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Analyzing Behavior of Agents of Economic Processes in Time

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Abstract.
From Xenophon to Myrdal and Hicks, time has been an enigma in economics. The objective of this paper is not to analyze issues around the concept of time we associate with the clock or the mechanical time, but what some authors have named, 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 on the analyses a production function for economic processes in time is proposed. The paper gives a rational explanation for economic metaphors such as the law of diminishing returns and *property rights* or *ownership* in economic processes in time.

KEYWORDS: Time; value; management; economics; processes; dynamics; property rights.

1. *Introduction*[1]

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

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

logical choice is to turn to philosophy of science to re-examine the theoretical platform for the discipline in question. This can in turn result in a new paradigm for the discipline, as was the case in physics with Einstein and his Theory of Relativity. Most efforts however will lead to moderate change in the theoretical framework or, as presented in this paper a moderate addition. The objective of this paper is to analyze and define the value of time in economic processes, a phenomenon that has been unsatisfactory explained since the discipline emerged as an independent form of study.

There are a number of economic theorists that have been occupied with time and economics but very few that have devoted their analyses to what Currie and Steadman (1990) name *time of intent* or *relative time* as opposed to the *mechanical* or the *clock time*. In the mainstream economics the clock or the Newtonian time is the conception that is most frequently used. Actually, some writers go in to a length in arguing that although relative time may exist it is fruitless to incorporate the conception in economic analyses.

"Unsettling questions about the fundamental nature of time have disturbed physicists and philosophers since Einstein's special theory of relativity, but the economist's uses of time are very little concerned with those metaphysics. A simple conception of time per se-a human and social conception-is adequate in describing economic behavior and our analyses of it. Time in economics is a simple unidirectional linear flow, exogenous to the economic actors-even a Newtonian absolute time serves us nicely, as if a cosmic clock ticked away somewhere (C. Winston, 1982)."

Winston's statement above, that conception of time per se-a or the clock time (unidirectional linear flow) is the only one we need in economic theory is clearly constructed to dodge the many discrepancies in economic methods when it comes to the issue of time. There are countless numbers of situations were the clock time does not supply adequate explanation of economic phenomena and not surprisingly, many of the major theorists within economics have been occupied in explaining these phenomena. In this paper we will only name a few that can be used to illustrate the problems at stake or improve the analyses. Probably most cited of these authors is Alfred Marshall (Marshall, 1920). In his book *Principles of Economics*, Marshall frequently addresses the problem of time although he is unclear in his deliberation of the phenomena. It seems that the core of the problem in Marshall's view was, when predicting results from shorter processes and then extend them to apply for a longer period, the results could diverge considerably. Hence, in some mysterious (word used by Marshall himself) way somewhere along the unidirectional time line the results unexpectedly diverged. The only solution Marshall had to this problem was to propose to divide economic processes in to short periods and long periods and claim that there where no natural boundaries between the two.

Immediately after Marshall the Swedish economist Gunnar Myrdal (and later Lindahl) made also considerable effort to cast light on the same issue but from slightly different angle. Myrdal's way of looking at similar problem as Marshall, was through the concepts of the terms planned or *ex ante* and realized or *ex post* (Myrdal, 1939). This implies, as we will analyze further in this paper, that preferences in the beginning of a process (*ex ante*) may differ from the accumulated results for that same process (*ex post*). The similarity to Marshall's short and long periods is obvious when scrutinized in light of that the knowledge we have about imminent future. If we shorten down our time horizon of planning (short run) the better results we can expect to get. The longer the periods, the more difference we can expect between *ex ante* and *ex post.* Myrdal, as was the case for Marshall's long and short periods, does not offer any explanation of the boundaries between *ex post* and *ex ante*.

In his book, *Methods of Dynamic Economics* (Hicks, 1985), Hicks argues that if an economic theory is to be classified as dynamic it has to have preferences or tendency that can combine two points in time, which was obviously the flaw in both the Marshallian and Myrdal's theory. The suggestion of tendency points in economic processes in time lines up the economic path or the Traverse. The existence of the Traverse is a logical necessity if we are going to be able to predict within economic theory. Hicks argued that economic theory has to be divided in two fields, *economics of time* (EOT) and *economics in time* (EIT). The difference between the two is that EOT is engages in what happens within a period but EIT engages in what happens between periods where the Traverse of the process is made up by the sum of succession periods. Hicks' argues further that the tendency in economic processes, or what combines two points in time, is the *equilibrium* and offers a new definition of the term. As the analyses in this paper will show, the *short* and *the long periods*, *ex ante* and *ex post*, and the *time of intent* and the *clock time*, are all parts of the same problem, and that is how to precisely define the time and its value in economic processes in time. As we will see, the key to the definition is how agents conceive or evaluate values of resources they have at their possession when they run their respective economic processes in time.

To some extent the findings in this paper are in agreement with Hick's analyses and some problems areas, such as the *equilibrium theory* have been chosen in light of that. The following study was conducted independently of Hicks' theories although some idioms and names have been borrowed from him and added in retrospect. Before we address the problem of time directly, there is 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 *general 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. A frequent expression in various disciplines is that there exists a dynamic approach, which is better suited to analyze sequential occurrence than static approaches. This is scrutinized in Section 3 along with the issue of economics frequent use of *ceteris paribus* clauses. Section 4 discusses the tendency in economic processes in general and Section 5 defines economic processes in time and their boundaries (the economic space). In Section 6 we discuss the nature of the economic processes in time and Section 7 specifies their the values and Section 8 wraps up by providing practical applications on how to use the previous findings in explaining the economic phenomena property rights or ownership.

