quad (9a)$$

and define the elasticity of informational task complementarities with respect to the fraction of time the type-2 worker devotes to the two tasks as

$$\eta_1^c = -\frac{c_1'}{c_1} \tau, \quad \eta_2^c = -\frac{c_2'}{c_2} (1 - \tau) \quad (9b)$$

For expositional simplicity, we assume these elasticities to be constants.<sup>11</sup> Then condition (6) holds so long as  $1 + \eta_i^s + \eta_i^c > 0$ , for  $i = 1, 2$ , and  $n > 0$ . (The reason is that  $(\partial \lambda_i / \partial \tau) = (1 + \eta_i^s + \eta_i^c) \cdot (s_i \cdot c_i \cdot n) > 0$ .)

Then the first-order condition for the profit-maximizing allocation of time between tasks (summarized by  $\tau$ ) may be expressed as

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<sup>11</sup>This assumption is not one of substance. Lindbeck and Snower (1995b) allow for variable elasticities, constrained only by the positive first derivatives of the  $s$  and  $c$  functions and condition (6).

$$\frac{\partial \pi}{\partial \tau} = f_1 \cdot (1 + \eta_1^s + \eta_1^c) \cdot (s_1 \cdot c_1 \cdot n) - f_2 \cdot (1 + \eta_2^s + \eta_2^c) \cdot (s_2 \cdot c_2 \cdot n) = 0 \quad (10)$$

Define the elasticity of the marginal product with respect to labor as<sup>12</sup>

$$\varepsilon_{ij} = \frac{\partial f_i}{\partial \lambda_j} \frac{\lambda_j}{f_i} = \frac{f_{ij}}{f_i} e_j \nu n \quad (11)$$

for  $i, j = 1, 2$ , where  $\nu = \tau$  when  $j = 1$  and  $\nu = 1 - \tau$  when  $j = 2$ . Then it can be shown that the second-order condition is

$$\begin{aligned} \frac{\partial^2 \pi}{\partial \tau^2} = & (1 + \eta_1^s + \eta_1^c) \cdot (s_1 \cdot c_1 \cdot n) \cdot \left[ \frac{f_1}{\tau} [\varepsilon_{11}(1 + \eta_1^s + \eta_1^c) + (\eta_1^s + \eta_1^c)] - \varepsilon_{12} \frac{f_1}{1 - \tau} (1 + \eta_2^s + \eta_2^c) \right] \\ & + (1 + \eta_2^s + \eta_2^c) \cdot (s_2 \cdot c_2 \cdot n) \cdot \left[ \frac{f_2}{1 - \tau} [\varepsilon_{22}(1 + \eta_2^s + \eta_2^c) + (\eta_2^s + \eta_2^c)] - \varepsilon_{21} \frac{f_2}{\tau} (1 + \eta_1^s + \eta_1^c) \right] \end{aligned} \quad (12)$$

In this context we are now able to analyze the determinants of the restructuring process whereby Tayloristic organizations turn into holistic ones. We conceive of this process as being driven by two major forces, one concerning physical capital and the other human capital.

First, recent *changes in production and information technologies* appear to be strongly biased in favor of holistic organizations. The big breakthroughs in mass production that were originally responsible for the spread of Tayloristic organizations - such as assembly lines, specialized manufacturing equipment, organizational networks within firms - occurred predominantly in the first part of this century. The important recent advances - covering the introduction of computerized production, design, product development, and information gathering processes and the adoption of multi-purpose machine tools and programmable manufacturing equipment - favor the holistic organizations, since they provide rapid and cheap access to information and encourage the exercise of multiple skills, by increasing the complementarities across different tasks.

In terms of our model, the advances in production technology that increase the technological task complementarities may be represented by a rise in  $\varepsilon_{ij}$  for  $i \neq j$ , since they increase the amount by which the marginal product  $f_i$  rises in response to

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<sup>12</sup>Recall that, by symmetry,  $n = N$ .

additional labor services  $\lambda_j$ , i.e. in proportional terms, they increase  $(\partial f_i / f_i) / (\partial \lambda_j / \lambda_j)$  for  $i \neq j$ .

Moreover, the *advances in information technology* that increase the informational task complementarities raise the productivity of labor in task 1 when the fraction of time devoted to task 2 is increased, i.e. in proportional terms, they increase  $(\partial c_1 / c_1) / (\partial(1-\tau) / (1-\tau))$ . This means that they reduce  $-(\partial c_1 / c_1) / (\partial \tau / \tau)$ , which is the definition of the elasticity of the informational task complementarity. Thus, in general, they reduce  $\eta_i^c$ , for  $i = 1, 2$ .

Second, the *steady rise of human capital*, produced largely by education systems, has generated a steadily increasing supply of educated workers capable of performing the multiple tasks required by the holistic organizations.<sup>1314</sup> In our model, the advances in human capital that make workers more versatile may be represented by an increase of  $s_2(x)$  relative to  $s_1(x)$ , for any positive  $x$ ,  $0 \leq x \leq 1$ .

The profit-maximizing responses of work organization to these changes are summarized in the following proposition:

*Proposition 1: In response to a sufficiently large (a) improvement in information technology that reduces  $\eta_i^c$ , for  $i = 1, 2$ , (b) improvement in production technology that raises  $\varepsilon_{ij}$ , for  $i \neq j$ , and (c) improvement in the versatility of human capital that raises  $s_2(x)$  relative to  $s_1(x)$ , for any positive  $x$ ,  $0 \leq x \leq 1$ , Tayloristic organizations restructure into holistic organizations.*

(Proof: Suppose that initially  $(\partial^2 \pi / \partial \tau^2) > 0$ . Then a sufficiently large reduction in  $\eta_i^c$ , for  $i = 1, 2$ , and rise in  $\varepsilon_{ij}$ , for  $i \neq j$  will lead to  $(\partial^2 \pi / \partial \tau^2) < 0$ . But  $(\partial^2 \pi / \partial \tau^2) < 0$  is still compatible with a corner-point solution, provided that the

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<sup>13</sup>These workers also have an intrinsic need to be stimulated at work and, since holistic work tends to be more varied, creative, and challenging than the narrowly defined Tayloristic jobs, these workers are less inclined to work for Tayloristic organizations than for holistic ones.

<sup>14</sup>A third force, that lies beyond the scope of our analysis, is a trend change in consumer preferences in favor of more highly differentiated products. This favors holistic organizations over Tayloristic ones since they are able to produce broader ranges of products in smaller batch sizes.

production possibility frontier is sufficiently skewed in favor of  $\lambda_1$ . However, a sufficiently large rise in  $s_2(x)$  relative to  $s_1(x)$ , for any positive  $x$ ,  $0 \leq x \leq 1$ , will diminish this skewness and lead to an interior solution.)

A simple way of visualizing these developments is in terms of changes in the organization's production possibility frontier and iso-profit curve. Specifically, equations (2) yield a production possibility frontier in  $\lambda_1 - \lambda_2$  space, denoted by PPF in Figures 1. The iso-profit curve, denoted by IPC in the figure, is given by  $f(\lambda_1, \lambda_2) - wn - WN - \bar{\pi} = 0$ . The organization's problem is to choose  $\tau$  so as to reach the highest iso-profit curve achievable along its production possibility frontier. In this context, the advances in information technology make the production possibility frontier less convex (since the slope of the frontier is  $(\partial\lambda_2 / \partial\tau) / (\partial\lambda_1 / \partial\tau)$ ), and the advances in production technology make the iso-profit curve more convex (since the slope of this curve is  $-f_1/f_2$ ). Furthermore, the increases in the versatility of human capital reduces the skewness of the production possibility frontier.

Suppose that initially a Tayloristic organization of work is worthwhile, so that the firm's profit-maximization point for type-1 labor may be depicted by point  $E_T$  in Figure 1a. Now observe that each of the developments discussed above helps to transform the initial corner-point optimum into an interior optimum. Consequently the firm's initial profit-maximization problem eventually turns into that pictured in Figure 1b, with the optimal allocation of type-1 labor given by point  $E_H$ .

Finally, the role of task complementarities and returns to specialization can be brought into sharpest relief by examining two polar extremes of a worker's human capital across the two tasks: complete specialization and complete versatility:

(I) When there is *complete specialization*, each worker is productive only at the task in which he has a comparative advantage:  $s_1(\tau) > 0$  and  $s_2(1-\tau) = 0$  for type-1 workers, and similarly type-2 workers. In this case equation (10) becomes

$$\frac{\partial\pi}{\partial\tau} = f_1 \cdot (1 + \eta_1^s + \eta_1^c) \cdot (s_1 \cdot c_1 \cdot n) > 0 \quad (10')$$

Since an interior optimum in the allocation of time across tasks is impossible in this case, the organization of work will invariably be Tayloristic.

(II) When workers are *completely versatile*, they are equally productive at both tasks:  $s_1(x) = s_2(x) = S_1(x) = S_2(x) = s(x)$  and  $c_1(y) = c_2(y) = C_1(y) = C_2(y) = c(y)$  for any positive  $x$  and  $y$ ,  $0 \leq x, y \leq 1$ . Here type-1 and type-2 workers can no longer be distinguished from one another. Then, by our assumption of symmetry,  $f_1 = f_2 = f'$ ,  $\varepsilon_{11} = \varepsilon_{22} = \varepsilon_{ii}$ ,  $\eta_1^s = \eta_2^s = \eta^s$ ,  $\eta_1^c = \eta_2^c = \eta^c$  and  $\varepsilon_{12} = \varepsilon_{21} = \varepsilon_{ij}$  for  $i \neq j$ . Thus the second-order condition (12) reduces to

$$\frac{\partial^2 \pi}{\partial \tau^2} = 4(1 + \eta^s + \eta^c) \cdot (s \cdot c \cdot n) \cdot \left[ f' \cdot \left[ \varepsilon_{ii} (1 + \eta^s + \eta^c) + (\eta^s + \eta^c) \right] - \varepsilon_{ij} \cdot f' (1 + \eta^s + \eta^c) \right] \quad (12')$$

The implications of complete versatility, contained in this equation, become transparent in the following special cases.

Case IIa: When there are constant returns to labor (so that  $f_{ij} = \varepsilon_{ij} = 0$ , for  $i, j = 1, 2$ ), the organization of work depends entirely on the returns to specialization relative to the informational task complementarities: When an increase in time at a task raises the productivity of labor at that task by more than it raises the productivity of labor at the other task, then work will be organized along Tayloristic lines. In other words, there will be complete specialization when an increase in experience at a task raises the proportional returns to specialization at that task by more than it raises the associated informational task complementarities, i.e. when  $\eta^s + \eta^c > 0$ . Conversely, the organization of work will be holistic when an increase in experience at a task raises the informational task complementarities by more than the returns to specialization, i.e. when  $\eta^s + \eta^c < 0$ . In sum:

*Proposition 2a: If the marginal products of labor are constant ( $\varepsilon_{ij} = 0$  for  $i, j = 1, 2$ ), then the organization of work will be holistic when  $\eta^s + \eta^c < 0$ , and Tayloristic when  $\eta^s + \eta^c > 0$ .*

It can be shown that when  $\eta^s + \eta^c > 0$ , this production possibility frontier is convex, as shown in Figure 2a. If  $\varepsilon_{ij} = 0$  for  $i, j = 1, 2$ , then the iso-profit curve *IPC* is linear in  $\lambda_1 - \lambda_2$  space. When workers are completely versatile, the production



possibility frontier is symmetric in  $\lambda_1 - \lambda_2$  space, and by our symmetry assumption across tasks, the iso-profit curve is symmetric in the same sense. The highest iso-profit curve is reached at the two end-points of the production possibility frontier:  $(0, \bar{\lambda}_2)$  and  $(\bar{\lambda}_1, 0)$ , which implies a Tayloristic organization of work, with  $\tau^* = 0$  and  $\tau^* = 1$ , respectively.<sup>15</sup>

On the other hand, when  $\eta^s + \eta^c < 0$ , the production possibility frontier is concave, as illustrated in Figure 2b. Then, clearly, the highest linear iso-profit curve is attained in the interior of the production possibility frontier, at  $(\lambda_1^*, \lambda_2^*)$  in the figure. This implies a holistic organization of work, with  $\tau^* = 1/2$ .

Case IIb: When the returns to specialization and the associated informational task complementarities are equally responsive to changes in the fraction of available time devoted to the relevant task, then the organization of work depends on the degree to which tasks are technologically complementary or substitutable: In particular, if an increase in the fraction of time devoted to a task raises the returns to specialization at that task by the same proportional amount as the associated informational task complementarities ( $\eta^s + \eta^c = 0$ ), the organization of work will be Tayloristic when the marginal product of labor service  $i$  ( $i=1,2$ ) diminishes more rapidly with labor service  $j$  ( $j \neq i$ ) than with labor service  $i$ :  $\varepsilon_{ij} < \varepsilon_{ii}$ . Conversely, the organization will be holistic when  $\varepsilon_{ij} > \varepsilon_{ii}$ . In sum,

*Proposition 2b: If  $\eta^s + \eta^c = 0$ , then the organization of work will be holistic when  $\varepsilon_{ij} > \varepsilon_{ii}$  and Tayloristic when  $\varepsilon_{ij} < \varepsilon_{ii}$ , for  $i \neq j$ .*

(Given that  $\varepsilon_{ii} < 0$ , this implies of course that work will be organized along holistic lines whenever there are technological task complementarities, so that  $\varepsilon_{ij} > 0$  for  $i \neq j$ .)

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<sup>15</sup>Needless to say, this solution is not one of multiple equilibria. Rather, when workers are completely versatile, type-1 and type-2 workers are identical, and thus the organization will find it worthwhile to devote half its workforce to task 1 and the other half to task 2.

If  $\eta^s + \eta^c = 0$ , the production possibility frontier is linear; and if  $\varepsilon_{ij} < \varepsilon_{ii}$ , the iso-profit curve is concave to the origin, as shown in Figure 2c. Thus, the highest iso-profit curve is once again attained at the end-points of the production possibility frontier, and workers will specialize by task. However, if  $\varepsilon_{ij} > \varepsilon_{ii}$ , the iso-profit curve is convex to the origin, as illustrated in Figure 2d. Here the highest iso-profit curve is reached in the interior of the a linear production possibility frontier, so that workers engage in multi-tasking.

