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Abstract.
Time has been an enigma in economics for many theorists, from Xenophon to Myrdal and Hicks. The objective of this paper is not to analyze issues around the time we associate with the clock or the mechanical time, but the time of intent or relative time. The paper uses philosophical approach to establish logical platform for analyses and definition of economic processes in time. On basis of the analyses a production function for economic processes in time is purposed. The paper closes by practical application were the new findings are used to give an economic rational explanation for the metaphor *property rights* or ownership.

KEYWORDS: Time; Value; Management; Economics; Processes; Dynamics; Property rights.

1. Introduction[1]

It has often been stated, and rightfully so, that the philosophy is the mother of all scientific disciplines. With an aid of philosophical approach we lay the logical foundations and frameworks for other disciplines. In explaining, the disciplines however are limited to the foundation of their logical frameworks. There comes a time in most disciplines when the theoretical foundation fails to provide proper explaining for some explicit phenomenon. In these cases a new knowledge has to be acquired by other means than the draw it from the logical framework of the

[1] The author would like to thank Dr. Sveinn Agnarson for valuable comments.

respective disciplines. This can in turn result in a whole new paradigm for the discipline, as was the case in physic with Einstein and his Theory of relativism. Most efforts however will lead to moderate change in the theoretical framework or, as presented in this paper, a moderate addition to the framework. The objective of this paper is analyze and define the value of time in economic processes, a phenomena that has been unsatisfactory explained since the discipline emerge as a independent form of study.

In his book, *Methods of Dynamic Economics* (Hicks, 1985), Hicks divides the economic discipline in to two major fields according to their respective treatment of the time issue; *economics of time* (EOT) and *economics in time* (EIT). In EOT, which makes up the overwhelming share of the literature within economics, time is defined and used as a parameter of measure in same manner as kilometer, kilogram or a mile. As for the kilograms, there are no fundamental theoretical problems involved in use of time as a parameter of measurement. The time in EOT is often named mechanical time or clock time. As we will see later in this paper, the time in EIT is treated as a resource variable. To distinct the mechanical time in EOT from the variable time in EIT, the latter will be named *resource time* as will become apparent later in the paper.

There are number of economic theorists that have been occupied with time and here we will only name few of them. In his major writings, Alfred Marshall (Marshall, 1920) frequently takes up the problem of time issue. The core of the problem, for Marshall and everybody else, was that when results from rational agents of similar or compatible economic processes were analyzed and compared, the results could diverge considerably from what was to be expected, especially if they are analyzed for longer periods. Given the economic theory assumes rational behavior of agents of economic processes such results is rather disturbing. In both cases, something happens during the process between points of measurements, an impact that economic theory had no rational explanation for. Without any Traverse (Hicks, 1985) through observation points in time the discipline of economics lacks the ability to predict. Marshall suggestion to solve the problem of the time issue was to dividing economic processes in to long-, and short run periods, were results could differ. Marshall did not give any explanation on how to get from the short-, to the long run, he only claimed that there were no natural boundaries between the two, an explanation that is not scientifically satisfactory

Immediately after Marshall the Swedish economist Gunnar Myrdal (and later Lindahl) made also a considerable effort to cast light on the same issue but from slightly different angel. Myrdal's way of looking at the problem of economics in time was through the aspect of the terms *ex ante*, *ex post*. Preferences in the beginning of a process (*ex ante*) may differ from the accumulated results for that same process (*ex post*) (Myrdal, 1939). Many other theorists have written about the issue[2], but those mentioned above have approached the problem from similar perspective as is done in this paper. All these authors (Marshall-Myrdal-Hicks) describe the same phenomena but none of the offers any explanation of the cause, just a classification of the effects. An exemption from this is to some degree Hicks that claimed that tendencies (the Traverse) in the economic processes in time are *the equilibrium*, a claim that we will scrutinize in the next section.

The objective of this paper is to analyze economic processes *in time* as opposed to processes were time is solely treaded as a parameter (EOT). There is however a range of auxiliary definition problems connected to the issue of time in economics such as, dynamic vs. static processes, the *general equilibrium theory* and rationality. These auxiliary problems are dealt with in Sections 2-4. The equilibrium theory is central in economic theory and Hicks' suggestion of using that idiom, as a tendency in economic processes cannot be ignored. In Section 2 we analyze and determine whether *the equilibrium* can be used as tendency in economic processes and thus, be the fundament that must be in place in order to predict. A frequent expression in various disciplines is that there exists a dynamic approach, which is better suited to analyze sequential occurrence in the *state of affairs*[3] than static approaches. This is scrutinized in Section 3. Economic methods have been criticized for frequent use of *ceteris paribus* clauses. In section 4 we will see that *ceteris paribus* clauses are necessary in any scientific prediction. Section 5 defines the rational behind tendencies in economic processes and Section 6 defines the boundaries, or the economic space for these tendencies. Section 7 specifies the directions of economic

[2] Here we could name a range of economists, and in addition some members of the Austrian school, such as Lachman, Menger and Hayek that have made a contribution to the issue. This paper is however not a literature survey and we will only name those that can contribute to enlighten the line of argument.

[3] The term, *state of affairs* has similar meaning as in Wittgenstein's Tractatus (Wittgenstein, 1918) i.e., things that happens in the real world as opposed to the description of what goes on there, in books, tongue or on the blackboard.

processes in the economic space and in Section 8, the value of the time resource is defined on basis of the findings in previous sections and a general production function for economic processes in time is presented. The paper wraps up in Sections 9-10 by providing practical applications and observations with the acquired knowledge about the time resource in the economic processes.

2. The General Equilibrium Theory and Dynamic Processes

A central issue in the discussion of time in economics is the *general equilibrium theory*[4]. This is the case in the line of argumentation for the neo-classical economists as well as the Austrian ones. The Austrians however, have used the "credibility" of the *equilibrium theory* to attach the neo-classical branch of economics[5]. Friedrich Hayek attacks in his article "Economics and Knowledge" the equilibrium theory from several different angles. Hayek especially attacks the fundamental assumption of the *general equilibrium theory* on perfect markets. Perfect markets requires a perfect knowledge, a society where everybody knows everything about everybody, at the same time it is assumed that the same market is infinity large and thus impossible for everybody to know everything (Hayek, 1937). Although one has to agree with Hayek that it is doubtful that such a condition or requirements will ever exists in societies, we cannot exclude that the idiom could be useful in some aspects in economic analyses. The ideal or the optimal situation, *the equilibrium*, may never occur in real live situations but it may be a useful "norm" or a "standard" which can be used to measure different variables of the processes that are active in the market(s). The limitation of the *general equilibrium* theory to explain dynamic processes in the *state of affairs* was evident to some of the neo-classical economists and especially Alfred Marshall[6].

> The statical theory of equilibrium is only an introduction to economic studies; and it is barely even an introduction to the study of the progress and development of industries, which show a tendency to increasing return. Its limitations are so constantly overlooked, especially by those who approach it from an abstract point of view, that there is a danger in throwing it into definite from at all (Marshall, 1920).

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[4] In this context we mean the Walrasian general equilibrium theory.
[5] An example of this critiques are Driscoll's and Marios's discussions in their book, *The Economics of Time and Ignorance* (Driscoll and Rizzo, 1985).
[6] See for example Winston, Gordon C. 1981, and Currie M. and Steedman I. 1990.

The basic idea of *equilibrium* is that the forces of the market will eventually, in one way or another, reach an optimal steady state. In the literature definitions of the general equilibrium may vary, but the main concept is the same. This concept of equilibrium makes it difficult to use in a "dynamic context". To assume that an optimal point can be in a steady state (in equilibrium) and at the same time moving to a different equally optimal equilibrium is a statement that is difficult if not impossible to perceive. If the process was at its optimum in equilibrium at first instance, why bother to move to another equally economically optimal location? In addition, it is tedious to assume that a rational economic agent strives to push his process towards an economic equilibrium, a point where his profits are minimized. As we will see later in the paper, it is difficult to image a rational economic ag ent as the "tendency" that propels the economic process towards equilibrium. The agenda of a rational economic agent must be to maximize his profit. The agent would not stay on a path that he knows that will steadily reduce his net income down to zero as the process approaches its equilibrium.

Marshall and Hicks, who both tried to solve the problem around time, but within the context of equilibrium theory, were aware of these critiques and stressed the importance of solving the matter through, not only of a precise definition of the idioms, but also a precise description on of how to use the term (Marshall, 1920, Hicks, 1985). Marshall however, as we will see later, endorsed a static approach to dynamic problems. Hicks on the other hand, made efforts to incubate the *equilibrium theory* in a *general dynamic equilibrium theory*.

There are few theoretical economists that have used as much effort in solving the problems of time and economics as Hicks and his efforts culminated in his book *Methods of Dynamic Economics*. In that book Hicks tries to solve the dilemma between dynamics of the Marshall's *long* and *short periods* along with Myrdal's observations of *ex ante* and *ex post*, and the static *equilibrium theory*. His solution to the problem was to redefine the idiom *equilibrium*. The first step in his process was to alter the Walrasian definition of the term *equilibrium*, or rather, create a new one.

The static equilibrium of mechanics is a balance of forces; but though economist began by thinking of their static equilibrium as a balance of forces-a, for instance, the "forces" of supply and demand-that is a very poor account of what the static equilibrium of economics means. (Hicks, 1985).

In the case of *mechanics equilibrium*, the forces will inevitably reach a steady state and be there. As aforementioned, from there should not exist any intensive in moving further on. In order to give the equilibrium intention or tendency, as Hicks phrases it, is necessary to equip the idiom with a quality (tendency) that makes rational (logical) move from one point in time to another. The neo-classical economics has one of its fundaments based in the definition the rational economic man. The definition provides the economic processes with tendencies and therefore predictability. Consequently, any definition within neo-classical economics must be based upon that quality.

The static economic (in which wants are unchanging, and resources unchanging) is in a state of equilibrium when all the 'individuals' in it are choosing those quantities, which, out of the alternatives available to them, they prefer to produce and consume. (Hicks, 1985).

Hicks' definition of *static equilibrium* is simply that in a given steady state the rational economic agents (individuals) will use what is available to them to achieve their goals, and stating that a dynamic economics is a situation were; wants and/or resources are changing. Here however it is difficult to fathom what Hicks means by "wants" and his discussions later in the book does not imply that economic agents have other "wants" than the rational economic man. More precisely Hicks' definition of *static equilibrium* is:

The alternatives that are open are set in part by *external constraints* (which may differently defined, according as we select the data of a particular problem, but must generally include the supplies of land and of physical capital, and the state of technology); these, in a static economy must be taken to be constant. But they are also set in large part by the choices made by other 'individuals'; and the way in which the choices made by 'individuals' set constraints on the choices made by other individuals will differ from one market form (or more generally from one type of organization) to another. (Hicks, 1985).

Evidently as intended, Hicks definition of *equilibrium* has little resembles to the Walrasian definition of the same idiom, were the market forces of demand and supply will come to rest in an optimum steady state. If we accept his definition of Hicks on general equilibrium we have a fundamental logical problem. We have at least two definitions of the same term, equilibrium, and there are more of them in the literature. The term is therefore diluted and cannot be used without references to the respective authors, Hicksian-equilibrium, Walrasian-equilibrium etc. In this paper we leave the idiom *equilibrium*, solely to the Walrasian precise and static definition. Although the findings in this paper may seem to be in a disagreement to the Hicks analyses and conclusions (Hicks 1985) many of the findings in this paper are in agreement and similar to Hicks although the analyses in this paper and its predecessors are not based upon Hicks work at all. In Section 6 for example, the idiom economic space (ES) is introduced, which is in large similar or same the idiom as Hicks' definition of the *equilibrium* within economic processes in time.

3. Dynamic vs. Static Processes

Although many prominent Classical and Neo-Classical economics theorists have been occupied with problems of dynamics and time, the discipline has been criticized from various other disciplines of social sciences (and especially, Austrian economists) for being a science based solely upon static theories and methods. A common conclusion for most of these critics is that the Neo-Classical economics is ill suited to describe economic processes in the *state of affairs*. This criticism can be summarized by a citation from the book of Hollis and Neil, *Rational Economic Man: A Philosophical Critique of Neo-Classical Economics*:

> Neo-Classical theory is essentially static and its growth models, which define growth equilibrium in which all variables grow equiproportionally, portray nothing more dynamic than a "dynamic stasis." (M. Hollis and E. J. Neil, 1975).

Hollis and Neil criticism of Neo-classical theory and methodology is undeniably justifiable, but to before we condemn the discipline on the bases of being static, we should take a brief look at the methodologies of other sciences as well. We can use the methods of physics in analyzing a cyclist in a frozen moment in time and calculate the weight of all vectors that contribute to keep him balanced and in an onward motion. We can extend the analyses of the cyclist to include two points in time or more. Still, the analyses will employ solely static methods, including definitions of the relationships between any two variables at any two different points in time, and this also applies when we analyze changes between more than two points in time. Furthermore, the instance we turn our attention to analyze one or more variables in a process, the same variables and the rest of the process has already gone through changes and moved to a different point in time. Scientific methods that are used to analyze dynamic processes in the *state of affairs* are not only always *static* but also always *historical*. Regardless of the shortcoming of static methods, they are of high importance and probably the only way to generate new scientific information/knowledge and contribute to better understanding of dynamic processes in the *state of affairs*.

Most of us have limited capacity to process information without an aid of tools, computers or by other apparatuses. Given more than one variable in the process and more than two points in time, the solution to the problem domain will in most cases require an aid of simulations, computerized or otherwise. It can be debated whether simulated processes are dynamic ones or not. In simulations, all variables are defined beforehand and the same applies for the stochastic distributions that may be used. Furthermore, no random generator used in a simulation is completely random. The results of simulated processes are therefore more or less given in advance and the simulations can then probably be d efined as *nothing but dynamic stasis*. When we analyze simulations however, we use the same static methods (as described in the case of the cyclist) as we use for the processes in the *state of affairs*.

The discussion around dynamics and time has followed the humanity for a long time. The ancient Greek philosopher Zeno argued that dynamics in the state of affairs did not exist. Until this day, none has proved him wrong although some have made the disputed claim that the problem has been solved by introducing *limits point* or *point of accumulation* in mathematics. This paper agrees with Zeno except that he got his line of argument upside down. We do believe that *motion and dynamics exist in the state of affairs* but the analytical methods, today as in the days of Zeno *are and can only be static*. The conclusion is that the dynamics or *an economic process in time* can only exist in the *state of affairs*. Consequently, if we image time as a resource that is used by agents of economic processes, this resource can only exists, and thus, only have value in *the state of affairs*. If the correct perception of the value of time in economic processes is not already incorporated in the logical framework of economics, at least part of the theory must be re-examined. This line of argument also applies for simulated processes regardless of, whether they can be defined as independent identities (autonomous computer simulations) or not. Simulated processes, as other processes in the *state of affairs* have to be analyzed afterwards. In investigating what happened in the process we compare the points at different stages of the process, ex ante, ex post for example.

Connected to the lack of dynamics in economic theories and methods is the discipline's use of *ceteris paribus* clauses. In this context, it is enough to refer to the discussion provided by Hollis and Nell (1975), and McCloskey (1986). They argue, among other things, that all conditions for testing of economic theories are staged with an aid of *ceteris paribus* clauses, and that in turn makes the outcome *a priori*. If we apply the same criticism on the methods of physics, the ones that are used to analyze the cyclist, every single element of the environment that can possibly have an impact and change his balance and his forward motion should be included. Evidently, almost everything can happen to the cyclist, like the Earths loss of gravity along with all other possible unlikely things. To analyze things in the *state of affairs* without a *ceteris paribus* is impossible. In order to explain something in the *state of affairs* we have to have a point of reference, perception or a picture of what we want to describe and analyze as we will scrutinize further in the next section.

4. The Tendency of Economic Processes in Time

Let us consider the following scenario. In the windows of the interdisciplinary Norwegian College of Fisheries are three scientists looking over the fjord and watching a huge industry trawler sailing by. The fishery biologist looks at it and sees that its fishing capacity may be a threat to the fish resources. The scientist from the economic department sees that this vessel is going to add considerably to the gross national product and the naval engineer sees that this ship of this size and build is going to withstand all the rough sees of the Barents Sea. All three scientists have a different perception of the same object in the state of affairs and by using *ceteris paribus* clauses they may predict the future of trawler or how the process in time will unfold. The conclusion or the result of the process may also differ but within their respective disciplines, but nevertheless they may all be proven to be equally right. The predictions in all three cases are dependent upon the construction or the logical foundation of respective disciplines. Methods of all disciplines of science are based upon *a priori* knowledge or assumptions that contribute to dictate the perception of the observer, and thus, the analyses and the results. Economics are no exception.

The notion, that the objects in the *state of affairs* may have several different qualities is well known in modern philosophy. In this context, it is sufficient to name Kant's "Das Ting an Sich" and Wittgenstein's picture theory. This paper however, will make use of Hanson's framework that he published in his book, *Patterns of Discovery*

(Hanson, 1958). Hanson makes a distinction between *see as* and *see that*. The scientists of The Norwegian School of Fisheries mentioned afore, all *see* the factory trawler *as* such, but each of them *sees that* (percepts the object in the *state of affairs*) differently. One scientist sees that it will bring prosperity and another sees that it will bring devastation and both may be right.

We can use also use this line of argument within an economic process in time. Within the process there may be many agents on different levels that will have a different focus, *see that*, on the process. Furthermore, the results from *seeing that* from one focusing level to another are not necessarily transferable, simply because the point of reference *see as,* may be different. An example, a goal of maximum economic efficiency of a firm(s) within an industry may collide with the government's goal of maximum economic efficiency of the society. The firm(s) may strive to be a market leader and maximize their profit while the government may embrace a market with many firms of equal size in order to secure competition and low prices.

Let us picture a process in the state of affairs and assume that we are looking at a company in the mining industry. A division manager of the mining operation may focus on the costs generated by the digging and his time horizon may be a year or shorter. The general manager may include the fixed costs in his analyses and will probably not bother to analyze the operation costs in any detail. His time horizon will probably extend to some years. A legislator may *see that* the process is nothing but one of the many inputs necessary for the economic efficiency of the society and his time horizon may be counted in decades. In all accounts, the economic agents are *seeing* the process *as* economic and will strive for an optimum results. Nevertheless their processes may yield different results. The reason for this is that their *seeing that* is differs; the different agents within the process have different focus on the *state of affairs*.

When *seeing* an agent *as* manager for an economic process we *see that* he will lead the process in a certain manner. The economic agent will in all cases try to optimize his process according to his a priori view of the process, *see that*. All activities that strive in other directions than optimizing the economic results are *a priori* irrational in the context of economic theory. An agent that is irrational is unpredictable and can therefore not be driving force behind the tendency or the *Traverse* through time.

A term frequently used in economics and connected to the tendency in economic processes is, b*ounded rationality.* In the social science literature, the definition of this term has become diluted in a same way as the term equilibrium. The reason for this may reside in part in imprecise construction of the phrase. The only acceptable economic definition of the term is that by bounded rationality we mean an agent that is limited or bounded in his action. In that case, it is the agent's actions that are bounded but not his rationality. Logically, an economic agent can either be rational or not. We agree along with Hick's (see citations afore) the agents of economic processes are bounded in their actions in one way or another, as we will see later in this paper. To avoid confusion we will choose to use different term for *bounded rationality*, than the special case described above, as an idiom for limitation of agent´s actions within economic processes in time. Henceforward, we will call the agent's economic opportunity at a decision point in time, his *economic spaces* (ES) which we will examine closer in Section 5, and the unavoidable rational decision at the same point in time and within the same space, the *projected outcome of the process* (POP) which we will examine further in Section 6.

5. The Economic Process in Time

In his book *Methods of Dynamic Economics*, Hicks stresses the importance of keeping exact track of the sequential occurrences in dynamic processes. Hicks' perception of a process is a set of equilibrium points that create the *Traverse* or the tendency of the *process* through time (Hicks, 1965). Afore we argued that an economic agent was unlikely to have equilibrium as a tendency in his process. The tendency must be based on an economic value that the agents seek to maximize and that issue will be scrutinized further in the next section. In this section we will take a look at the traverse of economic processes and the necessity of sequential observations. The first question that arises is whether economic space of an agent is different in time than space. Will he see two objects that are two meters apart in the *state of affairs* differently from objects that are two hours apart?

Let us assume that we have two identical diamonds. One of them will be available tomorrow for an economic agent, on the spot, and the other one will be available two thousand kilometers away, a distance that will take exactly one day to travel. Obviously, if no costs are involved an economic agent will not have any preferences for either choice. Indeed, if no costs are involved it does not matter for the agent whether he gets a diamond at all. Another example is horse carriage in London in

1850 and exactly the same object in 1950. The value of the object in 1850 can clearly be different from the value in 1950. The economic space is different for the two cases; a cab driver in 1950's would see that there are limited possibilities to sell services of a horse carriage. Let us now assume that exactly the same type of horse carriage is staged in three places Seattle, Calcutta and Ulan Bator. In all three cities the carriage will most likely be valued differently. Whether we are analyzing objects in the state of affairs that are apart in space whether they are apart in time we use exactly the same methods. We compare the difference between the economic spaces of the two objects, whether we use to name our measurements miles or kilograms does not change anything. In both cases the methods of comparison are exactly the same and equally static.

Nevertheless, in practice we undoubtedly perceive a difference between some objects that link together in time and other that we link together in space. The difference does not resist in the nature or our perceiving of objects in the *state of affairs*, but in *the a priori* assumptions (*seeing that*) that we have about the same objects. In the case of an object in Seattle, Calcutta or Ulan Bator we assume that the objects are independent of each other in some way and therefore what happens to one object will not necessarily have an impact on the other objects. In the case of the horse carriage we may *see that* in 1850 that the same object may become obsolete in 1950. We assume that there exists a chain of events, or causality, in the *state of affairs.* Assuming that causality exists in the *state of affairs* is just another *a priori, Ceteris Paribus* assumption, which is less dynamic than the Rock of Gibraltar. This procedure, painstakingly comparing two points in time along the *Traverse*, has to be repeated for every time interval we choose to analyze along the Traverse, and there is no "dynamic" involved. Marshall had similar perception.

> The element of time is a chief cause of those difficulties in economic investigations which make it necessary for man with his limited powers to go step by step: breaking up a complex question, studying one bit at a time, and at last combining his partial solution of the whole riddle. In breaking it up, he segregates those disturbing causes, whose wanderings happen to be inconvenient, for the time in a pound called *Cæteris Paribus*. (Marshall, 1920. P.366).

In an economic process in time an economic agent will at each decision point in time analyze his economic space and choose (*see that*) the optimal path within its boundaries. We have chosen ton name this optimal path at each decision point in time *the projected outcome of the process* (POP). The "trail" of POPs through time set the tendency for the economic process through time and mark *Traverse*. This is illustrated in Figure 3 were the POP is broken up for the time and reciprocal dimension.

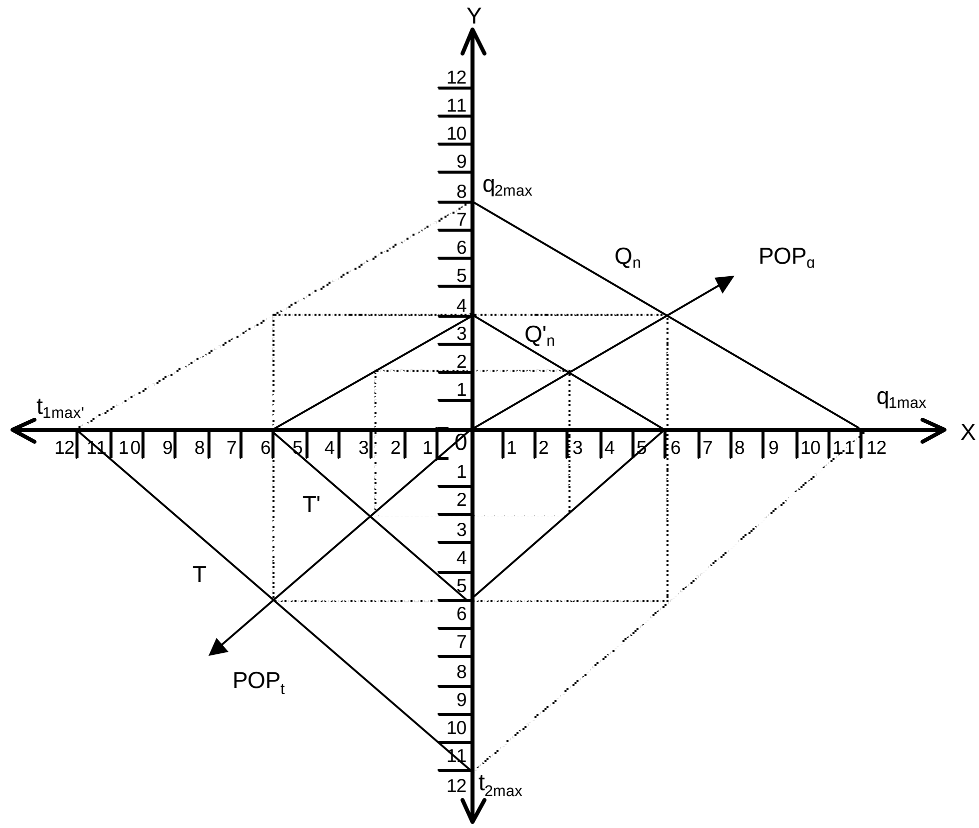

Figure 3. An Economic Process in Time. T,Q_n: Resources. Q'_n,T': Point to point transformation. t_{1max}, t_{2max},q_{1max},q_{2max}: Maximum output of a process. POP_q, POP_t: Projected outcome of a process.

Figure 3 percepts an agent in the *state of affairs* at a decision point 0, in an ongoing process in time. At each point in time the agent will have expectation to the outcome of the process. In Figure 3 the POP is splinted up in two vectors, POP_Q and POP_T and the numbers have been added to Figure 3. The directions of the POP's in their respective dimensions are drawn solely for illustration purposes. The values on the X'-, and Y'-axis could for example represent weeks, months or years and X- and Y-axes use of the reciprocal resources measured in metric tons, kilograms or grams. The economic process illustrated in Figure 3 will at the peak of its capacity, in time and quantity (at point a and b), use ten units of the reciprocal resource and twelve of the time resource. The process will need six units of the reciprocal resource, six units of the time resource to produce q_1. Likewise, the process will need to use four units of the reciprocal resource and six units of the time resource to produce four units of q_2. We see that after point to point transferring T to T' (the process is half a way in time) the process will use ten units of time vs. nine units of the reciprocal resources.

Different agents could have interests in viewing the processes in time on a different time scale. The numbers may represent periods such as weeks, years, decades, or hundreds of years. Different focus on by various agents on a process may yield not only different *see as* but *also see* that. By focusing in on a process the analyses may include more of details and omit the larger "objects" of the picture. For instance, when focusing on a process with a time horizon of less than a one-year it may be unnecessary to include fixed costs in the analyses. When zooming out on the same process, to several years or decades, it may be appropriate for the agent to include the fixed costs. Again, it depends on how the respective agents *see as* and consequently *see that*. Similarly in the reciprocal dimension, an agent in space will have a different focus on Miami than an agent that is on the beach. Marshall's distinction between long- and short-term time periods has therefore little to do with the problem of time in economic processes. The terms are just an expression for different focuses on the problem domain.

Once a process is running in time the agents do not have any choices or alternatives. They have to use resources that are available to them at each decision point in time or abandon the process. Obviously, if the agent chooses to abandon the process there is no economic process in time for anyone to analyze. Once, an economic process is running, the agent will keep it going as long as the outcome of the process is satisfactory. As the process advance in time, the economic space may change from one point in time to another. A change in T in Figure 3 at some decision point X_t (or zero as shown in the Figure) is due to the interdependency of the resources bound to have an impact on Q, and therefore have an impact in the ES and change the agent's window of opportunities. Another way to look at same issue is; if a change has occurred at a decision point the agents are forced to reallocate their resources in order to maintain the goal of economic efficiency[7].

If the elasticity of substitution between the resources in an economic process is zero, the Traverse of EIT and EOT will the same (linear). In case of a substitution we can expect the Traverse to be non-linear, as we will see in the next section. Resources of processes will in most cases have some degree of elasticity of substitution were the time resource will be the most versatile one. This among other issues we will explore further in the next section.

6. The Value in Economic Processes in Time

In former section we have come to the conclusion that all resources of processes in the *state of affairs*, including the time resource, are equally static and should be treated in a same way. So far, the analyses and the discussions have been without an explicitly defining what we mean by values of economic processes in time. The closest we have gotten definite the term is with Hick's economic tendency. In this section we will define the economic value in economic processes in time more explicitly. On the basis of the definition we will propose a production function for EIT.

The ancient Greek Xenophon was probably the first analyst to address the issue of economic value. Although his observations were made several thousands years before what we see as modern economics his observations and conclusions are equally valid today as they were then.

> The greater number of superfluous dishes set before man, the sooner a feeling of repletion comes over him; and so, as regards the duration of his pleasure, too, the man who has many courses put before him is worse off than the moderate liver (Xenophon).

As the Xenophon's observations imply, values are generated or perceived from pictures we have of objects and their interdependencies in the *state of affairs*. A man for example, that depicts a landscape with the knowledge that there are diamonds deep in the ground will probably value it differently from a man that is not in a possession of that knowledge. Economic values are purely subjective; they are not

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[7] The rationale for running of a process is a priori given. The criteria for keeping a process running may be other than maximizing profits but the agent will in all circumstances be interested in keeping the costs at minimum as becomes self-explained in the next section.

objects in the *state of affairs.* Furthermore, an object cannot posses a value without a reference to another objects in the picture we have of processes in the *state of affairs*, and in addition the purpose of the process (seeing that).

The cause for Xenophon's rezoning of value is scarcity. If something is scarce, it is likely to become relatively more valuable than the other resources in the process. It is a common knowledge that gold and silver are scarce and therefore of higher value than other more common minerals. This concept of scarcity applies to measurement of value in the *state of affairs* in general. A substance that is needed in a process, lets say in the ratio 1:100, obviously has the potential to be higher priced relatively to other resources that are required in greater quantities in that same process. Two resources that are needed in an economic process and available in an even ratio are likely to be of equal value. Altering the ratio will consequently alter the relative value of the two resources. The quantities of resources and values are therefore interdependently related. The relativity of values is one of the foundation pillars of contemporary economic theory as is revealed in the theory of supply and demand.

Values, or prices are qualities that we choose to add to objects in the *state of affairs* in order to make them comparable and thus, help to decide what is preferable. By seeing something *as* (within an economic context) we *see that* an agent's preference in a picture he has of objects in *state of affairs* is pointing in a certain direction.

Although there are no indications of prices in the processes, perceived in Figure 2 and 3, we have already made *a priori* statements about the matter. Use of resources, in this case T and Q_n, will in an economic context, generate costs. Obviously, if the process perceived in Figure 3 shifted from producing q_2 towards q_1, then relatively more would be used of the resource Q_n and relatively lesser of the T resource. In that case, if we assign values (costs) to the processes we would expect that the T resource would become more valuable relatively to Q_n. In general we would expect a process with a characteristic described in Figure 3 to shift towards to solely produce q_1, where the quantity of Q_n is relatively lowest compared to the quantity of T. We will return to this particular point in Section 7.

Evidently, an economic process in time and its production functions must possess a value for tendency in contrast to production functions within economics of time. Let us now depict the resources T and Q_n in a classical Leontief function (EOT) as shown in Expression 1:

$$MIN(Q_n, T) = POP \text{, were } Q_n, T > 0. \qquad (1)$$

Obviously, the Expression 1 cannot be used as a production function in economics in time for two reasons. Firstly, the Leontief production function does not possess any tendencies that can tie one decision point in time with another. The meaning of the Expression 1, perceived as a production function in EOT, is to minimize the use of quantities of the resources within the process. An economic intention that simply minimizes the quantities of resources used in a process cannot be a meaningful economic expression in EIT. If the production function is used over several decision points in time it simply advices to use no resources at all, and thus, no economic activities will take place. Secondly, in an ongoing process in time (EIT) the use of the resources must be based on relative values as discussed afore. This relative value can however not be based on market prices. At each decision point in time the economic agents are price takers, at that immediate moment they have no possibility of influencing the market prices. If one or more of his resources can act as substitutes he has the possibility of changing the outcome of the process. The Expression 1 can therefore not be a production function within economics in time. Let us now close in on the definition of the value of economic processes in time.

Let us assume that the costs of the resources in a process were indifferent and the revenues were not. Then, we would expect the agent to use as much resources as possible in order to create as large output as possible. The size of the output will at any given decision point in time be dependent on how the possibility frontiers demarcate the agent's economic space and thus, his economic process in time. Adding values to the objects in the process will not change this agenda, because the agent is, as discussed afore, always maximizing his economic output. However, adding prices to the process, as will be demonstrated later, may alter the direction of the POP within the economic space. For prices applies the same argument as for the quantities of resources, if they are going to have an impact at all on the direction of the POP, at least some the resources within the process must be substitutes to some degree. If none of the resources are substitutes the results in EOT and EIT are bound to be the same. There are number of possible substitution of resources economic processes, were the labor and capital is probably one of the most referred examples, but the time resource is the most versatile resources in this respect.

Before we add values to the production function let us for the shake of clarification look briefly at Figure 4. Let us start an economic process in time with a situation were T and Q_n are equal, i.e., $T=Q_n$ at i=0.

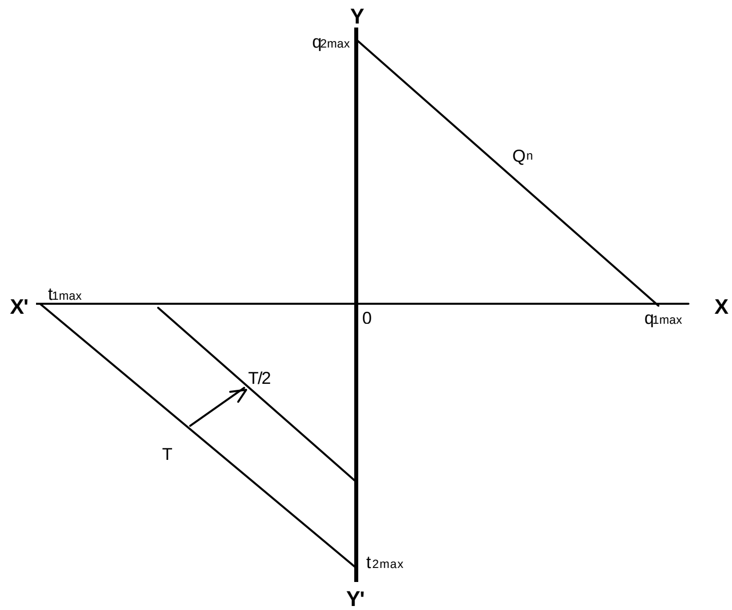

Figure 4. Demarcation of the economic space at time, from i_0 to i_n (T to T/2). T,Q_n: Resources. t_{1max}, t_{2max},q_{1max},q_{2max}: Maximum output of a process. POP_q, POP_t: Projected outcome of a process.

Let us now assume that at time point i_n, the time resource available to carry through the process is reduced from T to 1/2*T. The time resource has now become relatively more scarce compared to the reciprocal resources Q_n, and therefore potentially more valuable. We would therefore expect, *ceteris paribus*, the agent to use relatively more of Q_n at each decision point in time, if he has the possibility within the "design" of the process. Consequently, if we reduce one of the reciprocal resources Q_n, we expect the agent tend to use relatively more of T. By default using resources generates costs and assigning costs to each of the resources Q_n and T, we get C_Q and C_T, respectively. At each point in time i, all possible outputs, including the optimum solution, of the process is given and therefore, POP is a constant. The production function for the economic process in time, for the two resources T and Q_n

at each point in time i, with a maximum length of the process P, can therefore be expressed as:

$$\sum_{i>0}^{P}(MIN\left[\frac{C_{Qi}}{Q_{ni}},\frac{C_{Ti}}{T_i}\right] = POP_i), \text{ were } \mathrm{Q_{ni}}, \mathrm{T_i} > 0 \qquad (2)$$

Given that reciprocal resource Q_n can represent all resources used in a process, included the time resource T, the general function for an economic process in time can be expressed as:

$$\sum_{i>0}^{P}(MIN\left[\frac{C_{Q1i}}{Q_{1i}},\frac{C_{Q2i}}{Q_{2i}}......\frac{C_{Qni}}{Q_{ni}}\right] = POP_i), \text{ were } \mathrm{Q_{1i}}, \mathrm{Q_{2i}}..\mathrm{Q_{ni}} > 0 \qquad (3)$$

The agent will usually have some criteria for keep the process running and will check that criteria at each point in time. Such criteria may be that the sum of the cost of the reciprocal[8] resources may not exceed a certain limit. The agents do not involve the time costs in their criterion although they are always an inseparable part of the decision. Possible changes in the processes frontiers may be another set of criteria. The criterion for keeping a particular process running does not have to be an economical one as is the case for charity work for example. In that instance it could be debated whether the overall intension of charity work is economical or not but that discussion is not within the scope of this paper.

Expression 3 is a nonlinear, n-dimensional function where the possible optimal solutions can be more than one, as can be the case for labor and capital mentioned above. The possibility of multiple optimal solutions for economic processes in time can provide a rational explanation for a number of behavior patterns that have been regarded as irrational or thrown in the big basket of externalities. Let us image a process that constitutes of labor and capital and that has potentially two economic efficient solutions. Let us further assume that the process has limited access to capital compared to labor. The development of such a process will most likely tend towards using more of labor than capital. The direction of the economic process in

[8] Henceforward, it will be assumed that the resources are only two, the resource addressed and the reciprocal resources. To work with n-resources are too tedious and difficult to depict

time and thus, the optimal solution, will be depended on the ratio of values and quantities in the economic space at the start of the process. The high cost of labor through ban on slavery in West-Europe was probably one of the factors that fueled the industrial revolution. If West-Europe and especially England at that time did not possess huge stocks of capital and relatively limited labor, the optimal solution of the process that drove that society could have been different.

Expression 2 and 3 state that POP should be seen as the slope, or rather the direction economic space at each decision point in time. This is logical because at each decision point in time the agent makes his decision on what is possible within his economic space i.e., what he his going to have but not what he has. This becomes more clear if we increase the number of the decision points i, within given time length of the process P. It is therefore the ratios of C_Q/Q_n and C_T/T in Expression 2 that decide the direction of POP. In Figure 6 the possible outcome of the ratio for the two resources is plotted. We start out at an imaginary point in Expression 2 were all values are equal, or $Q_n=T=C_Q=V_Q$.

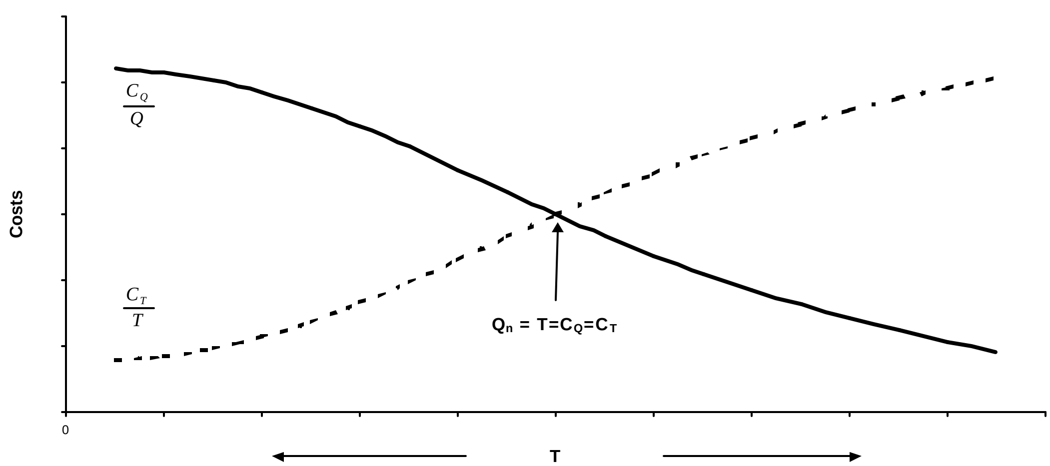

Figure 6. Use of the Time Resources in an Economic Process in Time. Derived from Expression 2[9]. C_Q: Value of the reciprocal resources. Q: Quantity of the reciprocal resources. C_T: Value of the time resource. T: Quantity of the time resource.

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on two-dimensional paper and such discussion would be of limited value at least within the scope of this paper.

[9] Figure 6 can be used in general. If we for example, substitute the time resource in Figure 6 with a stock of money it will show the effect of inflation and deflation.

Figure 6 demonstrates the effect of increasing or decreasing the time resource, T. Given that POP is constant, the use of reciprocal resources will decrease, and consequently, if the time resource is increased the impact is the opposite. This is not special for the time resource but Figure 6 can apply for any two resources that are perfect substitutes in the economic process in time. The T and Q_n could be replaced with labor and capital respectively or used to analyze Hume's famous statement about commodities and money.

> It seems a maxim almost self-evident, that the prices of everything depend on the proportion between commodities and money, and that any considerable alteration on either has the same effect, either of heightening or lowering the price. Encrease the commodities, they become cheaper; encrease the money, they rise in their value. As, on the other hand of the latter, have contrary tendencies (David Hume).

As aforementioned it is difficult to image (see that) how a path of a sequence of equilibrium stasis can stake out a path for a dynamic process. Earlier we came to the conclusion that the causes of the Traverse must be based on an economic evaluation, a value or utility. In its simplest form this value must be based on relative quantity of resources in the process. As we have shown with the argumentation afore, the values/prices/utilities in EIT, cannot be the market prices. The values used as a base for a decision criteria within the EIT are therefore not necessary the same as within the EOT. Therefore, it is not a contradiction to claim that a perfectly rational agent in EIT can achieve different results as perfectly rational agent in EOT as puzzled Myrdal and spurred his *ex post* and *ex ante* analyses.

There are number of cases that are of interest to explore when it comes to use of the time resource vs. the reciprocal resources but in this paper it is only space to briefly mention few of them.

7. Property Rights or Ownership in Economic Processes in Time

A metaphor frequently used in economics is *Property rights* or *ownership*. The term or the idiom does not have any economic dimension, just a notion that it is usually more economic efficient if agents own the resources they use in economic processes. Let us now scrutinize the conception of property within a context of economic processes in time (EIT).

As long as a process yields satisfactory results the agent will keep the process running. As the process moves through time it has the possibility of expanding in all directions, i.e. expansion time as well as expansion on the reciprocal frontiers. In the *state of affairs*, the processes will always be limited in a one way or another, if not in one of the reciprocal resources then in the time resource. When the reciprocal resources are unlimited, the time resource will by default, be the limiting factor. In that situation the cost of the time resource will consequently be very high (go towards infinity), which can easily bee seen with an aid of Expression 2 and Figure 6. In that situation the agent will use as much as possible of the reciprocal resources in shortest possible time. This situation in the literature has sometimes been referred to as *tragedy of commons*, or a situation that potentially can lead to the so-called *tragedy of commons*, a situation that has often been associated with a number of "odd behaviors" like wasting of resources. A good examples of processes in time that had extremely high time costs, is the hunting process that nearly brought the American Bison to extinction and the row stripping fishery of the West Coast of Northern America in the 20th century were only the more valuable rows of the Alaska Pollock was utilized and tens of thousand of tons (maybe hundreds of thousand) of the carcasses was thrown overboard. In both cases, at each decision point in time the biological resources are regarded as practically unlimited and the time resource limited. In these high time costs' processes the agents will use as much of the reciprocal resources as possible in order optimize the output of their processes.

If legislators or owners of processes, are interested in altering the economic behavior of the agents they alter the relative costs of the processes. In the case of the Bison, to lower the time cost relatively to the reciprocal costs. Allocating individual cattle's between the hunters could contribute to lower the time costs. After the allocation the time may become excess compared to the reciprocal resources and relatively lower priced at each decision point in time. Consequently, the new owners will start to pay more attention to processes that require relatively more time. They could focus their attention towards improving their part of the heard by breathing or they could put their empathies towards utilizing all parts of the Bison or both. The biggest economic advanced by introducing agriculture in the human society is the potential lowering of the time costs.

This effect of introducing ownership is however not an automatic one. By introducing restrictions in the ES of a process (altering the frontiers) the effect of introducing ownership can easily be countered. When economists speak of weak and strong ownership they are actually speaking of high and low cost of the time resource compared to the reciprocal resources. Let us scrutinize weak-strong ownership and the cost of the time resource more closely. Let us start with an economic process in time as depictured in Figure 3 and transferred to Figure 7, were line Q_n is representing a resource and furthermore, let the same line (Q_n) represent the technical production frontier for the process. Let the time resource T in this particular case represent one year. The output products, q_1 and q_2 could represent products, unrefined and refined respectively, i.e. assuming it takes longer to process the refined ones. Using Expression 2 we would expect that at next decision point in time; the process should expand from point b towards q_{1max} along the resource line Q_n and from point a towards t_{1max} on the resource line T as shown in Figure 7. This because, as frequently discussed afore, due to relatively lower prices of the reciprocal resources.