Although a philosophical approach offers some degree freedom in analyzing problem domains, a study cannot be done without a point of reference as Descartes demonstrated. This study is no exemption and has its base in Wittgenstein's picture theory that was published in *Tractatus Logico Philosophicus* (1918), where he states that we have to make clear distinction between reality (*state of affairs*) and the conceptions we may have thereof.

"The first phase, expressed in the Tractatus, posits a close, formal relationship between language, thought, and the world; there is a direct logical correspondence between the configurations of simple objects in the world, thoughts in the mind, and words in language. Thus the shape of ideas in the mind and the relationship of words in a sentence are identical in form with the structure of reality or "state of affairs" they represent. Language and thought work literally like a picture of the real, and to conceive or speak of any state of affairs is to be able to form a "picture" of it. (The Columbia Encyclopedia, Sixth Edition. 2001)."

2. The General Equilibrium Theory and Dynamic Processes

A central issue in the discussion of time in economics is the *general equilibrium theory*[2]. This is the case whether neo-classical economists or the Austrian ones debate the term. The Austrians economists however, have explicitly used the *credibility* of the *equilibrium theory* to attach the foundation of neo-classical branch of economics[3]. Friedrich Hayek attacks in his article "Economics and Knowledge" the equilibrium theory from several different angles. Hayek especially targets the fundamental assumption of the *general equilibrium theory* on perfect markets. Perfect markets require 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 requirement will ever exists in societies, we cannot rule out 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 concept or a rather a point of reference which can be used to measure different variables of the processes that are active in the market. The problem with the idiom *equilibrium* arises when we try to use it in a dynamic context. 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, Alfred Marshall included[4].

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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[2] In this context we mean the Walrasian general equilibrium theory.
[3] Good example is O'Driscoll's et al discussions in the book, *The Economics of Time and Ignorance* (Driscoll and Rizzo, 1985).
[4] For further information, 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 because to perceive an optimal point in a steady state (in equilibrium) and at the same time the same point moving to a different equally optimal equilibrium is difficult to fathom. If the process was at its optimum in equilibrium at first instance, why bother to move to another equally economically optimal location? In addition, the theory assumes that general equilibrium is in a point where actually nobody is making a profit. Assuming that a rational economic agent strives to push his process towards an economic equilibrium, a point where his profits are minimized is rather contra dictionary. To perceive the *Walrasian equilibrium* as the tendency that able us to predict what an economic agent does between two points in time (EIT) is therefore rather fare fetched. A single economic agent in economic process in time 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. As we will discuss further in this Section and in Section 4 the agenda of a rational economic agent must be to maximize his profit or rather as we will see, minimize the costs.

Hicks was well aware of the line of argument afore, and made efforts to incubate the *equilibrium theory* in a *general dynamic 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 economists 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 stay so. If we intend to use *the equilibrium* to explain how to get between two points in time it has to have tendency. One of the fundaments of the neo-classical economics is the definition of the rational economic man. The definition provides the economic processes with tendencies and therefore predictability. The problem is that the definition of the rational economic man contradicts him being a tendency in an economic process that moves towards zero profits. Hicks tries to solve this contradiction in following manner:

> 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 a situation where the tendency is constant, no changes in wants and no way of prediction between two points in time. Here, however, it is difficult to fathom and therefore a potential causality for misinterpretation what Hicks means by "wants" but his discussions do not imply that economic agents have other "wants" than similar to the *rational economic man*. More precisely Hicks' definition of *equilibrium* is:

> The alternatives that are open are set in part by *external constraints* (which may be 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 resemblance to the Walrasian definition of the same idiom, where the market forces of demand and supply will come to rest in an optimum steady state. Hicks' definition of the equilibrium is of an agent which window of opportunity (preference) is demarked by physical as well as economic and social constraints. In the following analysis the paper concludes in a similar way but there is a problem in using the term equilibrium in this context. We have at least two definitions of the same term equilibrium (Hick's and the Walrasian), 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. In Section 5 for example, the idiom *economic space* (ES) is introduced, which is in large similar or the same idiom as Hicks' definition of the *equilibrium* within economic processes in time.

3. Dynamic Methods versus Static

The discussion around use of dynamic versus static methods is closely related to the debate around the *general equilibrium* theory. Economics have been frequently under fire from other disciplines for using almost exclusively static methods. 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 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 to analyze 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. Furthermore, the instance we turn our attention to analyzing 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 *historical*. Regardless of the shortcomings 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 other instruments. 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 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 defined 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*. Simulated processes, as other processes in the *state of affairs,* have to be analyzed afterwards. We conclude therefore that simulated processes have to be treaded exactly in a same way as any other processes in the *state of affairs*.

The discussion around dynamics and time has followed humanity for a long time. The ancient Greek philosopher Zeno argued that dynamics 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 that analytical methods, today as in the days of Zeno *are and can only be static*. We therefore conclude that the *economic processes in time* can only exist in the *state of affairs* and we are only capable of making a static conception of them.

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), where its argued 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 to 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 on and change his balance and thus, his forward motion should be included. Evidently, almost everything can happen to the cyclist, like the Earth's loss of gravity along with all other possible unlikely things. To analyze things in the *state of affairs* without a *ceteris paribus* clause's is practically impossible. There are to many variables to count for.

