

# INNOVATION, COMPETITIVENESS, AND THE BLACK BOX OF PRODUCTION

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12/09/05

## References

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## Note on methodology

- The aim is to make a synthesis of concepts and ideas in the first place.
- Hence a system of these interrelated concepts must be complete in the sense that in our synthesis "we must not leave out anything important". For example how can we describe the element oxygen if we only take into account 7 electrons instead of the existing 8?
- For the time being let us concentrate on the description and significance of concepts. Their measurement will come later: we must first know that a planet exists before we attempt to measure its characteristics.

## Competitiveness

- 1<sup>st</sup> definition: a firm's dream is to have a monopoly in the market: then no other firm can compete. If the firm is not a monopolist then at least an oligopolist or a monopolistic competitive; the worse situation for the firm would be to be part of a very strong competitive market (the 'perfect competition').
- 2<sup>nd</sup> definition: how is a given firm performing in relation to other firms? Is it surviving, growing, or are its profits and/or market share reducing?
- 3<sup>rd</sup> definition: are the costs of a firm growing fast, or are they steady, or are they reducing? Or are its prices low enough to compete with the prices of other firms?

## What does competitiveness evoke to you?

- Comparative advantage: differences in opportunity costs is the source of trade and survival and growth of firms, sectors and countries; this might lead to differences in profit.
- Entrepreneurship: ability to respond to opportunities in markets.
- Innovations: creative destruction (Schumpeter), and ability to imitate.
- First mover advantage: cost leadership and differentiation.
- Acquiring resources and capabilities.
- Transaction costs and imperfect information
- Porter's 5 forces: supplier power, threat of entry, threat of substitutes, buyer power, industry rivalry

## Consequences of competitiveness

- On the other hand we need to know the consequences of competitiveness. Hence we need to determine proxies like:
  - productivity
  - exports
  - prices
  - quality
  - ratio of inventories to sales
  - etc

## Innovation and technology

- Technology is not only technical or embodied innovations (TIs: e.g. a new machine) but also organizational or disembodied innovations (OIs: e.g. the just-in-time—JIT-system).
- The impact of OIs on economic growth may be as important as that of TIs, or it can be quite independent from that of TIs.
- The grouping of all major OIs into three axes facilitates the understanding of their impact on economic and societal growth. In particular, the main axis of the firm's internal organization of labour and capital, the JIT cum Fordism system, is emphasized. The other 2 axes are vertical integration and networking.

## The history of the production function (an incomplete path...)

- At the beginning there was the production function: Thunen in the 1840s discovered ...the Cobb-Douglas function (1928)! (see Humphrey, 1997)
- $Q = f(K, L, T)$  where K is stock of capital, L is stock of labour, and T is "technology". Later and more recently Q was enriched with mainly human capital and knowledge.

## Then transaction costs

- Then in 1937: Coase: transaction costs:
- "...What happens in between the purchase of the factors of production and the sale of the goods that are produced by these factors is largely ignored...The firm in mainstream economic theory has often been described as a 'black box'. And so it is. This is very extraordinary given that most resources in a modern economic system are employed within firms..."

## Then institutions and rules

- Another Nobel laureate, North (1992) has combined the theory of transaction costs with the evolution of institutions and organizations and made it clear,
- that when transaction costs are positive,
- institutions matter,
- and economic growth is heavily influenced.

## Then firm resources

- Penrose (1959) started a new wave of awareness about the role of firm resources, which in turn became the basis of the impact
- of capabilities and competences on the growth of firms.
- More recently Prahalad and Hamel (1990) developed the concept of core competences of the resource-based view of the firm.

## Then capabilities

- Hodgson (1998) suggested that the transaction costs-based view of the firm can and should be complemented by the competence-based view.
- Thus, these competences create a culture, an institution, trust and loyalty none of which is translated as a contract but rather it becomes tacit knowledge difficult or impossible to buy and sell.

## Need for synthesis

- Can we put all that together?
- The Thunen, Cobb-Douglas and many other standard production functions need an urgent overhauling, a drastic revision to take into account transaction costs, capabilities, competences, and so on.
- We also need to look at some other aspects of what firms do to survive, grow and dominate as well what firms do not do so they die or do not grow, and so on.
- The same applies for sectors and countries.

## The suggested synthesis

- We need to go inside the core of the firm and see its existence and reasons for growth.
- We should have a theory or method that possesses the following elements: complete, dynamic, categorized, as general as possible.
- Hence the “process of the black box” (PROBB): 4 categories of interdependent, mutually exclusive, negentropic open systems of activities and operations.

