

## DIVISION OF LABOR AND AGGLOMERATION ECONOMIES (\*)

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Location theory has been unable to provide an endogenous foundation of agglomeration economies (Scott, 1990), that is, to relate them with production costs. The reason of this inability follows from the underlying assumptions of neoclassical production theory, where production is treated as a «black box», a production function, that is, a technical relation between purchased inputs and sold output, without any regard to the internal connections of the productive process. The necessary change of perspective on production is well summarized by Leijonhufvud:

The one point about it (the production function) that is germane here is that it does not describe production as a process, that is, as an ordered sequence of operations. It is more like a recipe for bouillabaisse where all the ingredients are dumped in a pot ( $K,L$ ), heated up,  $f(.)$  and the output  $X$  is ready. This abstraction from the sequencing of tasks, it will be suggested, is largely responsible for the well-known fact that neoclassical production theory gives us no clue to how production is actually organized. [Leijonhufvud, 1986, p. 204.]

Even more clearly Stigler says:

That is we partition the firm not among the markets in which it buys inputs but among the functions or processes which constitute the scope of its activity. [Stigler, 1968, p. 130.]

### 1 — Division of labor: the time dimension

The view of production as a *process*, an ordered sequence of operations, was stressed, by Adam Smith in the opening chapters of *Wealth of Nations*. The smithian concept of division of labor is the starting point of our analysis.

Suppose that a productive process is an ordered sequence of three tasks 1,2,3. There are three workers that we label  $a,b,c$ . Each worker uses a differ-

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ent tool for each task. If labor is undivided, each worker performs three tasks. The workers perform the operations in parallel. This situation is depicted in fig. 1.

With the division of labor, each worker specializes in one task. The workers operate in a series rather than in parallel (Georgescu-Roegen, 1982). The situation is depicted in fig. 2.

As was remarked by Adam Smith [1981 (1776)], the division of labor increases labor productivity according to three reasons:

- 1) As the individual task becomes simpler, worker's dexterity increases;
- 2) Time losses following from the change of task by the worker (change of place and tool) are avoided. A strict time phasing of tasks takes place;
- 3) Some tasks become so simple that they can be mechanized.

According to Adam Smith [1981 (1776)], division of labor has a fourth effect, namely it saves capital, both physical and human (Leijonhufvud, 1986; Georgescu-Roegen, 1982). Without division of labor, each worker has three tools, two of which remain permanently idle. With division of labor, each worker has only one tool which is permanently in use. The division of labor also entails a loss of qualification for the worker: instead of three tasks, each worker learns only one now.

## 2 — Division of labor: the space dimension

With the division of labor depicted in fig. 2, transactions take place between workers with connected tasks (Coase, 1937). According to Williamson:

A transaction may thus be said to occur when a good or service is transferred across a technologically separable interface. One stage of processing or assembly terminates and another begins. [Williamson, 1981, p. 1544.]

Clearly, a transaction can happen between two spatially separated workers, although it implies a distance related cost (inventory and transport cost). Each kind of transaction supports a maximum inventory and transport cost, that is, distance between transactors must not exceed a certain amount (the maximum distance is conditional upon the efficiency of the transportation system). Therefore, we can give a precise meaning to Smith's saying that «the division of labor is limited by the extent of the market»: in order that labor is divided, workers must transact. Transactions can only take place if distance between two related workers does not exceed a maximum.

In figs. 3,4,5 the maximum transaction distance corresponds to the diameter of a circle. Locations of six workers — *a,b,c,d,e,f* — of a process with three tasks — 1,2,3 — are represented.

Without division of labor, each worker performs three tasks. The workers can be scattered in space, at distances larger than the maximum transaction

distance. Therefore, each worker locates in the center of a circle whose diameter is the maximum transaction distance and these circles do not intersect (see fig. 3).

With the division of labor represented in fig. 2, workers *a,b,c* must locate at distances smaller than the maximum transaction distance — circles surrounding *a,b,c* must form a connected set. Isolated workers *e,d,f* remain unspecialized (see fig. 4).

If labor is further subdivided so that each task is decomposed in two (there are now six tasks), each worker in the set  $\{a,b,c,d,e,f\}$  performs a single task and six circles must form a connected set (see fig. 5). If the means of communications improve, maximum transaction distance increases and the circles expand, so that, for the same workers' locations, wider connected sets are formed and division of labor can be carried further.

As Marx reminds:

Just as a certain number of simultaneously employed workers is the material pre-condition for the division of labour within manufacture, so the number and density of the population, which here corresponds to the collection of workers together in one workshop, is a pre-condition for the division of labour within society. Nevertheless, this density is more or less relative. A relatively thinly populated country with well-developed means of communication, has a denser population than a more numerous country with badly developed means of communication. In this sense, the northern states of the USA, for instance, are more thickly populated than India. [Marx, 1976(1890), pp. 472-3].

Allyn Young (1928) stresses the reverse viewpoint. The market for a specialized worker is created by the existence of another specialized worker or, as he says, «[...] the division of labour depends in large part upon the division of labour» (Young, 1928, p. 533). In our example (fig. 3), assume that a worker, for instance, *c*, decides to specialize in task 3 whose output is directly sold to final consumers. The specialization of *c* creates the market for a specialized *b* and the latter induces *a* to specialize in task 1. Therefore, specialization propagates itself in a cumulative way.

The implicit geographical assumption here is that each worker changes his location in order to get access to the market opened by specialization. Therefore, when *c* specializes in task 3, *b* approaches *c* in order to supply him the output of task 2 and *a* gets near to *b* in order to supply him the output of task 1. Geographical concentration is an outcome, rather than a precondition of the division of labor.

### 3 — Vertical integration and geographical concentration

Do workers *a,b,c* form a single firm? Or is each one an independent firm? Clearly, without division of labor, there is no reason for the workers to be under the authority of a single entrepreneur.

If labor is divided, the specialized, time-coordinated and clustered workers may either belong to a single firm or be independent producers. In the former case, their transactions are organized inside the firm, while in the latter the goods transferred will be commodities exchanged in an open market (Coase, 1937).

The first relevant question concerning the comparative institutionalization of transactions is the following one: does the difference (between markets and firm hierarchies) matter? Adam Smith's answer is *no* — the difference is purely subjective and concerns only the «visibility» of the division of labor:

[...] but in those trifling manufactures which are destined to supply the small wants of but a small number of people, the whole number of workmen must necessarily be small; and those employed in every different branch of the work can often be collected into the same workhouse, and placed at once under the view of the spectator [the emphasis is ours]. In those great manufactures on the contrary which are destined to supply the great wants of the great body of the people, every different branch of the work employs so great a number of workmen, that it is impossible to collect them all into the same workhouse. We can seldom see more, at one time, than those employed in one single branch. Though in such manufactures, therefore, the work may be divided into a much greater number of parts, than in those of a more trifling nature, *the division is not near so obvious, and has accordingly been much less observed* [the emphasis is ours]. [Smith, 1981(1776), p. 14.]

On the contrary, Marx esteems that the opposition between the division of labor in the factory (where workers are wage-earners from the same capitalist) and the social division of labor (where workers are independent producers of commodities) is essential:

Division of labor within the workshop implies the undisputed authority of the capitalist over men, who are merely the members of a total mechanism which belongs to him. The division of labour within society brings into contact independent producers of commodities, who acknowledge no authority other than that of competition, of the coercion exerted by the pressure of their reciprocal interests [...] [Marx, 1976 (1890), pp. 476-7.]

As we shall see below, when we compare american and japanese production management, the way the division of labor is institutionalized determines productive efficiency.

The second important question is under what conditions workers *a,b,c* specialized in tasks 1,2,3 either will form a single firm (vertical integration) or become independent (vertical disintegration). According to Williamson (1981), vertical integration occurs on account of «asset specificity». If the assets (both human and physical) that support a transaction are specific to that transaction, that is, if the relation is bilateral, so that the seller has a single buyer and the buyer has a single supplier, an open market relation is difficult to be managed

by contract. Each part can threaten to break the transaction, in order to get a more favorable price. Under these conditions, integration of the parts in a single firm is an institutional solution.

«Asset specificity» arises namely on account of «site specificity»: the worker has several potential suppliers and purchasers, but only a single supplier and a single purchaser lie beyond the maximum transaction distance. Therefore, geographical concentration is a prerequisite for the organization of transactions among specialized workers as open market exchanges. If workers  $a_1, b_2, c_3$ , depicted in fig. 6, are independent producers, there must be in their neighborhood workers  $d_1, e_2, f_3$ , so that non-bilateral transactions take place. On the contrary in the configuration depicted in fig. 7 transactions are necessarily bilateral and production is vertically integrated.

#### 4 — Division of labor and problem solving ability: the Japanese workshop

The advantages of the division of labor, namely the increase of the productive powers of labor, are partially compensated by the shortcomings of the saving of human capital that it determines.

The organization of production must solve continually problems that arise from daily operation, namely technical contingencies (machine breakdown, quality defect of product) and contractual problems in the transactions between related workers. Without division of labor, the latter are minimized, while the former are solved by labor skills. With the division of labor, the loss of qualification by workers decreases their solving problems ability. According to Smith:

In the progress of the division of labor, the employment of the far greater part of those who live by labour, that is, of the great body of the people, comes to be confined to a few very simple operations; frequently to one or two. But the understanding of the greater part of men are necessarily formed by their ordinary employments. The man whose whole life is spent in performing a few simple operations, of which the effects too, perhaps, are always the same, or very nearly the same, has no occasion to exert his understanding, or to exercise his invention in finding out expedients for removing difficulties that never occur. He naturally loses, therefore, the habit of such exertion, and generally becomes as stupid and ignorant as it is possible for a human creature to become. [Smith, 1981(1776), pp, 781-2.]

Therefore, the smithian division of labor implicitly assumes the existence of a solving problems staff (SPS). The cost of the SPS should be weighted against the economies of specialization. The balance of advantages and shortcomings of the smithian factory depends on the degree of uncertainty in technology and market organization.

According to Aoki (1990), the management of production in the Japanese firm is different from the American firm. While the latter corresponds more or less to the smithian division of labor described in point 1, in the former each worker,  $a, b, c$  also performs one of three tasks (so that he is specialized). The

difference consists on the fact that there is rotation of workers among tasks, so that each worker learns the three tasks.

Less capital (human and physical) is saved in the Japanese shop, but the problem solving ability by the individual worker increases, as was noticed by Adam Smith (see quotation above). Furthermore, an economy of a staff of solving problems specialists (SPS) is made. Production responds smoothly and quickly to contingencies. If worker  $c$  must be retired on account of a technical reason, the American scheme  $a_1 \rightarrow b_2 \rightarrow c_3$ , stops. If orders decrease  $\frac{1}{3}$ , each work station in the American scheme has  $\frac{1}{3}$  of idleness. On the contrary, in the Japanese shop in both cases new productive combinations without idle capacity  $a_1 \rightarrow b_{2,3}$ , or  $a_{1,2} \rightarrow b_3$ , or  $a_{1,2} \rightarrow b_{2,3}$ , easily arise.

The optimal size of the Japanese firm is smaller than the optimal size of the American firm. Job rotation becomes too costly on a wide organization. Therefore, heterogeneous functions are disintegrated and become subcontracting suppliers.

Geographical proximity of the work stations is also crucial for the efficiency of the Japanese shop. Workers do not merely transfer goods in process — as they rotate, they also share information about the tasks. In fig. 8, a smaller circle depicts a Japanese workshop.

## **5 — Conclusion: Division of labor and geographical concentration of production**

We were able to conclude that geographical concentration (the smithian «extent of the market») limits both the degree of specialization of productive tasks and the degree of autonomous firm formation by vertical disintegration. On the other hand, the institutional framework of production matters: the less capital (human and physical) is saved by the division of labor — as it occurs with Japanese production management — the more firms are vertically disintegrated and the higher geographical concentration should be.

FIGURE 1  
Undivided labor

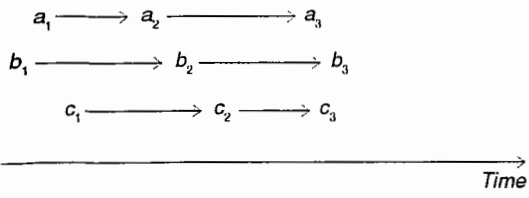


FIGURE 2  
Divided labor

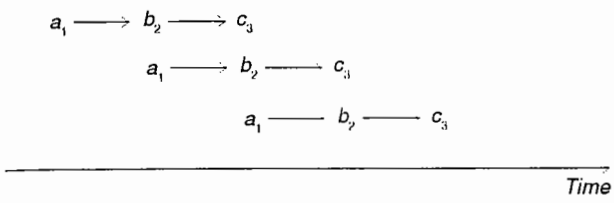


FIGURE 3  
Landscape of undivided labor

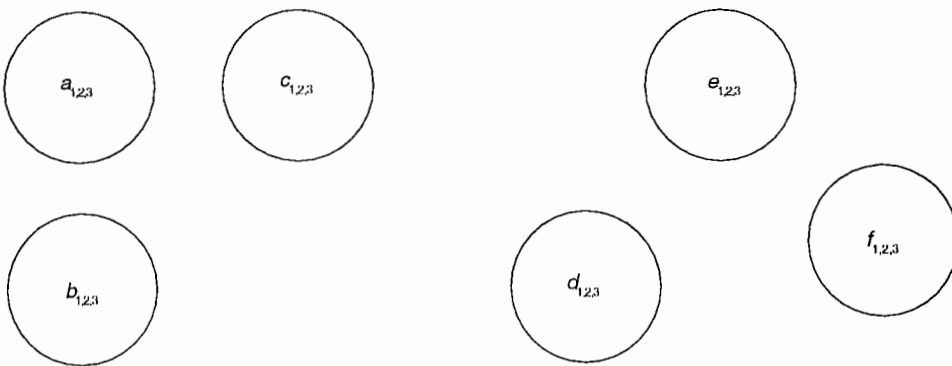


FIGURE 4  
Landscape of divided labour

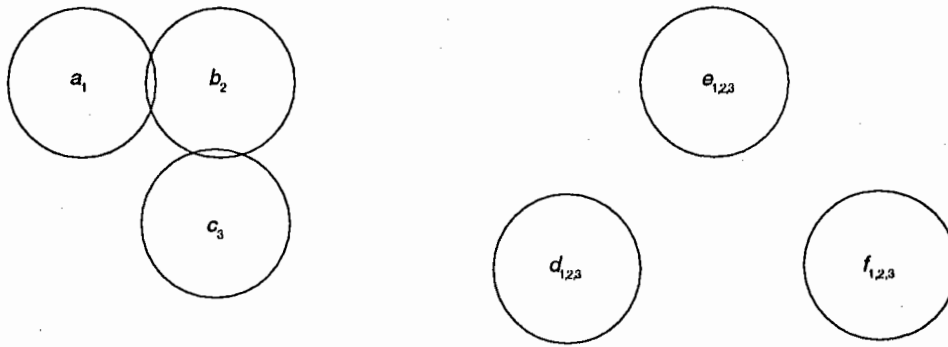


FIGURE 5  
Landscape of further subdivision of labour

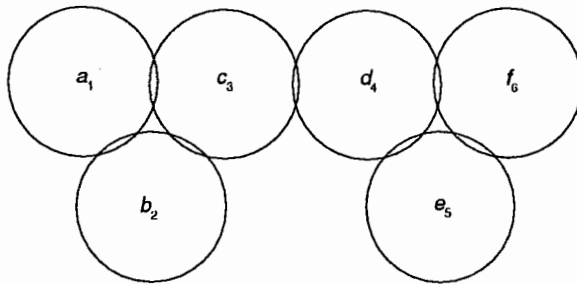


FIGURE 6  
Market organization of transactions

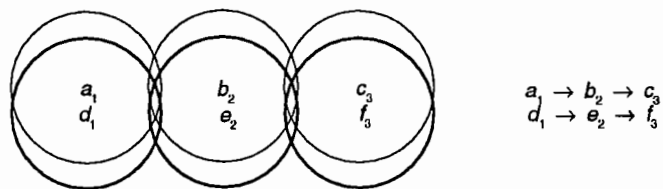


FIGURE 7

Vertical integration (site specificity of assets)

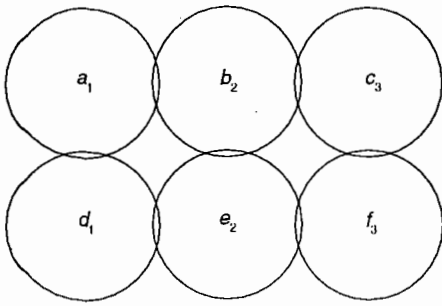
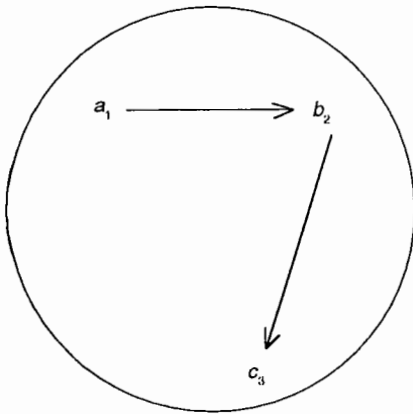
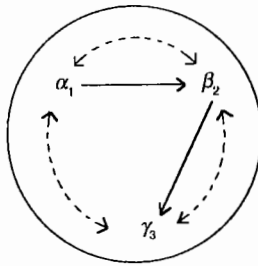


FIGURE 8

American and Japanese workshop



American



Japanese

→ Goals in process.

← - - - -> Information.

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