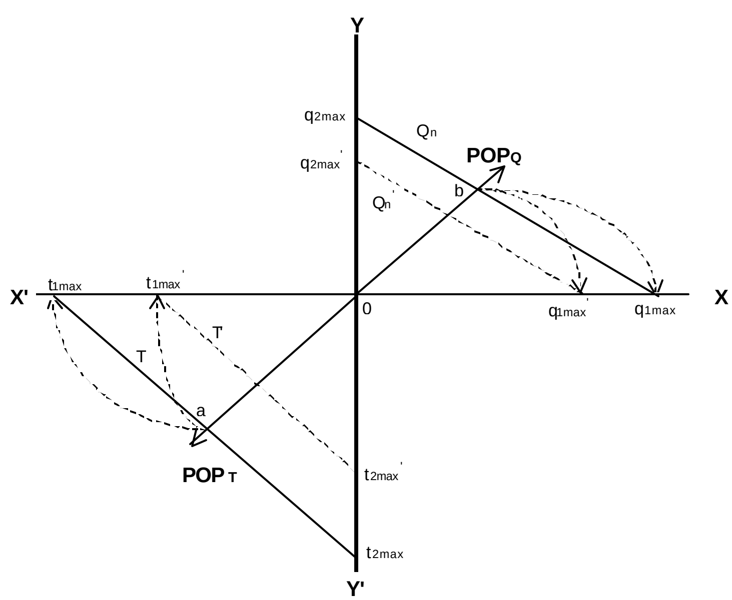

Figure 7. Relatively High Time Costs in an Economic Process in Time (Weak Ownership). T,Q_n: Resources. Q'_n,T': Point to point transformation. t_{1max}, t_{2max}, q_{1max}, q_{2max}: Maximum output of a process. POP_q, POP_t: Projected outcome of a process. a,b: Starting points of the process.

Let us furthermore assume that the ruler's agenda is to achieve maximum utilization of the reciprocal resource over time. His goal could be to have as much resources as possible for future generations. One way of doing so is to demark the available time that the agent(s) are allowed to harvest per year or reduce the hunting season for Bison. This is shown in Figure 7 were we have reduced time resource from T to T'[10]. The point-to-point transformation yields the corresponding quantity of the resource used, represented by the line Q_n' in Figure 7. We now got tendencies towards q_{1max}' and t_{1max}' as shown in Figure 7. It is easy to deduct from Figure 7 that by reducing the time resource the relative values between the resources will remain unchanged. The economic preferences of the agents are therefore also unchanged along with the overall tendency of the process. This solution (open access) will not contribute to lower the cost of the time resource and the economic efficiency of the process will remain the same per time unit.

This solution (open access) would probably equal to the most efficient solution if the there exists no substitution between the resources in the process. From Figure 6 and Expression 2 it's easy to deduce that any tendency that favors the output of q_2 instead of q_1 will increase durability of the resource. This is because processing q_1 requires more quantity than processing q_2, and the optimum solution for the legislator's (ruler's) goal is clearly in our case at q_{2max} and t_{2max}. To lower the price of the time resource (T) compared to the reciprocal resources could evidently be done by simply increase the T. In our case that is not an option because the T is exactly one year and the line Q_n is the annual production possibility frontier for the process. The Open access management of resources can therefore reduce the outtake per time unit but will most unlikely increase the economic efficiency of the process.

The introduction of quotas or ownership of resources on the other hand has the potential of increasing the economic efficiency of open access resources. Let us assume that we start with a similar situation as described in Figure 7 but this time we do not reduce the time resources as shown in Figure 8.

[10] In general, reduction of the time resource could be caused by number of factors in the economic space, from limitation by fluctuation in nature to restrictions by competitors.

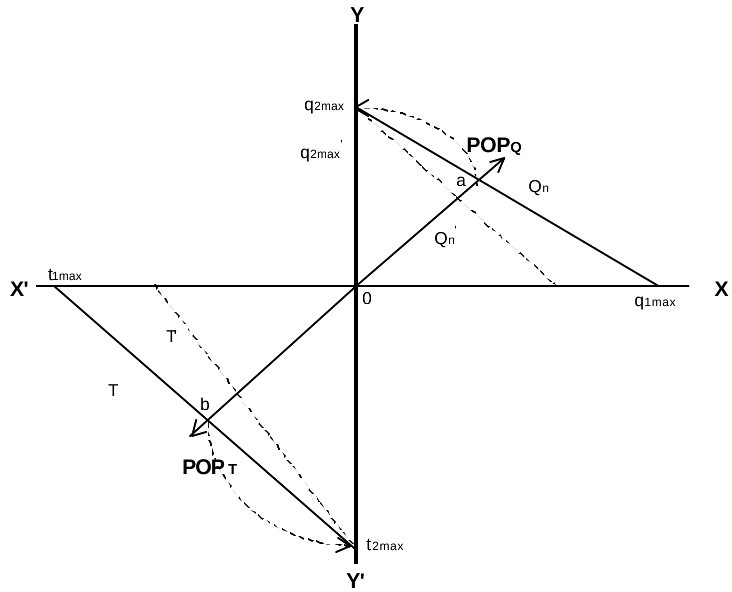

Figure 8. Relatively Low Time Costs in an Economic Process in Time (Strong Ownership). T, Q_n: Resources. Q'_n, T': Point to point transformation. t_{1max}, t_{2max}, q_{1max}, q_{2max}: Maximum output of a process. POP_q, POP_t: Projected outcome of a process. a,b: Starting points of the process.

Let us divide the resource among the agents in such a manor that it does not matter if they produce q_1 or q_2, they will get the same quantity of the reciprocal resource (same number of Bison). This is shown by the line Q_n' on Figure 8. The point-to-point transformation correspondently yields the line T' for the time resource. From Figure 8 and Expression 2 it is easy to see that by moving along the time frontier, the agents can reduce cost of the time resource by moving along the T' line. The tendency will therefore be towards t_{2max} and consequently q_{2max}. This Traverse of the process can only happen if there exists is a substitution between the time-, and the reciprocal resources in the economic process. In other words, if the agents can use relatively more time resource to produce and less reciprocal resources and get an economic result from the process that is at least better than at last decision point. If the requirements of substitutability of resources are in place, the processes run under property rights/quota/ownerships management systems will in most cases be more efficient than processes run under the open access system.

The conclusion on the difference between the open access management on one hand and system that we refer to as having ownership/property rights/on the other should nevertheless be accepted with some caution. The efficiency of any system is dependent on how economic space of a particular process is shaped. We can easily image restrictions that cause increase in costs that will in turn alter the relative prices and general outcome of a particular process. We can with ease define economic spaces of a process that is running under "strong property rights" in such a way that its time costs are very high and consequently the agent would behave in similar manner in what we connect to the open access management. What is in the literature usually referred to by the metaphors as *weak to strong ownership or property rights*, can be expressed in economic terms as a scale of relative values for a time resource within a economic process in time.

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