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A note on multitask learning and the reorganization of work

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Abstract

In this note, we investigate the necessary condition for a firm to be able to move from Tayloristic to ohlistic organization of work, whatever the economic conditions and the incentives to do it: that workers have the ability to allocate their work−time to several tasks.

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1 Introduction

In a recent article Lindbeck and Snower (2000) investigate why firms shift from Tayloristic to Holistic organization of work. They build their analysis on two broad types of learning : "intertask" and "intratask" learning. The first one arises when a worker can improve his performance at one task using the information acquired at another task. The second one is an Arrow (1962) learning-by-doing. They demonstrate that advances in production technologies, advances in information technologies, changes in worker preferences and advances in human capital contribute to the transformation of work organization in favor of multitasking, increasing incentives for workers to operate on many tasks. To derive their results, they assume that workers must have the ability to allocate their working time to several tasks. Nevertheless they do not examine fully under what conditions this assumption is verified.[1]

In this note, we argue that this assumption must be carefully investigated because it represents the necessary condition for a firm to be able to move from Tayloristic to Holistic organization of work, whatever the economic conditions and the incentives to do it.

Developing a general framework where we only take into account workers characteristics, we demonstrate that the necessary condition for workers to be *able* to allocate their working time to several tasks implies that *intertask learning* (coming from information spillovers between tasks) must contribute more to the rise of the worker's productivity on a given task than *intratask learning* (coming from learning by doing on the task), when the time allocated to this task increases.

If this implication may be seen as trivial, it has a major implication. The advances in information technologies, in human capital or in workers preferences in favor of versatile work, are not only some of the driving forces which incite workers to allocate their time to several tasks. They represents the prerequisite components of such a restructuration because, they make multitasking organization *feasible* by increasing informational spillovers between tasks and by giving the ability of workers to exploit them, whatever production technologies or economic conditions. This

[1] Even if they state that human capital growth increases this ability and so may contribute to the shift from Tayloristic to Holistic organization by increasing the profitability of the second with respect to the first (p.370). Note that the human capital growth must affect mainly general knowledge and not specific knowledge which rather favorishes specialization.

reinforces the results found by Lindbeck and Snower (2000), strengthening the influence of such advances in multitasking reorganization of work, irrespective of the incentives to shift from Tayloristic to Holistic organization. This also enables to reconcile different streams of explanation to work reorganization – those who view economic conditions as the reason of the shift from Taylorian to ohlistic organization of work and those who emphasize the role played by advances in information technologies, in human capital and so on – because even if economic conditions are central, advances contribute greatly to the reorganization of work.

The plan of this note is as follows. In section 2, we expose the basic framework. In section 3 we examine the necessary condition for a firm to implement a holistic organization of work.

2 The basic framework

We consider an economy in which all markets are competitive. Firms produce a homogeneous good and need only labor as input. Production requires the realization of two tasks $i = 1, 2$. If N_i is total labor measured in efficiency units devoted to task i, the firm's production function can be written as:

$$y = F(N_1, N_2),$$

where y is the firm's output and F is a concave and homogeneous function of degree one. An increase in the total amount of efficient labor devoted to one of the two tasks raises the level of production ($F'_{N_i} > 0$), but at a decreasing rate ($F''_{N_i N_i} < 0$). Moreover there are technological complementarities between the tasks ($F''_{N_i N_{-i}} > 0$).

The population is normalized to one and divided in two types of workers : type-1 workers (with a number n^1) and type-2 workers (with a number n^2). Each worker inelastically offers one unit of work time. According to diversity in labor skill and task performance requirements, the worker's contribution to production may depend on her task assignment. Therefore we assume that each firm determines its organization of work by choosing the allocation of each employee's work time between two production tasks.

We define τ_i^j (for $i = 1, 2$ and $j = 1, 2$) as the fraction of time during which the firm assigns type-j workers to task i, and we have $\tau_{-i}^j = 1 - \tau_i^j$. When type-$j$ workers devote all their work time to the realization of one single task i ($\tau_i^j = 1$), the work time allocation of type-j workers is called "Taylorian" with a specialization in task i. When type-j workers perform both tasks ($0 < \tau_i^j < 1$), the work time allocation of type-j workers is called "holistic".

The total amount of efficient labor devoted to task i is the sum of the efficient labor devoted by each worker to this task:

$$N_i = h_i^1 \times n^1 + h_i^2 \times n^2, \qquad i = 1, 2, \tag{1}$$

where h_i^j is the amount of efficient labor provided by type-j workers at task i:

$$h_i^j = \tau_i^j \times e_i^j = \mathcal{G}_i^j(\tau_i^j), \qquad i = 1, 2 \text{ and } j = 1, 2. \tag{2}$$

where $\mathcal{G}_i^j(\tau_i^j)$ is assumed to be a positive increasing function of τ_i^j : when a type-j worker increases its time-allocation τ_i^j on task i, it increases her amount of efficient labor allocated. e_i^j is the "efficiency units of labor per hour" of type-j workers performing task i.

Following Lindbeck and Snower (2000), we assume that the type-j worker's productivity on tasks is determined be the returns to specialization and the returns to informational task complementarity. Therefore e_i^j depends on the fraction of time τ_i^j devoted to task i (*intratask learning*), and on the fraction of time $\tau_{-i}^j = 1 - \tau_i^j$ devoted to the other task which benefit to type-j worker when she operates on task i due to informational spillovers (*intertask learning*). We express the intratask learning for type-j worker on task i as a positive continuous increasing function of τ_i^j, noted $\mathcal{S}_i^j(\tau_i^j)$, and the intertask learning for the type-j worker on task i (resulting from the time $\tau_{-i}^j = 1 - \tau_i^j$ on task $-i$) as a positive continuous increasing function of $1 - \tau_i^j$, noted $\mathcal{C}_i^j(1 - \tau_i^j)$. So we write the type-$j$ worker's productivity on task i as:

$$e_i^j = \mathscr{E}_i^j[\mathcal{S}_i^j(\tau_i^j), \mathcal{C}_i^j(1 - \tau_i^j)] = \mathcal{E}_i^j(\tau_i^j), \qquad i = 1, 2 \text{ and } j = 1, 2. \tag{3}$$

For the time being, we just assume that the function $\mathscr{E}_i^j$ is a positive increasing function of $\mathcal{S}_i^j$ and $\mathcal{C}_i^j$, and therefore that $\mathcal{E}_i^j$ is a continuous function of the variable τ_i^j. The purpose of the rest of the article is to find conditions about the function $\mathcal{E}_i^j$ to make multi-tak organization of work "*feasible*" for type-j worker.

3 The necessary condition for implementing a holistic organization of work

Since h_i^j is assumed to rise with τ_i^j, from (2) $\tau_i^j e_i^j$ increases with τ_i^j, which gives, from (3), a first condition on $\mathcal{E}_i^j(\tau_i^j)$:

$$\mathcal{E}_i^j + \tau_i^j \frac{d\mathcal{E}_i^j}{d\tau_i^j} > 0 \tag{Cond. 1}$$

The unit of time devoted to work by each worker is split between the two tasks so $\tau_1^j + \tau_2^j \leq 1$. Since (2) implies $\tau_i^j = \left\{\mathcal{G}_i^j\right\}^{-1}(h_i^j)$, there is a relation between h_1^j and h_2^j which determines, in plane $(h_1^j,\ h_2^j)$, the maximal amount of labor that a type-j worker can "produce" on both tasks with only one unit of work time defined by:

$$\Theta^j(h_1^j, h_2^j) = 1 - \{\mathcal{G}_1^j\}^{-1}(h_1^j) - \{\mathcal{G}_2^j\}^{-1}(h_2^j) \geq 0, \tag{4}$$

We call $\Theta^j(h_1^j, h_2^j) = 0$ the "*production possibility frontier*" of type-j workers.

This "*production possibility frontier*" defines h_2^j as a decreasing function of h_1^j, and the determination of a work time allocation $(\tau_1^j,\ \tau_2^j)$ for type-j workers will correspond to a point on this frontier. If $\tau_1^j = 0$ (resp. $\tau_2^j = 0$), we have $h_1^j = 0$ and h_2^j is maximum (resp. $h_2^j = 0$ and h_1^j is maximum). It means that Tayloristic organization of work corresponds to one of the two extremities of the "*production possibility frontier*". For all other points on the "*production possibility frontier*", the work time allocation is holistic.

Figure 1: (*Concave*) Production Possibility Frontier of the Two Types of Workers

Proposition 1

Multi-task organization of work is a "feasible" solution of the work time allocation problem of the firm if and only if the total amount of efficient labor at task i is a strictly concave function of the total amount of efficient labor allocated to the other task $-i$. Otherwise, the solution of time allocation decision is a corner solution which means Tayloristic organization of working time.

Proof 1

See above.■

In our framework, the conditions for the concavity of the "*production possibility frontier*" of a worker come down to the following proposition.