### Summary of the 4 PROBB

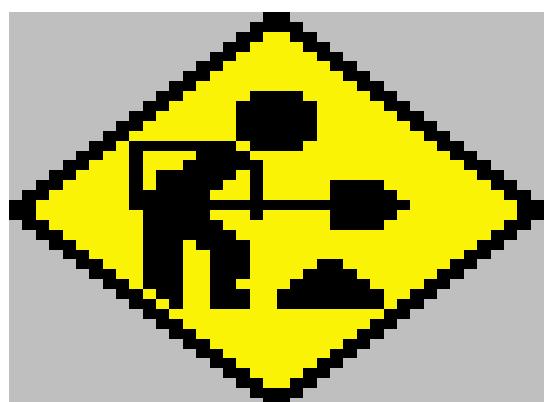
- In summary, the four vital PROBB constitute the fundamental elements of producing work:
- We need knowledge (Process of wisdom=POW) and rules (Process of contracts=POC) in order to decide (Process of strategies=POS) how much of each tangible factor of production (TIOP, e.g. machines, people) is efficient to execute the desired work in an organized way (Process of movements=POM) in order to attain the objectives and mission of the firm (POS).
- If we only have rules, quantities of factors, knowledge and decisions, work cannot take place unless there are the right movements of execution and effort. Thus, the POM (not necessarily the shop floor) is the ‘heart’ of the firm.

### The PROBB


### The PROBB

POW	POS	POM	POC
<u>Knowledge</u>	<u>Emergence</u>	<u>Movements</u>	<u>Hierarchy</u>
e.g. R&D	e.g. inertias	e.g. timing	e.g. governance
e.g. tacit kn/e	e.g. momentum	e.g. feedback	e.g. status
<u>Techniques</u> (e.g. financial)	<u>Planning</u> (e.g. policies)	<u>Teamwork</u> (e.g. prob solving)	<u>Rules</u> (e.g. informal)
<u>Culture</u>	<u>Deciding</u>	<u>Effort</u>	<u>Conflict</u>
e.g. attitudes	e.g. sense making	e.g. fatigue	e.g. trust
e.g. virtue	e.g. Inspiration	e.g. satisfaction	e.g. incentives
<u>Experience</u>	<u>Risking</u>	<u>Space</u>	<u>Standards</u>
<u>Sophistication</u>	<u>Mistakes</u>	<u>Execution</u>	<u>Contracts</u>

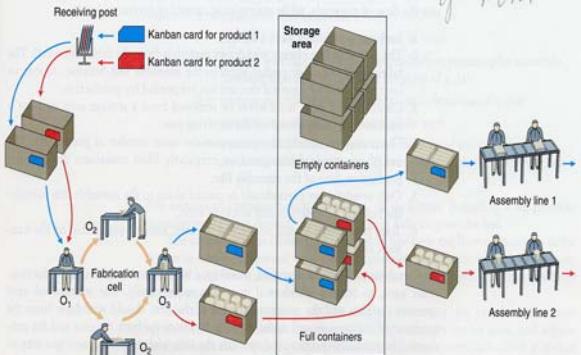
### Movements is the essence



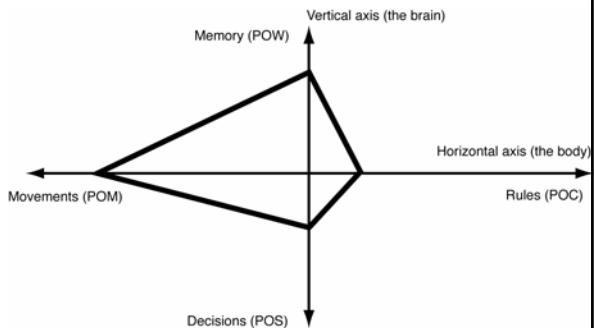
## Process chart: movements

Summary						
Activity	Number of steps	Time (min)	Distance (m)			
Operation	5	23	—			
Transportation	9	11	815			
Inspect	2	8	—			
Delay	3	8	—			
Store	—	—	—			
Step no.	Time (min)	Distance (m)				
1	0.50	15	X			
2	10.0	—	X			
3	0.75	40	X	X		
4	3.00	—	X			
5	0.75	40	X			
6	1.00	—	X			
7	1.00	60	X			
8	4.00	—	X			
9	5.00	—	X			
10	2.00	200	X			
11	3.00	—	X			
12	2.00	200	X			
13	3.00	—	X			
14	2.00	—	X			
15	1.00	60	X			
16	4.00	—	X			
17	2.00	160	X			
18	4.00	—	X			
19	1.00	20	X			
Step description						
Enter emergency room, approach patient window Sit down and fill out patients history Nurse escorts patient to ER triage room Nurse inspects injury Return to waiting room Wait for available bed Go to ER test Wait for doctor Doctor inspects injury and questions patient Nurse takes patient to radiology Technician x-rays patient Return to bed in ER Wait for doctor to return Doctor provides diagnosis and advice Return to emergency entrance area Check out Walk to pharmacy Pick up prescription Leave the building						