### 3. Wage and Employment Determination

Thus far we have been concerned with what determines the organization of work, along Tayloristic or holistic lines; and for this purpose it sufficed to assume that workers' comparative advantages at the two tasks are symmetric: specifically,  $(e_1(\tau)/e_2(\tau)) = (E_2(T)/E_1(T))$  for  $\tau = T$ . The next step is to analyze how the reorganization of work leads to a resegmentation of the labor market, in which the traditional occupational (task-oriented) boundaries break down and the distinction between versatile workers (who can perform multiple tasks) and non-versatile ones (who can perform only one) becomes important instead. For this purpose, it now becomes appropriate to differentiate workers in terms of their degree of versatility. For expositional simplicity, it will be convenient to assume that workers of type  $i$  ( $i=1,2$ ) can each be divided into two distinct groups: “versatile workers” who are capable of both tasks and “non-versatile workers” who are capable of only one.

The labor endowment of a type-1 versatile worker at task  $i$  ( $i = 1,2$ ) is given by equation (8):  $e_i = \xi_i(s_i, c_i) = s_i \cdot c_i$ ,  $i = 1,2$ ; and analogously for the type-2 worker. The labor endowments of the type-1 and type-2 non-versatile workers are  $e_1 = s_1(1) \cdot c_1(0)$  and  $E_2 = S_2(1) \cdot C_2(0)$ . In words, a non-versatile type-1 worker has the endowment that a versatile type-1 worker would have if he performed only the first task; and similarly for the non-versatile type-2 worker.

A fixed proportion  $\alpha$  of the working population is able to perform task 1 and an identical proportion is able to perform task 2. Of the groups of workers able to perform one particular task, a fixed proportion  $\beta$  is also able to perform the other

task. Normalizing the aggregate size of the working population to unity, the aggregate supply of versatile type-1 workers ( $A_1^v$ ) and versatile type-2 workers ( $A_2^v$ ) is

$$A_1^v = A_2^v = \alpha \cdot \beta \quad (13a)$$

and the aggregate supply of non-versatile type-1 ( $A_1^s$ ) and non-versatile type-2 workers ( $A_2^s$ ) is

$$A_1^s = A_2^s = 1 - \alpha \cdot \beta \quad (13b)$$

Holistic organizations, clearly, require only versatile workers. The Tayloristic ones, on the other hand, are able to use both versatile and non-versatile ones.

We assume, along the traditional lines, that the wage and employment decisions are made in two stages: first the wage is set, taking the employment repercussions into account; then the employment decisions are made, taking the wage as given. For brevity, this paper focuses on the effect of work organization on employment<sup>16</sup> and thus we will adopt a standard, reasonably general, model of wage determination.

Quite simply, the wage offer  $w_j^o$ , for any homogenous group  $j$  of workers, is assumed to depend positively on the reservation wage  $r_j$  (that makes the workers indifferent between employment unemployment) and negatively on the unemployment rate  $u_j \equiv 1 - (N_j^D / N_j^S)$ , where  $N_j^D$  is the aggregate demand and  $N_j^S$  is the aggregate supply:

$$w_j^o = w_j^o(u_j, r_j), \quad \frac{\partial w_j^o}{\partial u_j} < 0, \quad \frac{\partial w_j^o}{\partial r_j} > 0 \quad (14a)$$

A wide variety of union, efficiency wage, and bargaining models yield wage equations belonging to this broad family.

By symmetry, the wage setting equation for the type-2 workers is

$$W_j^o = W_j^o(U_j, R_j), \quad \frac{\partial W_j^o}{\partial U_j} < 0, \quad \frac{\partial W_j^o}{\partial R_j} > 0 \quad (14b)$$

where  $W_j^o$  is the wage of the  $j$ 'th group of type-2 workers,  $U_j$  is their unemployment rate, and  $R_j$  is their reservation wage.

In line with the discussion of Section 1, we assume that versatile workers have a higher reservation wage for Tayloristic jobs than for holistic ones. For simplicity, let

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<sup>16</sup>Lindbeck and Snower (1995b) also examine how work organization influences the nature of wage setting.

the versatile workers' reservation wage at Tayloristic jobs be  $r^+$  (a constant) and all other workers' reservation wage be  $r^-$  (another constant), where  $r^+ > r^-$ .

Turning to the organizations' employment decisions, note that in each Tayloristic organization, workers specialize: the type-1 workers specialize in task 1 ( $\tau = 1$ ) and the type-2 workers specialize in task 2 ( $T = 1$ ), so that the production function becomes

$$q_T = f((s_1(1) \cdot c_1(0) \cdot n), (S_2(1) \cdot C_2(0) \cdot N)) \quad (15T)$$

and in a holistic organization, where both types of workers perform both tasks, the production function becomes

$$q_H = f \left[ \begin{array}{l} (s_1(\tau) \cdot c_1(1-\tau) \cdot \tau \cdot n + S_1(1-T) \cdot C_1(T) \cdot (1-T) \cdot N), \\ (s_2(1-\tau) \cdot c_2(\tau) \cdot (1-\tau) \cdot n + S_2(T) \cdot C_2(1-T) \cdot (1-T) \cdot N) \end{array} \right] \quad (15H)$$

where  $0 < \tau, T < 1$ .

We specify the profit functions of the Tayloristic and holistic organizations as

$$\Pi_i = q_i - w_i n_i - W_i N_i - \psi_i(n_i) - \Psi_i(N_i) - \phi_i, \quad i = T, H \quad (7')$$

where  $i = T, H$  stands for the type of organization (Tayloristic or holistic),  $w_i$  and  $W_i$  are the real wages paid to type-1 and type-2 workers by these organizations,<sup>17</sup>  $\phi_i$  is a fixed cost, and  $\psi_i(n_i)$  and  $\Psi_i(N_i)$  may be interpreted as the cost of resources (e.g. capital services, training) used in conjunction with the number of people employed, where  $\psi_i', \Psi_i' > 0$ , and  $\psi_i'', \Psi_i'' > 0$  so that as employment rises, increasingly costly resources are brought into use. For algebraic simplicity, but without substantial loss of generality, we assume constant returns to labor, i.e. that  $f_1 = \bar{f}_1$  and  $f_2 = \bar{f}_2$  are constants. Inserting these constants into the profit-maximizing condition (10), we obtain the profit-maximizing time allocation decision  $\tau_H = \tau_H^*$  for holistic organizations and  $\tau_T^* = 1$  for Tayloristic organizations. (Recall that symmetry permits us to focus exclusively on the type-1 workers) Given these time allocation decisions,

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<sup>17</sup>Holistic organizations, as noted, employ only the versatile workers. By symmetry, the type-1 and type-2 versatile workers have the same marginal product and the same reservation wage and thus receive the same wage. In Tayloristic organizations the marginal products of versatile and non-versatile type-1 workers are identical (and similarly for the type-2 workers), and we assume that these organizations pay the same wage to workers from both groups. (Allowing them to pay different wages to versatile and non-versatile workers would make no substantial difference to our conclusions.)

the profit-maximizing number of people to employ in the Tayloristic and holistic organizations may be solved from

$$\frac{\partial \Pi_i}{\partial n_i} = a_i - w_i - \Psi_i(n_i) = 0, \quad i = T, H \quad (16)$$

where  $a_i = \bar{f}_1 \cdot s_1(\tau_i^*) \cdot c_1(1 - \tau_i^*) \cdot \tau_i^* + \bar{f}_2 \cdot s_2(1 - \tau_i^*) \cdot c_2(\tau_i^*) \cdot (1 - \tau_i^*)$ . The associated labor demand function is<sup>18</sup>

$$n_i = g_i(a_i - w_i) \quad (16a)$$

where  $g = (\Psi')^{-1}$ . By symmetry, the labor demand function for type-2 labor is

$$N_i = g_i(A_i - W_i) \quad (16b)$$

where  $A_i = \bar{f}_1 \cdot S_1(T_i^*) \cdot C_1(1 - T_i^*) \cdot T_i^* + \bar{f}_2 \cdot S_2(1 - T_i^*) \cdot C_2(T_i^*) \cdot (1 - T_i^*)$ .

We now use the wage setting equations (15a) and (15b) and the labor demand equations (16a) and (16b) to describe the equilibrium in the labor market.

#### 4. Equilibrium in the Labor Market

We now describe the equilibrium in the labor market, taking the number of Tayloristic organizations ( $F_T$ ) and the number of holistic ones ( $F_H$ ) as given. To capture some salient differences between holistic and Tayloristic organizations in practice, we parameterize our model so that, in the labor market equilibrium, employment per Tayloristic organization exceeds employment per holistic organization ( $n_T^* > n_H^*$  and  $N_T^* > N_H^*$ ), and the holistic wage exceeds the Tayloristic wage ( $w_H^* > w_T^*$  and  $W_H^* > W_T^*$ ). This requires that<sup>19</sup> (i) the fixed cost  $\phi_T$  of operating the Tayloristic organization must be sufficiently large relative to the fixed cost  $\phi_H$  of operating the holistic organization or (ii) the number of versatile workers is sufficiently small relative to the number of non-versatile ones, or both.

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<sup>18</sup>Since non-versatile type- $i$  workers ( $i=1,2$ ) are equally productive as type- $i$  versatile workers who specialize at task  $i$ , the Tayloristic organization's labor demand function for these two types of workers is the same. The second-order conditions for profit maximization are guaranteed by  $\Psi_j''$ ,  $\Psi_j'''$ .

<sup>19</sup>To see these assumptions imply these two conclusions, observe that (as we will show in the next section) the greater is the fixed cost  $\phi_T$  relative to  $\phi_H$ , the smaller will be the equilibrium number of Tayloristic organizations relative to the number of holistic ones. Consequently, the larger will be the size of the Tayloristic organization in terms of employment relative to that of the holistic organization, and the lower will be the Tayloristic wage relative to the holistic wage. Moreover (as we show in this section) the smaller is the holistic labor supply relative to the Tayloristic one, the greater will be the equilibrium holistic wage relative to the Tayloristic one.

Since the holistic wage is higher than the Tayloristic wage in the labor market equilibrium and since versatile workers have a preference for holistic over Tayloristic work, the aggregate supply of workers<sup>20</sup> available to the holistic firms is the aggregate supply of versatile workers of that type,  $\alpha \cdot \beta$ . Under these circumstances, the labor market equilibrium can be derived recursively: the holistic equilibrium may be computed first, and this equilibrium then determines the supply of labor to the Tayloristic market, whose equilibrium may be derived next.

The aggregate labor market equilibrium is pictured in Figure 3. On the horizontal axis, aggregate Tayloristic employment,  $L_T^* = F_T \cdot (n_T^* + N_T^*)$ , is measured from left to right and aggregate holistic employment,  $L_H^* = F_H \cdot (n_H^* + N_H^*)$ , is measured from right to left. Accordingly, the aggregate Tayloristic labor demand curve ( $L_T^D$ ), wage setting curve ( $WS_T$ ), and labor supply curve ( $L_T^S$ ) are read from the left in the figure, and the holistic labor demand curve ( $L_H^D$ ), wage setting curve ( $WS_H$ ), and labor supply curve ( $L_H^S$ ) are read from the right.

#### 4a. The Holistic Market

The nature of the equilibrium in the holistic market depends on the demand for versatile workers (given by the labor demand function  $g_H$ ) relative to the supply of them ( $L_H^S = \alpha \cdot \beta$ ). There are two equilibrium scenarios, the first of which is illustrated by point  $H$  in Figure 3:

- If the demand for versatile workers is “small” relative to the supply, the equilibrium is given by the intersection between the labor demand curve and the wage setting curve:<sup>21</sup>

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<sup>20</sup>This is the supply of type-1 workers. Recall that the symmetry properties above permit us to focus just on type-1 workers.

<sup>21</sup>The equation number (S1H) represents “scenario 1 for the holistic market. By symmetry, the sum of the aggregate labor demands for the type-1 and type-2 workers is equal to twice the aggregate demand for the type-1 worker.

$$\begin{aligned}
L_H^D &= F_H \cdot 2 \cdot g_H(a_H - w_H) \\
w_H^o &= w_H^o \left( \frac{N_H^D}{\alpha \cdot \beta}, r^- \right) \\
w_H &= w_H^o
\end{aligned} \tag{S1H}$$

(where the first argument of the wage setting function is the unemployment rate of versatile workers,  $(1 - (L_H^D / L_H^S))$  and  $L_H^S = \alpha \cdot \beta$ ).

- If the demand for versatile workers is “large” relative to the supply, the equilibrium is given by the intersection between the labor demand curve and the labor supply curve:

$$\begin{aligned}
L_H^D &= F_H \cdot 2 \cdot g_H(a_H - w_H) \\
L_H^S &= \alpha \cdot \beta \\
L_H^D &= L_H^S
\end{aligned} \tag{S2H}$$

#### 4b. The Tayloristic Market

There are three possible equilibrium scenarios for the Tayloristic labor market, depending on the Tayloristic labor demand relative to the supply of non-versatile workers relative to versatile ones. The first of these scenarios is illustrated by point *T* in Figure 3:

- If the demand for non-versatile workers is “small” relative to the supply, the Tayloristic organizations do not need to hire versatile workers (who demand a higher wage than the non-versatile workers since their reservation wage is higher), and thus only the supply of non-versatile workers,  $L_T^S = 1 - \alpha \cdot \beta$ , is relevant to Tayloristic wage determination. Then the labor market equilibrium is given by the intersection of the Tayloristic labor demand curve and the lower segment of the wage setting curve (where workers have the reservation wage  $\bar{r}$ ):

$$\begin{aligned}
L_T^D &= F_T \cdot 2 \cdot g_T(a_T - w_T) \\
w_T^o &= w_T^o \left( \frac{L_T^D}{1 - \alpha \cdot \beta}, r^- \right) \\
w_T &= w_T^o
\end{aligned} \tag{S1T}$$

- If the demand for non-versatile workers relative to the supply is in the “intermediate” range, the Tayloristic organizations hire some, but not all, of the

available versatile workers. Thus the labor supply that is relevant to wage determination in the Tayloristic market is  $L_T^S = 1 - L_H^*$ , and the equilibrium is given by the intersection between the labor demand curve and the upper segment of the wage setting curve (where the marginal worker has the reservation wage  $r^+$ ):

$$\begin{aligned} L_T^D &= F_T \cdot 2 \cdot g_T(a_T - w_T) \\ w_T^o &= w_T^o \left( \frac{L_T^D}{1 - L_H^*}, r^+ \right) \end{aligned} \quad (\text{S2T})$$

- If the demand is “large” relative to the supply, the Tayloristic organizations hire all the available non-versatile and versatile workers. Then the equilibrium is given by the intersection between the labor demand curve and the labor supply curve:

$$\begin{aligned} L_T^D &= F_T \cdot 2 \cdot g_T(a_T - w_T) \\ L_T^S &= (1 - L_H^*) \\ L_T^D &= L_T^S \end{aligned} \quad (\text{S3T})$$