Proposition 2

The necessary condition for the implementation of a holistic work time organization is that the contribution of "intertask learning" to the increase of the worker'productivity on a given task must be greater in absolute value than the contribution of "intratask learning", when the time allocated to this task rises. The difference between the contributions must nevertheless be bounded.

Proof 2

The "production possibility frontier" for a type-j worker $\Theta^j(h_1^j, h_2^j) = 0$ defines h_2^j as a positive decreasing function of h_1^j – denoted $\mathcal{H}^j(h_1^j)$ – since h_1^j is an increasing function of τ_1^j and h_2^j is a decreasing function of τ_1^j.[2]

The "production possibility frontier" $\Theta^j(h_1^j, h_2^j) = 0$ is strictly concave if $\mathcal{H}^j(h_1^j)$ is strictly concave :

$$\frac{d^2\mathcal{H}^j}{d{h_1^j}^2} = \left(\frac{d\mathcal{G}_1^j}{d\tau_1^j}\right)^{-2} \left\{ \left[-2\frac{d\mathcal{E}_2^j}{d\tau_1^j} + (1-\tau_1^j)\frac{d^2\mathcal{E}_2^j}{d{\tau_1^j}^2} \right] - \frac{d\mathcal{H}^j}{dh_1^j} \left[2\frac{d\mathcal{E}_1^j}{d\tau_1^j} + \tau_1^j \frac{d^2\mathcal{E}_1^j}{d{\tau_1^j}^2} \right] \right\} < 0$$

[2] Its slope is given by $\frac{d\mathcal{H}^j}{dh_1^j} = \frac{-[\mathcal{E}_2^j + (1-\tau_1^j) d\mathcal{E}_2^j \mathcal{E}_2^j / d(1-\tau_1^j)]}{\mathcal{E}_1^j + \tau_1^j d\mathcal{E}_1^j d\mathcal{E}_1^j / d\tau_1^j} < 0$, from (2).

This condition is verified if the terms into brackets (which are symetric because $\tau_1^j = 1 - \tau_2^j$) are negative. It requires:

$$2\frac{d\mathcal{E}_i^j}{d\tau_i^j} + \tau_i^j \frac{d^2\mathcal{E}_i^j}{d{\tau_i^j}^2} < 0, \qquad j = 1, 2, \ i = 1, 2.$$

This conditions means that $\mathcal{G}_i^j(\tau_i^j)$ defined by equation 2 is strictly concave with respect to τ_1^j. From the definition of the concavity, we have $\frac{\mathcal{G}_i^j(\tau_i^j) - \mathcal{G}_i^j(0)}{\tau_i^j - 0} = \mathcal{G}_i^j(\tau_i^j)/\tau_i^j$ is a decreasing fonction of τ_i^j. Therefore, from equation (2), $h_i^j/\tau_i^j = e_i^j = \mathcal{E}_i^j(\tau_i^j)$ is a decreasing function of τ_i^j. It gives a second condition on the function $\mathcal{E}_i^j$:

$$d\mathcal{E}_i^j/d\tau_i^j < 0 \qquad \text{(Cond. 2)}$$

The two conditions on $\mathcal{E}_i^j$ (equations Cond. 1 and Cond. 2) may be written as :

$$-1 < \frac{d\mathcal{E}_i^j/d\tau_i^j}{\mathcal{E}_i^j/\tau_i^j} < 0 \qquad (5)$$

Using equation (3) let write the previous condition as follows:

$$-1 < \eta_{\mathcal{S}_i^j} + \eta_{\mathcal{C}_i^j} < 0, \qquad \textit{with } i = 1, 2, \quad j = 1, 2.$$

with $\eta_{\mathcal{S}_i^j} \equiv \frac{d\mathcal{E}_i^j/\mathcal{E}_i^j}{d\mathcal{S}_i^j/\mathcal{S}_i^j} \times \frac{d\mathcal{S}_i^j/\mathcal{S}_i^j}{d\tau_i^j/\tau_i^j} > 0$ and $\eta_{\mathcal{C}_i^j} \equiv \frac{d\mathcal{E}_i^j/\mathcal{E}_i^j}{d\mathcal{C}_i^j/\mathcal{C}_i^j} \times \frac{d\mathcal{C}_i^j/\mathcal{C}_i^j}{d\tau_i^j/\tau_i^j} < 0$. $\eta_{\mathcal{S}_i^j}$ (resp. $\eta_{\mathcal{C}_i^j}$) measures the contribution of "intratask learning" (resp. "intertask learning") to a variation of the efficiency units of labor when the time allocated to a task increases.

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