4. The Tendency of Economic Processes in Time

Let us consider the following scenario. In the windows of the interdisciplinary Norwegian College of Fisheries there are three scientists looking out over the fjord and watching a huge industry trawler sailing by. The fish biologist looks at it and sees that its fishing capacity may <u>be a threat to the fish resources</u>. The scientist from the economic department sees that this vessel is going to <u>add considerably to the</u>

gross national product and the naval engineer sees that a 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.* Based on *ceteris paribus* clauses that are derived from their respective disciplines, they may predict the future of the trawler or how the process in time will unfold. The conclusions or the results of the process may differ among the scientists, but nevertheless they may all be proven equally right within their respective disciplines. Methods of all disciplines of science are based upon *a priori* knowledge or assumptions that contribute to dictating 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 "Ding 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 *seeing as* and *seeing that*. The scientists of The Norwegian School of Fisheries mentioned afore all *see* the factory trawler *as* such, but each of them will on basis of their scientific training *see that* the factory trawler will yield different types of results. One scientist *sees that* the factory trawler will bring prosperity and another *sees that* it will bring devastation, and both may be right.

In addition to different logical or scientific foundation, the agents may be found at different levels in economic processes that may in turn generate different focuses, or *seeing as*. Furthermore, the results from *seeing as* from one focusing level to another are not necessarily transferable, simply because the point of reference of *seeing as* may be different (as is the case for *ex ante* and *ex post*). An example of this could for example be a goal of maximum economic efficiency of a firm(s) within an industry that 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 sizes in order to secure competition and low prices. The tendency in economic processes (*see that*) may therefore differ according to the individual agent's view of objects in the *state of affairs*. Let us take a look at another example. 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 a valuable input in the economy of the society as a whole and his time horizon may be counted in decades. On all accounts, the economic agents are *seeing* the process *as* economic and will strive for optimum results. Nevertheless their processes may yield different results. The reason is that they are not looking at the same object in the *state of affairs* (*see as*) from different angle, and consequently their processes may yield different results. The economic agent will in all cases try to optimize his process according to his a priori view of the process. All activities that strive in other directions than optimizing the economic results are *a priori* irrational within the context of economic theory (the rationality of the economic agent). 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 that can be associated 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 imply 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 view that the agents of economic processes are bounded in their actions and to avoid confusion we will avoid using the term, *bounded rationality*. The tendency in economic processes in time will always be bounded within the agent's economic space (ES) as discussed in the next Section.

5. The Economic Space of a Process

Let us picture a ongoing economic process in time, at a decision point 0, run by an economic agent in the *state of affairs* as shown in Euclidean space in Figure 1.

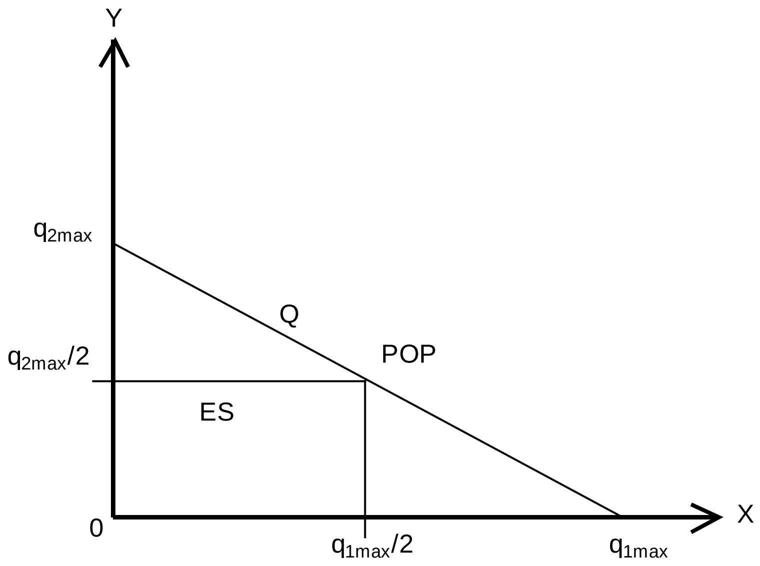

Figure 1. An Economic Space of a Process. ES: the economic space of the process. Q: A resource. POP: Projected outcome of the process. q_1,q_2: Quantity used of resource Q (output).

In Figure 1 the line Q represents a resource. In this case let us assume that Q represents a raw material that is necessary to run the process. In this particular process the agent can choose between two outputs q_1 and q_2. If the production consists solely of q_1 he will be able to produce q_{1max} quantity. Similarly, if he chooses to produce solely q_2 he will be able to produce q_{2max}. The agent can also choose to produce any combination of the two outputs from the resource Q, for example at point POP, where he produces equal shares of the two possible outputs. Then, the triangle 0,q_{1max},q_{2max} represents the agent's window of opportunity or his economic space (ES) as annotated in Figure 1. Let us further assume that the agent produces only output q_1, and doing so it will take him exactly one year to produce the q_{1max} quantity. Similarly, if he produces only q_2 it will take him exactly one year to produce the q_{2max} quantity. Then, any point on along the line Q will represent exactly one year of production and any line that is parallel but to the left of Q will represent a production time that is lesser than a year. The line Q is therefore also a technical production frontier for the process and for this particular process there exists no lines that are parallel and to the right. Here we can already draw one important conclusion about the ES of a process. The ES of a process will always be limited or bounded, if not in the use of the resources then in time. If the process has unlimited resources it will be bounded by time.

In Figure 1, there are no indication or reference to time but by drawing the figure (*see as*) in this way we have made some *a priori* statements about the issue (*see that*). We have assumed that the distances $0,q_{1max}$ and $0,q_{2max}$ in Figure 1 are representing one year of production and thus, can be used as a scale of time. By studying Figure 1 it comes clear that the production of q_2 requires less units of the resource Q per unit time than q_1. Another way to word the same thing is that when producing from resource Q the q_1 output will require lesser time to produce than when producing output q_2. Clearly, it is not enough to have the resource Q available in the process but equally important to have the available time to manufacture the respective outputs and that time and the resource Q are clearly interdependent. A change in one variable will require a change in the other. In the next Section we will come to the conclusion that variables in space and time should be treated in same way and for the time being let us assume it is so. Henceforward, we will refer to this idiom, a time that is treaded on equal bases with other resources of a process as the *time resource*.

The scales of measurement in Figure 1 are calibrated for the Q resource and not for the time resource. Obviously, the time resource cannot be measured by the parameters for the quantities (q_1 and q_2) because they are not scaled for that purposes, they are uneven in time. The distance for one year $0,q_{max1}$ is not the same as the distance for the one year $0,q_{max2}$. To create a scale of measurement for the time resource we have to separate the two interdependent resources and at same time, conserve all the qualities of their interdependencies. To achieve this we transfer all time points, in a Euclidean space (point to point transformation), of the line Q in Figure 1, in to the line T in Figure 2, through Expression 1:

$$(q_1, q_2) \rightarrow (q_1', \frac{q_2}{q_{2\max}} * q_{1\max}) \tag{1}$$

The transformed points will form the line T, representing the time resource as shown in Figure 2.

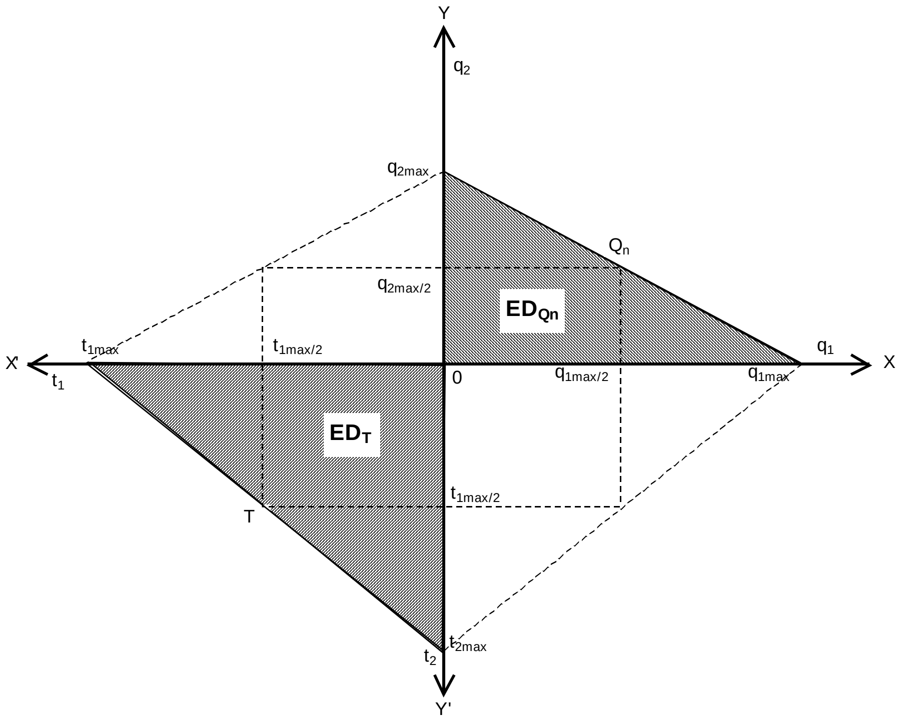

Figure 2. Separating the time resource T, from the reciprocal resources Q_n[5]. ED_{Qn}: The economic dimension of the Q resource. ED_T: the Economic dimension of the T resource. Q: A resource. POP: Projected outcome of the process. q_1,q_2: Quantity used of resource Q (Output). t1,t1: Quantity used of the time resource, T.

In Figure 2 the transformed axes, x' and y', are scales of measurement of time for the T resource, in a same way as x and y are scales to measure kilograms or metric tons of the reciprocal resources, Q_n. In Figure 2, the gray areas ED_T and ED_Q represents the economic dimension for each resource and the sum of the dimensions is the economic space of the process (ED_T+ED_{Qn}=ES). If we continue to use the same time horizon as afore, the points along the line t_{1max}, t_{2max} in the ED_T (Figure 2) is equal to a year. Consequently, only points along the line q_{1max}, q_{2max} in the ED_Q, will match the one-year line of the T dimension. The interdependency of the two resources is therefore intact in transforming from Figure 1 to Figure 2 as we will further proof in the next section.

As stressed afore, T is interdependent of Q_n and any change in either line or economic space in the process must result in change in the other resource. As can

[5] Henceforward, when speaking of the time resource specifically we will refer to other resources in the process as the reciprocal resources Q_n. Consequently, when speaking of other resources, the time resource will be a member of the reciprocal resources.

be seen in Figure 2 the two dimensions, ED_T and ED_Q, are not congruent. A change in the dimension of a one resource has therefore not necessarily the same impact as a similar magnitude of change in the other. If number of resources in a process is large (n is large) a change in the dimension of one resource can have an impact on the value of all the other as will become evident in Section 7.

6. 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 optimize 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 we engage in is the assumption from the previous Section that we have to tread two objects that are two meters apart in the *state of affairs* in the same way as objects that are two hours apart.