#### 4c. The Labor Market Equilibrium and Labor Market Segmentation

A simple explicit solution for the labor market equilibrium may be obtained if we linearize the labor demand and wage setting curves at the labor market equilibrium point. (None of our qualitative conclusions depend on this linearization, however.) Specifically, for positive constants  $\gamma_H$  and  $\gamma_T$ , let the aggregate holistic and Tayloristic labor demands<sup>22</sup> be  $L_H^D = F_H \cdot 2 \cdot \gamma_H \cdot (a_H - w_H)$  and  $L_T^D = F_T \cdot 2 \cdot \gamma_T \cdot (a_T - w_T)$ . Regarding the scenarios in which the wage setting curves help determine the labor market equilibrium, let the holistic wage setting curve (when the labor demand is “small” relative to the supply) be  $w_H^o = (\delta L_H^D / \alpha \cdot \beta) + r^-$ , for a positive constant  $\delta$ , and let the Tayloristic wage setting curve be  $w_T^o = (\delta L_T^D / (1 - \alpha \cdot \beta)) + r^-$  when the demand is “small” relative to the supply, and  $w_T^o = (\delta L_T^D / (1 - L_H^*)) + r^+$  when there is an “intermediate” demand.

Then, in the holistic Scenario 1H (a “small” holistic demand), the equilibrium employment-wage combination is

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<sup>22</sup>Linearizing these labor demand implies holding constant the second partial derivatives of the output function. Clearly, this still permits the existence of technological task complementarities.



$$L_H^* = \frac{F_H \cdot 2 \cdot \gamma_H \cdot (a_H - r^-) \cdot \alpha \cdot \beta}{\alpha \cdot \beta + F_H \cdot 2 \cdot \gamma_H \cdot \delta}, \quad w_H^* = \delta \cdot \frac{F_H \cdot 2 \cdot \gamma_H \cdot (a_H - r^-)}{\alpha \cdot \beta + F_H \cdot \gamma_H \cdot 2 \cdot \delta} + r^-$$

(S1H')

and in the holistic Scenario 2H (a “large” holistic demand), it is

$$L_H^* = \alpha \cdot \beta, \quad w_H^* = a_H - \frac{\alpha \cdot \beta}{F_H \cdot 2 \cdot \gamma_H} \quad (\text{S2H}')$$

Given these two alternative equilibria, the Tayloristic equilibrium employment-wage combination in Scenario 1T (a “small” Tayloristic demand) is

$$L_T^* = \frac{F_T \cdot 2 \cdot \gamma_T \cdot (a_T - r^-) \cdot (1 - \alpha \cdot \beta)}{(1 - \alpha \cdot \beta) + F_T \cdot 2 \cdot \gamma_T \cdot \delta}, \quad w_T^* = \delta \cdot \frac{F_T \cdot 2 \cdot \gamma_T \cdot (a_T - r^-)}{(1 - \alpha \cdot \beta) + F_T \cdot 2 \cdot \gamma_T \cdot \delta} + r^- \quad (\text{S1T}')$$

in Scenario 2T (an “intermediate” Tayloristic demand), it is

$$L_T^* = \frac{F_T \cdot 2 \cdot \gamma_T \cdot (a_T - r^+) \cdot (1 - L_H^*)}{(1 - L_H^*) + F_T \cdot 2 \cdot \gamma_T \cdot \delta}, \quad w_T^* = \delta \cdot \frac{F_T \cdot 2 \cdot \gamma_T \cdot (a_T - r^+)}{(1 - L_H^*) + F_T \cdot 2 \cdot \gamma_T \cdot \delta} + r^+ \quad (\text{S2T}')$$

and in Scenario 3T (a “large” Tayloristic demand) it is

$$L_T^* = 1 - L_H^*, \quad w_T^* = a_T - \frac{1 - L_H^*}{F_H \cdot 2 \cdot \gamma_H} \quad (\text{S3T}')$$

The  $M^* = 1 - L_H^* - L_T^*$  workers who do not find employment in the holistic or Tayloristic organizations are relegated to the “tertiary sector” in which people receive their reservation wage  $r = r^-$ , either by doing low-grade work or remaining unemployed.

In short, the labor market is segmented into a “high-wage” holistic sector, a “medium-wage” Tayloristic sector, and a “low-wage” tertiary sector. It is on this account that the process whereby Tayloristic firms are restructured into holistic ones has profound effects on labor market segmentation, as we shall show in Section 6.

The labor market equilibrium above is derived for a given number of holistic and Tayloristic organizations. We now examine the market for these organizations.

### 5. Equilibrium in the Market for Organizations

To model the restructuring process and determine the equilibrium number of holistic and Tayloristic organizations, we distinguish between three sets of fixed costs: (i) the fixed costs expended by incumbent firms in order to remain in operation: the positive constants  $\phi_H$  and  $\phi_T$  for the holistic and Tayloristic organizations, respectively.

(ii) the fixed costs of reorganization:  $\phi_H + \rho_{TH}$  for a Tayloristic organization to turn into a holistic one and  $\phi_T + \rho_{HT}$  for a holistic firm to turn into a Tayloristic one (where  $\rho_{TH}$  and  $\rho_{HT}$  are positive constants); and

(iii) the fixed costs of entry:  $\phi_H + \theta_H$  to enter the holistic sector and  $\phi_T + \theta_T$  to enter the Tayloristic one (where  $\theta_H$  and  $\theta_T$  are positive constants).

Let the equilibrium *gross* profit - viz, profit not including the fixed costs - of each incumbent Tayloristic and holistic organization be<sup>23</sup>

$$\pi_i^* = q_i^* - w_i n_i^* - W_i N_i^* - \psi_i(n_i^*) - \Psi_i(N_i^*), \quad i = T, H \quad (17a)$$

For the linearized labor demand and wage setting equations of Section 4c, this gross profit function may, after the appropriate substitutions, be expressed as

$$\pi_i^* = 2 \cdot \left[ (\bar{f}' - w_i^*) \cdot \gamma_i \cdot (a_i - w_i^*) - \psi_i(\gamma_i \cdot (a_i - w_i^*)) \right], \quad i = T, H \quad (17b)$$

where  $\bar{f}'$  is the constant marginal product of labor, and where the equilibrium wages depend positively on the number of firms (for the greater the number of firms, the greater is the demand for labor relative to the given wage setting curve), as shown in equations (S1H-S2H, S1T-S3T).

Let the equilibrium *net* profit of each incumbent Tayloristic and holistic organization be

$$\Pi_i^* = \pi_i^* - \phi_i, \quad i = T, H \quad (7'')$$

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<sup>23</sup>Here the “\*” stands for the labor market equilibrium value.

Along the same lines, let the equilibrium net profits accruing to Tayloristic organizations that restructure into holistic ones ( $\Pi_{TH}^*$ ) and to holistic organizations that restructure into Tayloristic ones ( $\Pi_{HT}^*$ ) be

$$\Pi_{TH}^* = \pi_H^* - \phi_H - \rho_{TH} \quad (18T)$$

$$\Pi_{HT}^* = \pi_T^* - \phi_T - \rho_{HT} \quad (18H)$$

Finally, let the equilibrium net profits new entrants - viz, newly created Tayloristic organizations ( $\Pi_{ET}^*$ ) and holistic ones ( $\Pi_{EH}^*$ ) be

$$\Pi_{ET}^* = \pi_T^* - \phi_T - \theta_T \quad (19T)$$

$$\Pi_{EH}^* = \pi_H^* - \phi_H - \theta_H \quad (19H)$$

Figure 4 describes a range of equilibria in the market for organizations. On the horizontal axis, the number of Tayloristic organizations is measured from left to right, while the number of holistic organizations is measured from right to left. The profit curves  $\Pi_H^*$ ,  $\Pi_{TH}^*$ , and  $\Pi_{EH}^*$  for each holistic scenario (given by a “large” and “small” demand for versatile workers) are downward sloping, as seen from the right-hand origin. The reason is that, in Figure 3, if the number of holistic firms increases, the aggregate holistic labor demand curve  $L_H^D$  shifts upwards, first along the holistic wage setting curve  $WS_H$  and eventually along the aggregate holistic labor supply curve  $L_H^S$ . In both cases, the equilibrium holistic wage  $w_H^*$  rises. As result, the gross profit  $\pi_H^*$  of each holistic firm falls. For expositional simplicity, the figure depicts these curves for only a single scenario (it does not matter which).<sup>24</sup> For the same reason, the profit curves  $\Pi_T^*$ ,  $\Pi_{HT}^*$ , and  $\Pi_{ET}^*$  in Figure 4 are all downward sloping, as seen from the left-hand origin, in each of the three scenarios.<sup>25</sup>

We assume that the costs of entry exceed the costs of reorganization (thus  $\theta_H > \rho_{TH}$  and  $\theta_T > \rho_{HT}$ ). For this reason the  $\Pi_H^*$  curve lies above the  $\Pi_{TH}^*$  curve, which in turn lies above the  $\Pi_{EH}^*$  curve, and similarly for the  $\Pi_T^*$ ,  $\Pi_{HT}^*$ , and  $\Pi_{ET}^*$  curves.

Entry into the holistic organization market proceeds until the profit of the entrant is reduced to zero:

<sup>24</sup>The transition from one scenario to another would introduce a kink into the each profit curve.

<sup>25</sup>Again, the figure depicts only a single scenario.

$$\Pi_{EH}^* = 0 \quad (20H)$$

For example, for the linearized labor demand and wage setting equations, this zero profit condition is

$$2 \cdot \left[ (\bar{f}' - w_H^*) \cdot \gamma_H \cdot (a_H - w_H^*) - \Psi_H(\gamma_H \cdot (a_H - w_H^*)) \right] - \phi_H - \theta_H = 0 \quad (20Ha)$$

where

$$w_H^* = \left( \delta \cdot \frac{2 \cdot \gamma_H \cdot (a_H - r^-)}{\frac{\alpha \cdot \beta}{F_H} + \gamma_H \cdot 2 \cdot \delta} + r^-, \quad a_H - \frac{\alpha \cdot \beta}{F_H \cdot 2 \cdot \gamma_H} \right) \quad (20Hb)$$

in the Scenario 1H and 2H, respectively. The value  $F_H = \underline{F}_H$  which fulfills this condition may be called the “minimum sustainable number of holistic organizations”, since any smaller number would induce the entry of new holistic organizations, as shown in Figure 4.

The entry condition for the Tayloristic organization market is

$$\Pi_{ET}^* = 0 \quad (20T)$$

The value  $F_T = \underline{F}_T$  which fulfills this condition may be termed the “minimum sustainable number of Tayloristic organizations”, also pictured in Figure 4.

Reorganization of Tayloristic organizations into holistic ones proceeds until the profit from continuing to operate a Tayloristic organization is equal to that from transforming into a holistic one:

$$\Pi_T^* = \Pi_{TH}^* \quad (21T)$$

For example, for the linearized labor demand and wage setting equations, this reorganization condition is

$$\begin{aligned} & 2 \cdot \left[ (\bar{f}' - w_T^*) \cdot \gamma_T \cdot (a_T - w_T^*) - \Psi_T(\gamma_T \cdot (a_T - w_T^*)) \right] \\ & = 2 \cdot \left[ (\bar{f}' - w_H^*) \cdot \gamma_H \cdot (a_H - w_H^*) - \Psi_H(\gamma_H \cdot (a_H - w_H^*)) \right] - \phi_H - \rho_{TH} \end{aligned} \quad (21Ta)$$

where  $w_H^*$  in Scenarios 1H and 2H is given by (20Hb), and

$$w_T^* = \left( \delta \cdot \frac{2 \cdot \gamma_T \cdot (a_T - r^-)}{\frac{1 - \alpha \cdot \beta}{F_T} + 2 \cdot \gamma_T \cdot \delta} + r^-, \quad \delta \cdot \frac{2 \cdot \gamma_T \cdot (a_T - r^+)}{\frac{1 - L_H^*}{F_T} + 2 \cdot \gamma_T \cdot \delta} + r^+, \quad a_T - \frac{1 - L_H^*}{F_H \cdot 2 \cdot \gamma_H} \right) \quad (21Tb)$$

in Scenarios 1T, 2T, and 3T, respectively. The value  $F_T = \bar{F}_T$  which fulfills the reorganization condition may be called the “maximum sustainable number of Tayloristic organizations”, since any greater number would induce Tayloristic organizations to transform into holistic ones.

Similarly, the holistic reorganization condition is

$$\Pi_H^* = \Pi_{HT}^* \quad (21H)$$

and  $\bar{F}_H$  is the “maximum sustainable number of holistic organizations”.

The market for organizations is in equilibrium whenever the number of holistic organizations lies between its maximum and minimum sustainable levels and similarly for the number of Tayloristic organizations:

$$\underline{F}_H \leq F_H^* \leq \bar{F}_H \quad \text{and} \quad \underline{F}_T \leq F_T^* \leq \bar{F}_T \quad (22)$$

In the figure, for example, every combination  $(F_H^*, F_T^*)$  lying within the interval between  $\bar{F}_T$  and  $\bar{F}_H$  in the figure may be an organizational equilibrium.<sup>26</sup>

Beginning from such an equilibrium, the next section investigates the forces inducing reorganization and entry into the holistic sector and explores the implications of these developments for the labor market.

## 6. The Restructuring Process

We now analyze how the major forces driving the restructuring process - advances in production and information technologies, and improvements in human capital, discussed in Sections 1 and 2 - influence labor market activity.

### 6a. Advances in Production and Information Technologies

We consider two types of sustained advances in production and information technologies: ones that increase the technological and informational task complementarities (as described in Section 2) and ones that reduce the holistic fixed cost  $\phi_H$  (while the Tayloristic fixed cost  $\phi_T$  remains unchanged). These changes can be shown to have qualitatively similar effects in our model. Specifically, they cause the

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<sup>26</sup>There is of course no reason why the  $\underline{F}_H$  point should necessarily lie to the left of the  $\bar{F}_T$  point, or why the  $\bar{F}_H$  point should necessarily lie to the left of the  $\underline{F}_T$  point.

profit curves  $\Pi_H^*$ ,  $\Pi_{TH}^*$ , and  $\Pi_{EH}^*$  in Figure 4 to rise period by period, while the profit curves  $\Pi_T^*$ ,  $\Pi_{HT}^*$ , and  $\Pi_{ET}^*$  remain unchanged. If the economy is initially in an organizational equilibrium, in which condition (22) holds, then it eventually will become worthwhile for Tayloristic organizations to be restructured as holistic ones (so that the restructuring condition (21T) becomes binding) and/or new holistic firms to enter (so that the entry condition (20H) becomes binding).

For the linearized labor demand and wage setting equations, a fall in the holistic fixed cost  $\phi_H$  and advances in the holistic production and information technologies - represented by increases in  $a_H$  - raise the profit from restructuring into a holistic organization,  $\Pi_{TH}^* = 2 \cdot \left[ (\bar{f}' - w_H^*) \cdot \gamma_H \cdot (a_H - w_H^*) - \Psi_H(\gamma_H \cdot (a_H - w_H^*)) \right] - \phi_H - \rho_{TH}$ , relative to the profit from remaining a Tayloristic organization,  $\Pi_T^* = 2 \cdot \left[ (\bar{f}' - w_T^*) \cdot \gamma_T \cdot (a_T - w_T^*) - \Psi_T(\gamma_T \cdot (a_T - w_T^*)) \right]$ , from equation (21Ta). To fix ideas, let us assume that this restructuring condition is binding in the initial equilibrium, so that the technological changes above lead some Tayloristic firms to turn into holistic ones. Furthermore, assume that if the restructuring condition (21Ta) and the entry condition (20H) are both binding, then restructuring takes place before entry.<sup>27</sup> Then the changes above lead to a rise in the equilibrium number of holistic organizations  $F_H^*$  and a fall in the equilibrium number of Tayloristic organizations  $F_T^*$ .<sup>28</sup>

In terms of Figure 5, this means that the profit curve of the restructured organizations,  $\Pi_{TH}^*$ , rises to  $\Pi'_{TH}$ , while the profit curve of incumbent Tayloristic organizations,  $\Pi_T^*$ , remains unchanged. As result, the intersection between these two curves shifts to the left, increasing the number of holistic organizations and reducing the number of Tayloristic ones.

The labor market implications of this change are straightforward. The increase in the number of holistic organizations shifts the holistic labor demand curve upwards in Figure 3. Consequently, as the holistic equilibrium equations (S1H') and (S2H')

<sup>27</sup>Recall that the costs of restructuring assumed to be lower than the cost of entry.

<sup>28</sup>This raises the equilibrium holistic wage  $w_H^*$  relative to the equilibrium Tayloristic wage  $w_T^*$ , and thereby brings the profit of the restructured organizations ( $\Pi_{TH}^*$ ) back into equality with the profit of the incumbent Tayloristic organizations ( $\Pi_T^*$ ).

show, the equilibrium holistic wage rises and the equilibrium level of aggregate holistic employment rises as well, provided that the supply of versatile workers has not been exhausted.<sup>29</sup>

The fall in the number of Tayloristic organizations  $F_T^*$ , associated with the rise in the number of holistic organizations  $F_H^*$ , reduces the equilibrium aggregate Tayloristic employment and also reduces the equilibrium Tayloristic wage, as shown in the Tayloristic equilibrium equations (S1T')-(S3T'). If the number of non-versatile workers is sufficiently large to satisfy the Tayloristic labor demand (Scenario S1), then the fall in Tayloristic employment is driven solely by the fall in the number of Tayloristic organizations. Yet if the number of non-versatile workers is small enough to make it necessary for the Tayloristic organizations to hire some versatile workers (Scenarios S2 and S3), then the employment decline in the Tayloristic sector is also driven by the rise in the number of holistic organizations, which reduces the labor supply to the Tayloristic organizations and shifts the wage setting equation upwards (since the reservation wage rises from  $r^-$  to  $r^+$ ).

In terms of Figure 3, the Tayloristic labor demand curve shifts downwards, and the Tayloristic labor supply curve shifts to the left. If the number of non-versatile workers is large (Scenario 1T), the Tayloristic equilibrium lies at the intersection of the labor demand curve and the lower segment of the wage setting curve, and then equilibrium employment and the wage in the Tayloristic sector both fall. If, on the other hand, the number of non-versatile workers is small (Scenarios 2T and 3T), the Tayloristic equilibrium lies at the intersection of the labor demand curve and the upper segment of the wage setting curve, and then the Tayloristic wage setting curve will shift upwards in response to the rise in holistic employment. As result, Tayloristic employment will fall by more and the Tayloristic wage will fall by less than in Scenario 1T.

The change in the number of “disadvantaged” workers, relegated to unemployment or a tertiary labor market, depends on the magnitude of the rise in holistic employment relative to the fall in Tayloristic employment. Assuming that employment per Tayloristic organization exceeds the employment per holistic

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<sup>29</sup>If, however, the aggregate holistic labor demand is “large”, aggregate employment is of course equal to the supply of versatile workers.

organization and that the unemployment rate among single-skill workers exceeds that among the versatile ones, the rise in aggregate holistic employment will be less than the corresponding fall in Tayloristic employment, and hence the number of disadvantaged workers rises.

As technological progress continues to increase the technological and informational task complementarities and to reduce the fixed cost  $\phi_H$  period by period, the restructuring of Tayloristic into holistic organizations will eventually be replaced by entry of new holistic organizations. In terms of our model, this means that the entry condition (20H) becomes binding, replacing the restructuring condition (20T).

It is easy to see why. Given the number of holistic and Tayloristic organizations, the technological progress above raises an organization's profit from entry into the holistic sector by the same amount as the profit from restructuring a Tayloristic organization into a holistic one, since the gross holistic profit ( $\pi_H^*$ ) remains unchanged. But as the number of holistic organizations increases, an organization's profit from entry into the holistic sector falls at a slower rate than the profit from restructuring a Tayloristic organization into a holistic one. The reason is that, as the restructuring process reduces the number of Tayloristic organizations, the profit of each remaining incumbent Tayloristic organization rises (since the wage in the Tayloristic sector falls), and this provides a disincentive to restructure. There is no corresponding disincentive to enter the holistic sector.

This is illustrated in Figure 5. Here we consider an initial equilibrium at Point A, where the marginal organization entering the holistic sector makes zero profit, and the marginal Tayloristic organization that restructures into a holistic one makes zero profit as well. Then the technological change raises the profit curve  $\Pi_{EH}^*$  by the same amount as the profit curve  $\Pi_{TH}^*$ . Thus, the magnitude of the upward shift from  $\Pi_{EH}^*$  to  $\Pi'_{EH}$  in the figure is equal to the magnitude of the upward shift of the profit curve from  $\Pi_{TH}^*$  to  $\Pi'_{TH}$ .



Assuming, as above, that restructuring takes place before entry,<sup>30</sup> the restructuring process moves the economy from Point A to B in the figure (i.e. the number of holistic organizations increases by AB and the number of Tayloristic organizations falls by an equal amount). But at Point B there are still positive profits to be made from entering the holistic sector. The reason is that the intersection of the profit curve  $\Pi_{EH}$  with the horizontal axis shifts to the left by a larger amount (from Point A to C) than the intersection of the profit curve  $\Pi_{TH}$  with the profit curve  $\Pi_T$  (from Point A to Point B). Consequently, the number of holistic organizations increases by  $\Delta F_H^* = BC$  in the figure. Since the aggregate number of organizations has increased by  $\Delta F_H^*$ , the left-hand vertical axis shifts leftwards by an equal amount, pulling the Tayloristic incumbent organization's profit curve leftwards by an equal amount as well (from  $\Pi_T^*$  to  $\Pi_T'$  in the figure).

At Point C, however, the profit from restructuring a Tayloristic into a holistic organization (given by  $\Pi_{TH}'$ ) is less than the profit from remaining a Tayloristic organization (given by  $\Pi_T'$ ). Thus when the technological progress in the following period shifts the holistic profit curves upwards again, only entry into the holistic sector - but no restructuring - will take place.

*Proposition 3: In sum, technological advances that increase the technological and information task complementarities and reduce the fixed cost of operating holistic organizations, have the following effects on labor market segmentation:*

(a) *In the “restructuring phase”, in which Tayloristic organizations are transformed into holistic ones: the high-wage holistic sector expands, the medium-wage Tayloristic sector contracts, and the low-wage tertiary sector or unemployment expands.*

(b) *In the “entry phase”, in which new holistic organizations enter the economy: the high-wage holistic sector continues to expand, the medium-wage Tayloristic sector remains constant, and the low-wage tertiary sector, or unemployment, contracts.*

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<sup>30</sup>If entry takes place before restructuring, then it can be shown that the number of holistic firms increases by AC and no restructuring takes place at all.

In the restructuring phase there is increasing labor market segmentation, characterized by increasing wage dispersion and growing inequality of employment opportunities. This is compounded by the rise of the holistic wage relative to the Tayloristic wage through time. The entry phase is characterized by less labor market segmentation in the special sense that the high-wage employment opportunities grow at the expense of the low-wage ones, but since the holistic wage rises through time, there is still increasing wage dispersion.

### *6b. Improvements in Human Capital*

We model education-induced improvements in human capital through an increased supply of versatile workers. This may be interpreted as “general training” acquired at school and college, leading to skills that are potentially useful to all firms. The effects of this training in our theory turn out to be quite different from those in the standard human capital theory. In the latter, general training raises wages in all firms since it raises workers’ productivity all over the economy. In our theory, by contrast, general training increases the supply of labor to holistic organizations and thereby expands the holistic sector at the expense of the Tayloristic one and reduces holistic wages relative to Tayloristic ones.

An increase in the supply of versatile workers  $L_H^S = \alpha \cdot \beta$  leads to a rise in the equilibrium level of holistic employment and a fall in the equilibrium holistic wage, as shown by equations (S1H’) and (S2H’). In terms of Figure 3, the increased supply of versatile workers shifts the holistic labor supply curve  $L_T^S$  to the left and thus shifts the wage setting curve  $WS_H$  leftward, so that aggregate holistic employment rises while the holistic wage falls.

The fall in the holistic wage implies that the gross profit of each holistic organization rises. Thus the holistic profit curves in Figure 4 shift upwards. This process continues until the restructuring condition (20T) becomes binding and thus some Tayloristic organizations turn into holistic ones. As shown in Section 6a, the restructuring reduces aggregate Tayloristic employment and further increases

aggregate holistic employment. In the process, the Tayloristic wage falls and the holistic wage rises (reversing its initial fall).

Under the assumptions of Section 6a,<sup>31</sup> the rise in aggregate holistic employment is less than the fall in aggregate Tayloristic employment, and consequently the restructuring process leads to a rise in the number of workers relegated to the tertiary sector or to unemployment.

Eventually, as described in Section 7a, this restructuring condition is replaced by the entry condition (20H), and the restructuring process stops and new holistic organizations enter the labor market. Then the tertiary sector or unemployment will contract. In sum,

*Proposition 4: General training that increases the number of versatile workers affects labor market segmentation in the following way:*

*(a) In the “restructuring phase”: the high-wage holistic sector expands, the medium-wage Tayloristic sector contracts, and the low-wage tertiary sector or unemployment expands.*

*(b) In the “entry phase”: the high-wage holistic sector continues to expand, the medium-wage Tayloristic sector remains constant, and the low-wage tertiary sector or unemployment contracts.*

The net consequences for relative wage depends, of course, on the degree to which the supply of versatile workers increases relative to the holistic labor demand on account of restructuring and entry. Here, once again, any rise in labor market segmentation during the restructuring phase is reduced in the entry phase.

## **7. Concluding remarks**

This paper has analyzed the contemporary restructuring of organizations and work, emphasizing the rise of multi-tasking and work-rotation in this process. We have focused on two driving forces behind the reorganization process, namely (i) advances in information and production technologies that favor holistic organizations, and (ii) increases in the supply of employees with general human capital, permitting them to perform multiple tasks and to exploit the technological advances above.

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<sup>31</sup>The assumptions are that employment per holistic firm is less than employment per Tayloristic one and the unemployment rate among non-versatile workers exceeds that among versatile workers.

The quantitative importance of these new organizational developments is still an open question. But from reading the literature in the field and from observing what is happening within a great number of firms nowadays, we have little doubt that a dramatic and broadly based process of organizational change, of the type discussed in this paper, has been underway for some time, and is likely to continue.

Our analysis shows that in an early “restructuring phase,” some Tayloristic organizations are transformed into holistic ones and the tertiary sector (including low-grade, low-wage work and unemployment) expands. The result is rising labor market segmentation in the sense of greater inequality of employment opportunities. Whether there is also increased wage dispersion depends on whether the restructuring process is driven by the technological advances or by improvements in human capital. In a later “entry phase”, dominated by the entry of new holistic organizations, the Tayloristic sector stops contracting and the tertiary sector stops contracts. Here the labor market segmentation can be expected to subside, in the sense that high-wage employment opportunities now grow at the expense of employment in the tertiary sector.

The paper provides a possible explanation for the growth of female employment relative to that of males and the narrowing of the male-female wage differentials in many advanced industrial countries over the past decade. Women may often have a comparative - and perhaps even absolute - advantage relative to men for work in holistic organizations. Physical strength is less important in such organizations, while verbal ability, general social competence and the ability to pursue multi-task activities tend to be more important. (After all, females have for long periods of time been engaged in multi-task activities in the household, while men have usually been more specialized - as early as when they were hunters.) Our analysis thereby provides an organizational rationale for the improving fortunes of women in the labor market.

In providing a theory of multi-tasking and the reorganization of work, our analysis may be viewed as a contribution to the contemporary debate on the sources of the increased dispersion of wages and job opportunities in the US and Europe. The dominant hypotheses thus far have been that these phenomena are the outcome of (a)

skill-biased technological change,<sup>32</sup> (b) skill-biased international trade flows,<sup>33</sup> and (c) deficient education and training.<sup>34</sup> However these hypotheses explain neither the widening inequality of wages *within* education, occupation, and job tenure groups in the US and the UK, nor the widening inequality of employment opportunities within these groups in various European countries. Our analysis offers another explanation, based on the reorganization of firms. In so doing, it goes further than the hypotheses above by specifying *how* changes in production and information technologies and *how* education and training may be expected to affect the dispersion of wages and employment opportunities in the context of organizational restructuring. Our analysis is also complementary with the hypothesis resting on international trade, since the expansion of trade has enabled an increasing number of firms in the advanced industrialized countries to shift to products and production processes requiring holistic organization, while contracting out the routine, assembly line work to other countries. Finally, since people within particular education, occupation, and job tenure groups are likely to vary considerably in terms of their social competence, judgment, and ability to perform multiple tasks, our analysis also suggests an explanation for the widening dispersion of wages and job opportunities within these groups.

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<sup>32</sup>See, for example, Berman, Bound and Grilliches (1993), Bound and Johnson (1992), Krueger (1993), Machin (1994), and Mincer (1989, 1991).

<sup>33</sup>See, for example, Leamer (1994, 1995) and Sachs and Schatz (1994).

<sup>34</sup>See, for example, Mincer (1991), Levy and Murname (1992), and Katz and Blanchflower (1992), among others.

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