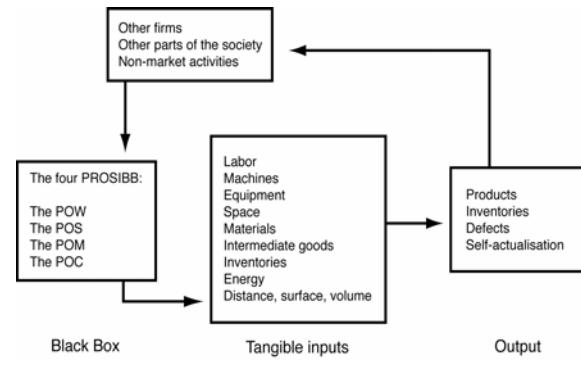
## Kanban and JIT: movements



## The diamond of the four PROBB



## The holistic bio-socio-economic process of production



## A new production function

- A typical model of endogenous growth (representing the mainstream theory of the firm and growth) is: (a)  $Y = F(K, L, N)$  and (b) change over time of  $N = R(K, L, N)$ , where  $K$  is capital,  $L$  is labor, and  $N$  is the stock of knowledge.
- These two equations can be more specific with the introduction of a Cobb-Douglas function, inclusion of intermediate goods, value of the stock market, prices of capital and labor, technology, and so on (e.g. cf. such a mathematical model by Marrewijk, 1999).
- Can these functions just cited be a realistic representation of the work carried out by people and equipment?

## The standard production function versus the POM and the PROBB

- In particular can these functions represent the POM or coordinated and organized movements of people and machines?



- The answer is NO.
- Hence a new function is needed:
- $Z = z(POW, POS, POM, POC, TIOP)$

## The 3 properties of the PROBB

- **Proposition 1:** The PROBB encompass all possible bio-activities of a firm (and related opportunity costs)
- **Proposition 2:** The four PROBB are mutually exclusive and interdependent
- **Proposition 3:** the PROBB is an open system, hence negentropic: thus the tendency of the organized firm is to counteract or diminish the natural tendency of all closed systems to increase their entropy (=disorder).

## The four PROBB are mutually exclusive and interdependent

- For the firm to exist all four PROBB must be in existence, or schematically we can say that  $POW \neq 0$ ,  $POS \neq 0$ ,  $POM \neq 0$ ,  $POC \neq 0$ . Also the four PROBB are non-overlapping.
- Thus a firm without any movements (POM) (e.g. walking, talking, lifting a hand, etc) cannot exist, as there is no work done.
- Similarly if there are no rules (POC) to tie down everybody into a constitution, contracts, etc, the firm will soon be in anarchy and hence collapse.
- If there are no decisions and initiatives for action (POS) the firm cannot take place or evolve, or compete.
- If there is no accumulated knowledge and memory (POW) nothing else can be created.
- If there are no TIOP, the firm cannot exist either.

## The PROBB is an open system

- An open system is negentropic, because it differentiates and elaborates with respect to its internal structure, as its growth takes place, in order to resist against the entropic process, that is, the tendency towards increasing disorder.
- To express all this in terms of the four PROBB, let E1 be the entropy of the POM during a particular stage of development of the firm. Together with the influence of the other four PROBB, the POM is altered (for example via the POS which always sees what happens inside and outside the firm) in order to release more energy (e.g. by removing bottlenecks in specific areas of the production process), thus lowering entropy from E1 to E2.

## The PROBB and Opportunity costs

- A set of TIOP can correspond to different sets of various elements of the PROBB. For example for the set TIOP1 it is possible to have three different sets of PROBB: PROBB1, PROBB2, and PROBB3.
- Thus the expenditure for TIOP1 is equivalent to three different streams of investment projects, that is the benefits due to the opportunity costs of the three different sets of PROBB.
- It is this possibility of alternatives within the PROBB that create substantial differences between firms.
- To see this possibility in a more analytical way, let us consider the method of linear programming (a non-linear programming would certainly confirm the conclusions) as a tool of analysis.