Let us assume that we have two identical diamonds that we are going to hand over to two agents. One of the agent will get his diamond tomorrow on the spot, and the diamond of the other agent is 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 in fact, if no costs are associated with the economic process it does not matter for the agent whether he gets a diamond at all. If costs are involved, such as cost of travel or costs of foregone income generated by the first agent possibility to sell the diamond today instead of tomorrow, it is the structure of these costs that will decide what is preferable, not whether these two diamonds are a day or thousand miles apart. Let us take another example of a horse carriage in London in 1850 and exactly the same object in 2000. The two objects may be valued differently in these two eras. That is not because of the objects in the *state of affairs* that are identical but due to difference in the economic space of the agents in these two eras. Let us now assume that exactly the same types of horse carriages are in Seattle and Ulan Bator at exactly the same time. It is possible that a cab driver in Seattle and the one in 2000 in London may value the carriage similarly and consequently it is equally likely that the cab driver in 1850 and the guy in Ulan Bator may evaluate the two things in a similar way. When analyzing objects in the *state of affairs* that are apart in space we use the same procedures as when they are apart in time. In both cases the methods of comparison are exactly the same and equally static.

Nevertheless, 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 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 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 object. 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. In order to unwrap the Traverse in economic processes in time we have to compare two points and repeat for every decision point in time we choose to include in hour analyses.

In an economic process an 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 will through time mark the tendency of the economic process and thus, draw up the *Traverse*. In Figure 3 we have broken the POP up in two dimensions, one for the time and the other for the reciprocal resource.

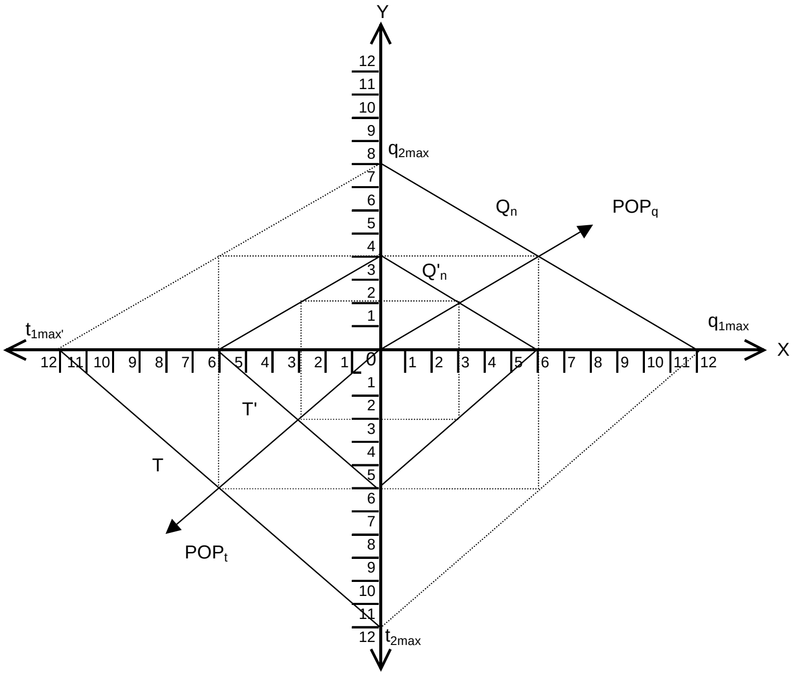

Figure 3. An Economic Process in Time. T,Q_n: Resources. Q'_n,T': Point to point transformation. t_{1max}, t_{2max},q_{1max},q_{2max}: Maximum output of a process. POP_q, POP_t: Projected outcome of a process.

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 that in turn generates the tendency of the process. In Figure 3 the POP is splinted up in two vectors, POP_Q and $POP_{T.}$ The directions of the POP's in their respective dimensions are drawn solely for an illustration purposes. Numbers have been added to Figure 3 for a illustration purposes where 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 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. In EIT the agents will at least on occasions have the possibility to choose in how much they use of respectively the T and the Q_n resources, but that requires that the one or more of the resources can act as substitutes. It is evident from the Figures 2-3 and the disscusion that if the elasticity of substitution between the resources in an economic process is zero, the result from the EIT and EOT will be the same (the Traverse will be the same). Nevertheless, resources of processes will in most cases have some degree of elasticity of substitution were the time resource will be the most versatile one.

As discussed in Section 4, different agents may view the processes in time on a different time scale. In Figure 3, the numbers may represent periods such as weeks, years, decades, or hundreds of years. Different focus by various agents on a process does not only yield a different *see as,* but consequently a different *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 for the reciprocal resources within a process, 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, the agent will keep it going as long as the outcome of the process is satisfactory. The rationale for running the process is given a priori where the criteria may be other than maximizing profits but as we will see in the next section, at each decision point in time the agents will in all cases seek to minimize their costs. As the processes advance in time, the economic space may change from one point in time to another. As mentioned afore the economic space will always be demarked, if not by the reciprocal resources, then by time. A change in one variable, T for instance, will alter the agent's economic space. Relative change in the input factors will require a re-estimation of the optimal path within the respective economic space. At each decision point in time the process may therefore have a new tendency because if a change has occurred the agents are forced to reallocate their resources in order to maintain their goal of economic efficiency.

7. The Value in Economic Processes in Time

In former sections we have come to the conclusion that all resources of processes in the *state of affairs*, including the time resource, 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 the idiom, economic tendency. In this section we will explicitly define the economic values in economic processes in time and on that basis we will define a production function for EIT.

According written records the ancient Greek Xenophon was one 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. Objects cannot have values without references to other objects in the picture we have of a process in the *state of affairs.* Economic values are purely subjective; they are not objects in the *state of affairs.*

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 conception of scarcity applies in general to our measurements of values in the *state of affairs*. A substance that is needed in a process, lets say in the ratio 1:100, has obviously the potential to be higher priced relatively to other resources that are in greater abundance 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 that ratio will probably alter the relative value of the two resources within the process. The conception of values in a process is therefore interdependent on the relative quantities of the resources in the *state of affairs*. 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. This relative value can however not be based on market prices. At each decision point (moment) in time the economic agents are price takers. At that particular moment all market prices (costs and revenues) are given and they have no possibility of having any influence thereupon. The agents only possibility of having impact on their economic processes is through re-allocating their resources, given that at least two of them can act as substitutes. The tendency of economic process in time can therefore only be generated by cost minimizing agents.

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 only produce q_1, where the quantity of Q_n is relatively high and the value consequently comparatively relatively low compared to T. We will return to this particular point in Section 8.

In order to put the discussion in context with EOT let us scrutinize the resources T and Q_n within a classical Leontief function as shown in Expression 1:

$MIN(Q_n, T) = POP$, were Q_n, T >0. (1)

The meaning of the Expression 1 as a production function 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 tendency. If Expression 1 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. To add market prices will not change anything because at each decision moment in time they are constant and cannot have any impact on the tendency or the POP of a process.

Let us assume that the costs of the resources in a process are indifferent and the revenues are not. Then, we would expect that a profit maximizing 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. Let us consider a situation as described in Figure 4. Let us assume that an economic process in time in a situation were T and Q_n are equal, i.e., $T=Q_n$ at i=0.

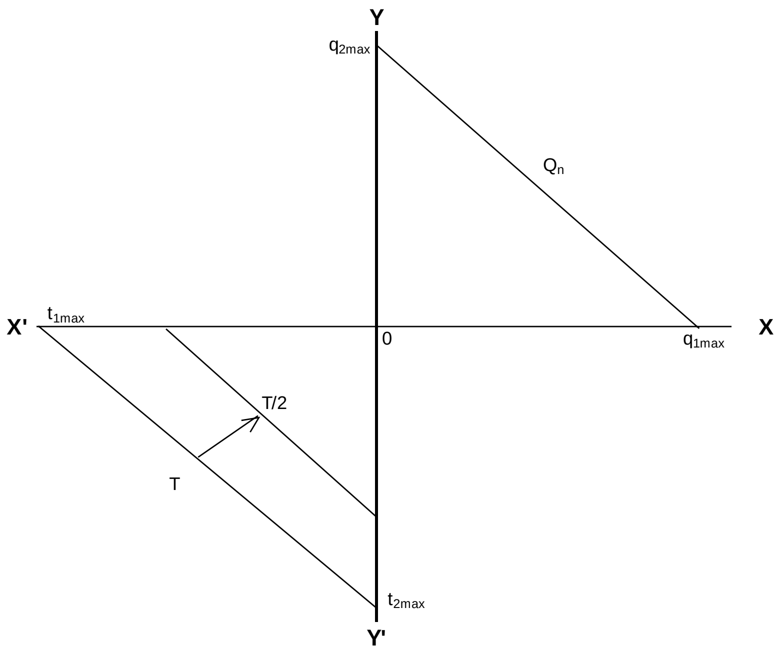

Figure 4. Demarcation of the economic space at time, from T to T/2.
T,Q_n: Resources. t_{1max}, t_{2max},q_{1max},q_{2max}: Maximum output of the process.

Let us assume that at some decision point in time the time resource available in 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, given that the two resources can act as substitutes. Consequently, if we reduce one of the reciprocal resources Q_n, we expect the agent tend to use relatively more of T and vice versa. Obviously, there is a conception of pricing the resources relatively. As discussed afore the agent can at each point in time, only have an impact on the use of available recourses within the process, and thus, the costs. Let us assign the perceptions of costs within a process as C_Q and C_T, respectively. At each decision point in time the shape of the ES is fixed. The direction of the optimal solution is therefore also given and POP is therefore 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 the time horizon of the process P, can therefore be expressed as:

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

The decision variables in Expression 2 are the quantities of the resources at each point in time were the POP is constant. Between decisions points in time however, the POP will most likely change and thus, create the Traverse through time. Expression 2 satisfies all criterion in the analyses afore. If the quantity of one resource within the process is increased it becomes relatively cheaper and the agent will seek to maximize his resource output. Later in this paper we will take a closer look at changes in values in the economic process in time. As mentioned afore the agent will usually have some criteria for keep the process running and will check that criteria at each point in time. This or these constraints are not included in Expression 2 but can by added in an applied exercise[6].

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:

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

Expression 3 is a nonlinear, n-dimensional function where the possible optimal solutions can be more than one. That the economic processes can have more than one optimal solution should not come as a surprise. More than one optimal solution for economic processes is well documented in the literature especially for the cases of labor and capital. 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. This can easily be demonstrated through simulations. The direction of the economic process in 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. The Expression 2 and 3 are not specially designed to explain the variations in the time resource but for resources in economic processes in time in general. For analytical purposes we could let T and Q_n represent any other resources that are desirable to investigate as for example Hume's famous statement about money and commodities.

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).

If we let T in Expression 2 represent stock of money and C_T and then we increase the stock of money while the reciprocal resources are fixed, the value of money will become relatively cheaper within the economic process in time. In other words we have the tendency towards inflation.

As can be derived from Expression 2 it is the ratios of C_Q/Q_n and C_T/T that determine the use of the resources of the process and therefore determine the allocation of the costs among the resources. In Figure 5 the possible outcome of the ratio for the two

[6] For more practical and detailed description on POP in economic processes in time see Arnarson and Jensson (2004).

resources is plotted. We start out at an imaginary point in Expression 2 were all values are equal, or $Q_n=T=C_Q=V_Q$.

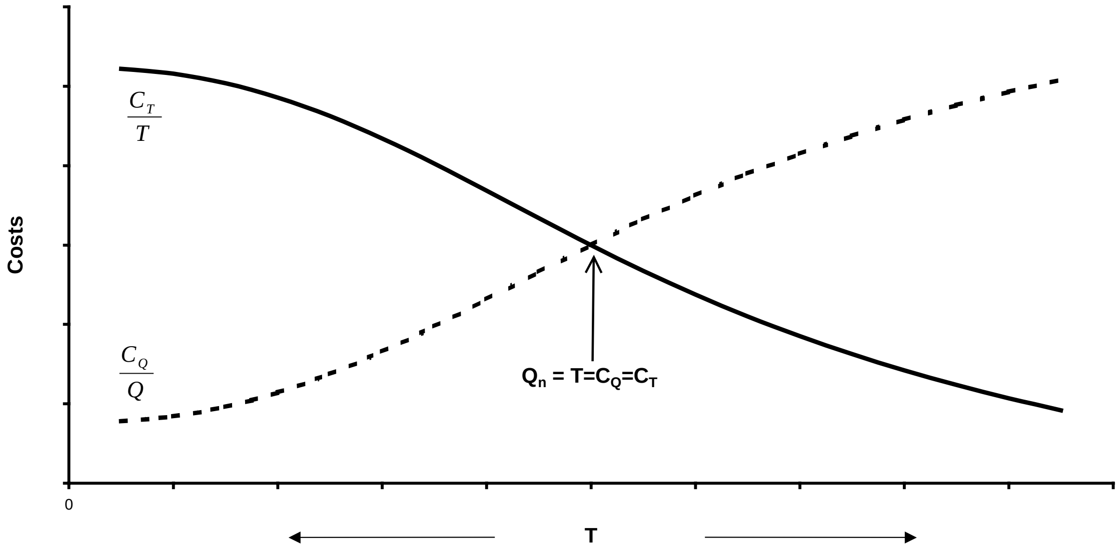

Figure 5. Use of the Time Resources in an Economic Process in Time. Derived from Expression 2. C_Q: Value of the reciprocal resources. Q: Quantity of the reciprocal resources. C_T: Value of the time resource. T: Quantity of the time resource.

Figure 5 demonstrates the effect of increasing or decreasing the time resource, T from a given point of reference[7]. At each point in time when the agent re-asses his economic process he will only include the reciprocal resources. The agents do not have any conception of the cost of the time resource although they are bound to take it in to consideration when the process is running as described afore. Figure 5 shows that as the time in a process become relatively less abundant the cost of the time resource within the process will increase. When assessing their processes at each point in time the agents do not include the cost of the time resource in their calculations. The cost of the time resource will nevertheless materialize through the calculated revenue that will show reduction as the processes reaches their peak of output. This has been known in the economic literature, as the *law of diminishing*

[7] Digernes (1982) presented a similar conception for fishing vessels were the parameter on the x-axis was traveling speed and the resource curves were fuel consumption and time respectively. By increasing fuel consumption the vessel could increase the speed and use more time for fishing. The time gained was expressed in reduction in the cost of the time resource.

returns but is simply an increase in cost of the time resource in the economic processes[8].

8. *Property Rights or Ownership in Economic Processes in Time*

Let us review the following from previous sections before starting the analyses in this Section: 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 5. In that situation the agent will use as much as possible of the reciprocal resources in shortest possible time. Economic processes with this characteristic are sometimes referred to in the literature as *the tragedy of commons*. The processes with high time costs are often 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 in the 18th century. In the case of the Bison the hunters regarded the "raw material" as unlimited and therefore it was indispensable to harvest as much as possible in the shortest possible time.

Let us start with an economic process in time were the costs are constant or indifferent as depictured in Figure 3 and transferred to Figure 6, were line Q_n is representing a resource and simultaneously representing the technical production frontier for the process. We start with the process at point b in the Q_n dimension and at point a in the T dimension. Let the time resource T in this particular case represent one year. The output products, q_1 and q_2 are representing unrefined and refined products 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

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[8] For more detailed description, see Arnarson and Jenson (2004) that demonstrated this effect with an aid of a simulation model.

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 6.

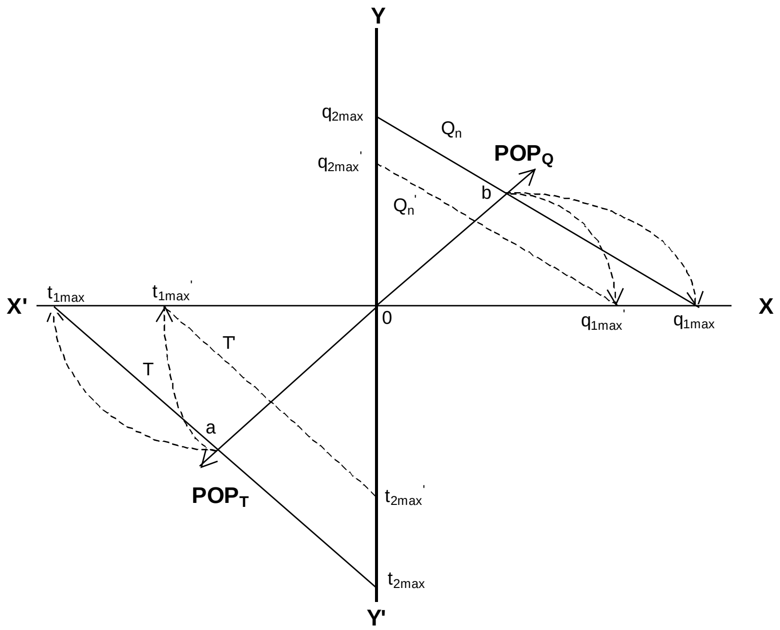

Figure 6. Relatively High Time Costs in an Economic Process in Time (Weak Ownership). T,Q_n: Resources. Q'_n,T': Point to point transformation. t_{1max}, t_{2max},q_{1max},q_{2max}: Maximum output of a process. POP_q, POP_t: Projected outcome of a process. a,b: Starting points of the process.

At these points, q_{1max} and t_{1max} were the quantities are highest the costs of the process is potentially at the lowest (see Expression 2). In a process with this characteristic the tendency will therefore always be to produce as much as possible in shortest possible time, or as long as the agent can relatively increase the quantity of the Q_n. Picturing the process in longer terms we would expect the agents to have tendencies to invest and increase the capacity i.e., expand the technological frontier. A process with this characteristic would most probably lead to capital stuffing, overexploitation and rapid extinction or depletion of the respective resource.

The ruler of the process may want the tendency described in Figure 6 to go in a different direction. One of his efforts may to achieve this may be by introducing limits on the time it is allowed to harvest. This is shown in Figure 6 were we have reduced time resource from T to T'. The point-to-point transformation yields the corresponding quantity of the reciprocal resource used at same technological frontier level, represented by the line Q_n' in Figure 6. The tendencies go now towards q_{1max}' and t_{1max}' as shown in Figure 6. Still the tendency of the process will be towards increase in harvesting capacity. As long as the agents' criteria for running the process is intact the capacity will probably increase and the outcome can be as unfortunate as described afore.

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 ruler, if the goal is to extend the durability of the resource as much as possible, is clearly in our case at the point's 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 but in this case that is not an option because the T is exactly one year. The resources are interdependent in the economic processes in time and if we cannot tamper with the time resource we maybe can with the reciprocal resources. This can be done by limiting the quantity each agent has to his disposition within the given time horizon, or introducing quota or ownership. If we continue with the Bison example then that would equal to give each agent a limited number of animals. 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' in Figure 7.

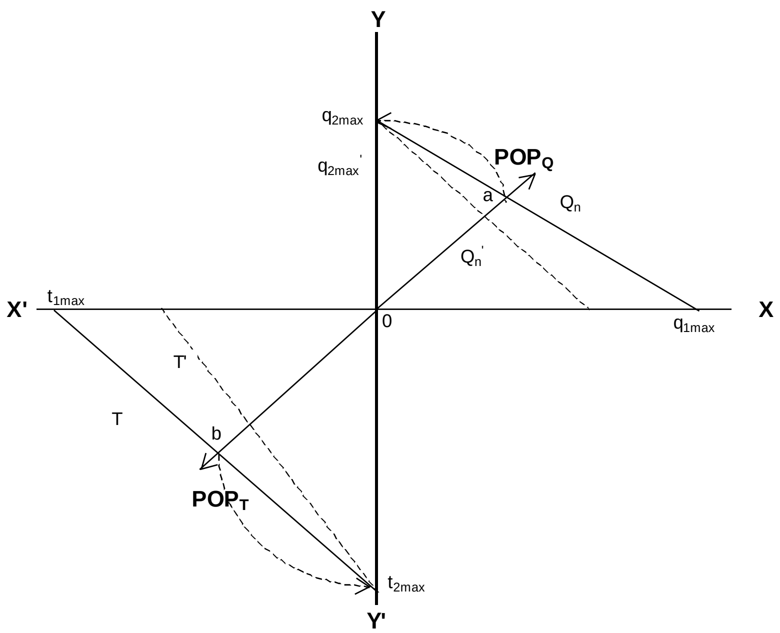

Figure 7. Relatively Low Time Costs in an Economic Process in Time (Strong Ownership). T,Q_n: Resources. Q'_n,T': Point to point transformation. t_{1max}, t_{2max},q_{1max},q_{2max}: Maximum output of a process. POP_q, POP_t: Projected outcome of a process. a,b: Starting points of the process.

The point-to-point transformation correspondently yields the line T' for the time resource. From Figure 7 and Expression 2 it is easy to see that by moving along the T' the agents can reduce cost of the time resource. The tendency of the process will now be towards t_{2max} and consequently q_{2max}. By lowering the cost of the time resource relatively to the reciprocal resources we have shifted the tendency of the process. The agent will now strive to use more of the time resource than reciprocal resources that in most cases will lead to so called *value added* production. The increased efficiency in economic processes where ownership is introduced, like going from hunting to agriculture, is therefore usually due to reduction in the cost of the time resource.

Introducing ownership in economic processes will however, not automatically lead to reduction in costs. By introducing restrictions in the ES of a process (altering the frontiers) the effect of introducing ownership can easily be countered. 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 values for a time resource within a economic process in time.

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W01:01 Tryggvi Thor Herbertsson: The Economics of Early Retirement

W00:20 Helgi Tomasson: Monitoring the trading intensity of a stock market under infrequent trading

W00:19 Helgi Tomasson: Computations of Bayesian Estimators in ARMA Models

W00:18 Helgi Tomasson: Estimation of Correlations in Financial Markets when Trading is Infrequent

W00:17 Ragnar Arnason, Gylfi Magnusson and Sveinn Agnarsson: The Norwegian Spring Spawning Herring Fishery: A Stylised Game Model

W00:16 Jon Danielsson, Bjorn N. Jorgensen and Casper G. de Vries: Risk Management and Regulation in Incomplete Markets

W00:15 Sveinn Agnarsson: Development of Efficiency in Icelandic Fish Processing Firms: A DEA Approach

W00:14 Sveinn Agnarsson: Productivity in Icelandic Fish Processing Industry 1985 – 1995: A Comparison of Methods