## The PROBB as opportunity costs

- Let ZP and ZD be the functions of optimizing output (hence profit or revenue plus self-actualization) and costs, ZP for the primary model and ZD for the dual model (not all indices are shown for simplicity).
- $\max ZP = \sum H_i Q_i$   
subject to  $\sum \beta_{ij} Q_i \leq (TIOP_j + PROBB_{ij})$
- Hence  $\min ZD = \sum y_j (TIOP_j + PROBB_{ij})$   
subject to  $\sum \beta_{ij} y_j \geq H_i$   
( $y_j$  are opportunity costs, or shadow prices)  
(System I)
- **Thus outputs  $Q_i$  are assigned profits per unit  $H_i$  and the constrained combinations of  $Q_i$  with parameters  $\beta_{ij}$  are limited by all the inputs of production, namely the  $TIOP_j$  and the  $PROBB_{ij}$ .**

## The PROBB as opportunity costs

- The duality theorem tells us that  $\max ZP = \min ZD$ , hence as only the  $y_j$  of the TIOP have market prices or explicit pecuniary prices  $P_j$ , then  $y_j < P_j$  since  $\sum y_j (TIOP_j + PROBB_{ij}) = \sum P_j TIOP_j$  and  $\sum (P_j - y_j) TIOP_j = \sum y_j PROBB_{ij}$ .
- Let the difference  $P_j - y_j$  be called the diamond value of the black box (a paradoxical expression indeed). The higher this diamond value is the higher the value of the firm is for given quantities of the TIOP. The diamond value of the PROBB clearly depends on the expression  $\sum y_j PROBB_{ij}$ , which is the value of the black box.
- Eventually we can use this concept of the diamond value in order to explain the birth, existence, evolution and death of firms.

### The diamond value of the firm, its birth and growth and competition

- For example, a firm is born when the perceived diamond value (for given quantities of the TIOP) is large enough to be competitive in the market for survival and prosperity. The survival and evolution of a firm depends on the evolution of and dynamic changes in the PROBB in relation to other firms.
- For instance, the  $y_j$  in the  $P_j - y_j$  are relatively low (due to excess supply of the labor components) during the beginning of industrialization of a country but the  $P_j$  tend to grow very fast due to the fast developments of the PROBB. Hence the diamond value of the PROBB is very high in these cases and consequently high economic growth takes place.

### The PROBB as opportunity costs

- Second, let us consider the optimization case whereby the PROBB is considered as a set of outputs. Consequently the PROBB can be viewed as quantities of production with intrinsic values per unit  $G_i$ , thus forming the following system.
    - $\text{Max } ZP = \sum G_i \text{PROBB}_i$  subject to  $\sum a_{ij} \text{PROBB}_i \leq \text{TIOP}_j$
    - Hence  $\text{Min } ZD = \sum y_j^* \text{TIOP}_j$  subject to  $\sum a_{ij} y_j^* \geq G_i$
- (System II)
- In this version of the analysis (and within the assumptions and limits of this example) the value max  $ZP$  equals the value max  $ZP$  of system I above since the firm is the same and the maximum value the firm can get by creating the appropriate PROBB should be the same as the value created by using the PROBB and the TIOP as inputs to optimize outputs  $Q_i$ .

### The PROBB as opportunity costs

- In the present case (system II) we optimize the PROBB given the limited amounts of TIOP. In the first case (system I) above we optimize  $Q_i$  given the limited amounts of all inputs (TIOP+PROBB).
- Combining systems II, and I, we can easily arrive at the following important conclusions. First, the opportunity costs (or maximum prices) of the TIOP are higher when the PROBB are not included in the optimization process than when they are:  
 $y_i < P_i < y_j^*$ , where  $y_j^*$  are the maximum prices of TIOP the firm can accept in order to optimize both the outputs and the PROBB.
- Second, the per-unit benefits of  $G_i$  in system II are larger than the  $y_j$  of the expression  
 $\sum y_j \text{PROBB}_{ij}$  of system I:  $G_i > y_j$  and the difference  $G_i - y_j$  is another way of appreciating the diamond value of system I.

### The PROBB can do many things

- The core of the firm and economic growth is the PROBB and in particular the POM.
- The PROBB of the firm can be extended to the PROBB of the society and the PROBB of individuals in each country.
- The PROBB is the true reason for economic growth and degree of competitiveness.

### Epilogue...

- Coordinated and organized motion, kinesis, is the essence of life, and indeed economic life (the POM and hence the PROBB). It is the source of many types of innovations (wisdom, kinetic, etc, hence OIs) and competitiveness:

