

***Replication and Selection :***  
***A Comparative Analysis of the Austrian and neo-Schumpeterian Understanding of the  
Market Process.***

**Abstract:**

By using some analytical tools borrowed from biology, neo-Schumpeterian analysis aims at renewing our understanding of the working of the market. The proximity of this intention with the one expressed by the Austrian school makes it legitimate to compare their methods and results. It will appear that the neo-Schumpeterian approach, built on the twin concept of population and replication, is unable to consider the singularity of the Austrian analysis of the market process.

## ***1. Introduction***

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Twenty five years ago, the Austrian revival generated a huge expenditure of time and energy to set up the elements which would allow the scholars belonging to the Austrian tradition to claim their intellectual independence from the then prevailing stream of thought in microeconomics (Walrasian general equilibrium and static game theory). Today, the issue facing Austrian economics is of a wholly different nature. Due to the major evolutions of contemporary economic research, this search for dissidence has become obsolete. We have to ask if Austrian economics can thrive on [??] the contemporary development of new approaches in order to find back a central place in the panorama of economic research.

Following Koppl (2006), we are witnessing for some years a deep mutation of the structuration of economics, through the emergence of a set of ‘views, models, theories and techniques’ (p. 232) which make up [form] what he calls the “heterodox mainstream”. Despite their heterogeneity, these approaches are federated around the acceptance of five major analytical characteristics: (1) bounded rationality; (2) the integration of the rules followed by agents in their decision-making; (3) the role given to institutions; (4) the role given to the cognitive processes effectively pursued by individuals; and (5) an evolutionary methodology<sup>1</sup>. A pleiad of authors and theories could legitimately claim to belong to this heterodox mainstream. Koppl, following Lewin (2001), refers to evolutionary economics, Austrian economics, complexity theory (Arthur *et al.* 1997, Blume *et al.* 2006), post-Keynesian economics, the Public choice school, old institutionalists –be they German or American? We can add to this ever long list computable economics (Velupillai 2000, 2005, 2007) and neo-Schumpeterian economics (Metcalf 1998, Andersen 1994).

This wide definition given by Koppl can be reduced to a sole unifying characteristic: the acknowledgment of the limits of the knowledge and of the cognitive capabilities of individuals. The interest given to rules and decision procedures, to institutions –basically defined as the “rules of the game”-, to the cognitive processes and the adoption of an evolutionary perspective –which allows for the integration of the individuals’ errors and innovations-, are all the consequences of this acknowledgement.

This new perspective contributed to the creation of new tools and now forms of modelisation, among which we can find computer simulations, artificial intelligence and agents models, network and graph analysis (Potts 2000), or diffusion models inspired by epidemiology and biology. These new forms of economic analysis do not blindly and opportunistically borrow these innovative mathematical techniques from other disciplines. On the contrary, they try to

go beyond the boundaries of the traditional tools of economics and to develop original works based on an evolutionary vision, innovative concepts and less restrictive hypotheses.

Lachmann<sup>1</sup> (1971) used the term “late classical formalism” to describe neoclassical economists who ‘adopt an arid formalism as their style of thought, an approach which requires them to treat the manifestations of the human mind in the household and market as purely formal entities, on par with material resources [...] From Walras to Samuelson we find the same manner of reasoning, the same arbitrary assumptions, the same unwarranted conclusions’ (1971: pp. 181-9). If one could (perhaps) make a case for this position in the 1970s, it seems to be impossible now. It is manifest that the deep evolution of the mathematical tools used at present by some burgeoning scholars requires a concomitant evolution of the Austrian position about the use of mathematics in economics and, more generally, in social sciences. It is at the same time unavoidable and in the interest of Austrian economics to refresh its position about these theoretical and methodological evolutions.

If we accept Koppl’s definition of the heterodox mainstream, numerous paths are open. Some of them have ever been followed: we can find today a great number of works which aim at establishing bridges between Austrian economics and other intellectual traditions. The major part of these works falls within the province of history of economic thought (for example Baird 2000, Butos 2003, Foss 2000, Lachmann 1959, 1976). A smaller number of works aims at applying new analytical tools on typically Austrian questions. For example, Klein et Selgin (2000) use a peculiar mathematical instrument –the Polya processes- to simulate the selection process of a commodity as a medium of exchange theorized by Menger (1976, 1996), what allows them to reinterpret the emergence of an “organic” institution such as money as the limit of a convergence path of an urn game (for extensive analyses of Polya processes, see Arthur *et al.* 1987, Benaïm *et al.* 2004 and Schreiber 2001).

Our paper falls within this second objective and propose to appreciate, with the Austrian school as our benchmark, the neo-Schumpeterian conception of the market process, as it notably appears in Stanley Metcalfe’s (*op.cit.*) writings. A cross reading of the Austrian and neo-Schumpeterian theses<sup>ii</sup> would allow us to precise of the Austrian perception of the market process can benefit from the recent developments of the neo-Schumpeterian approach. Our second section will expose the concept of replication which is at the heart of the analysis of the market process put forward by Metcalfe. Our third section will question the ability of this concept of replication to take into account the agents ignorance and the cognitive dimension

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<sup>1</sup> 1971, *Ludwig von Mises and the Market Process*, in Ludwig Lachmann (ed.), *Capital, Expectations and the Market Process. Essays on the Theory of the Market Economy*, Kansas City : Sheed Andrews and McNeel Inc.

of the market. We will show that the dynamic based on the replication concept is definite only when we take as given (or objectively identifiable) parameters which, from an Austrian perspective, have to be discovered by the agents in order to use them as efficiently as possible. Furthermore, we will show that it is impossible to integrate this entrepreneurial aspect of human action into the replicator framework. Our conclusion will establish that the neo-Schumpeterian and Austrian approaches to the market process remain dissimilar, due to deep differences in their respective treatment of the question of ignorance: to the monotonic vision of the selection process of the former is opposed the “open ended” vision of the latter.

## ***2. Selection Process and Dynamic Replicator***

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The neo-Schumpeterian approach<sup>iii</sup> can be summarily described as the analysis of the structural change of the economy (inter-population analysis) or of a population (intra-population analysis) as the consequence of the appearance of waves of innovations brought about by entrepreneurs; at the term of a selection process, only the entrepreneurs (identified as an innovation routine of the firms) who have adapted to the new characteristics of their environment, survive and develop. Such a development translates into the increasing of the relative frequency in the population of the characteristics of the surviving entities<sup>iv</sup>. Product, organization or method of production innovations generate variety; the evaluation of this variety by the market translates into a profitability differential which, in turn, translates into a growth differential of the firms; this selection process is at the origin of structural changes, identified as the firms' market shares. More precisely, the notion of selection means that the mean value inside the population of the chosen selection trait change over the process.

The evolutionary process of structural change is thus composed of three phases: a mutation phase, corresponding to innovation (whatever its concrete form); a selection phase, corresponding to the course of the market process; a retention and development phase, corresponding to (1) learning, at the individual (entrepreneurs, consumers), organizational (firms' routines (Nelson and Winter 1982)) and institutional (rules followed by the members of a community) levels and (2) the will to create new innovations in order to escape from the selection pressure<sup>v</sup>. In Vega-Redondo's terms: 'A dynamic model [will be] termed evolutionary if its laws of motion reflect the following « forces » : selection, mutation, and inheritance' (1996 : p. 1).

As can be seen, if these three phases echo the neo-Darwinian conception of biological evolution, they are nevertheless not strictly equivalent. They are only metaphors which, by definition, are necessarily imperfect (Hodgson 1999). However the intrinsic limitations of the biological metaphor does not preclude theoreticians from adopting some analytical tools and concepts used in biology. This is precisely what Stanley Metcalfe (1994, 1998) does when using the concept of dynamic replication and the Fisher's Theorems to analyze the market selection process.

In economy, and contrary to biology, variety does not result from a random process of genetic mutation ("random drift" and punctuated equilibrium). Innovation, novelty and variety do not result from a random prospecting by the firms, but from an orientated research of creation and exploitation of competitive advantages in order to escape from the selection mechanism; knowledge accumulation –the source of the economic dynamic- is necessarily endogenous. This teleological principle is completely absent in biology (for the neo-Darwinian conception of evolution at least). This conscious orientation of research allows to escape from what Metcalfe (1998: p. 99) calls the "combinatorial explosion": "The search for novelty cannot be random for if it were it would fall victim to the tyranny of combinatorial explosion, there being too many possible combinations of ideas to imagine and evaluate. Thus the creation of novelty involves guided variation within perceptions of a limited set of possibilities. Innovations are never entirely novel; they are always prefigured in some of their dimensions"<sup>vi</sup>. If the progress of knowledge heavily depends on the knowledge hitherto acquired, this creation process is characterized by a path dependency, that is, by the fact that the process asymptotic distribution is the consequence of its history (Castaldi et Dosi 2004, David 2001, 2007, Loasby 2001, 2003, Schlicht 2000)<sup>vii</sup>.

Metcalfe (1998) exposes a simple model of selection by replication in a given population. Like the major part of the evolutionary literature, this model considers a dynamic, continuous time, system. This simplicity makes the model general and allows us to focus on the principle of replication, rather than on the analytical details generally used to refine the model. We assume a population of firms producing the same homogeneous good. Firms are perceived as a pool of three routines: a production routine, an accumulation routine and an innovation routine (Metcalfe 1998 : p. 44). Depending on the efficiency of their routines, each of them produce this good with different unit cost. This efficiency distribution is invariant and given *a priori*. To use biology's terms, there is a finite population of firms, each of which being characterized by a given behavior (phenotype).

We furthermore assume that these various production processes have constant returns to scale. There are two factors of production: machines and labor. The firm  $i$  has to use  $a_i$  of labor and  $c_i$  of machine to produce one unit of commodity. If  $w$  and  $p_c$  are the respective prices of these two factors that every firm has to pay, the unit normal cost of the firm  $i$  is given by  $h_i = wa_i + (\bar{r} + d)p_c c_i$ , with  $\bar{r}$  the cost of capital (debtors' and shareholders' income) and  $d$  the accounting rate of depreciation. The unit margin  $m_i$  of the firm  $i$  is thus given by  $p_i - h_i$ .

We can establish a functional relationship between the unit margin and the rate of growth  $g_i$  of the firm  $i$  in this way:  $g_i = f_i m_i$ , with  $f_i$  the propensity to accumulate of  $i$ . We can assume that this propension reflects the accumulation routine of the firm. Be  $\pi_i$  the share of profits which finance the accumulation and  $\varepsilon_i$  the amount of external funding.

Two relations can thus be deduced, depending on the sign of the profit margin of the firm  $i$ :

$$g_i = \frac{\pi_i(1 + \varepsilon_i)}{c_i} [p_i - h_i] = f_i [p_i - h_i] \quad p_i > h_i$$

$$g_i = 0 \quad p_i \leq h_i$$

Two simplifying assumptions can be introduced. First, we can suppose that the propensity to accumulate (the accumulation routine)  $f$  is identical for every firm. Second, in order to shed light the mechanisms of selection and development, it is more convenient to suppose that all the firms are identical, except for a unique selection variable; the differential of labor productivity (production routine) will constitute in what follows the only dimension (the only "selection trait") on which will operate the selection process.

From these simple definitions and relations, we can segregate the firms' population between three mutually exclusive groups: (1) the exit firms which leave the industry, for which  $p_i < h_i$ ; (2) the marginal firms, for which  $p_i = h_i$ , (3) the dynamic or surviving firms, for which  $p_i > h_i$ .

The aggregate growth rate of the production of the surviving firms will be noted  $g$ ;  $g_s$  will designate the growth rate of the production of the dynamic firms;  $g_m$  will designate the growth rate of the production of the marginal firms. These three rates are connected through the relation  $g = (1 - \alpha)g_s + \alpha g_m$ , with  $\alpha$  the share of the marginal firms in total production.

To simplify even more the model, we can further assume that this share equals zero. Thus, we get the relation  $g = g_s = \sum s_i g_i$ , with  $s_i$  designating the market share or the “economic weight” of the production of the firm  $i$  in total output (of course,  $\sum s_i = 1$ ). This set of definitions allows us to construct a simple and intuitive principle of replication, which establishes that the structural change corresponds to the change in the distribution of the market shares of the firms:

$$\frac{ds_i}{dt} = s_i(g_i - g) \quad [1]$$

This principle can be made more precise. Suppose that the firms have the possibility to fix the selling prices and can be ranked regarding their unit normal cost, such that  $h_1 < h_2 < \dots < h_z$ . We can thus determine the normal growth rate for each firm  $i$  as :

$$g_i = g_D + \Delta[\bar{h}_s - h_i] \quad [2]$$

with  $g_D$  the average growth rate of the demand for the homogenous good;  $\bar{h}_s = \sum s_i h_i$ , the average unit cost of the dynamic firms’ population and  $\Delta = \frac{f\delta}{f + \delta}$  the coefficient which measures the intensity of the selection pressure over the firms and  $\delta$  which measures the degree of market imperfection (for example, the speed with which consumers switch from one seller to another). This  $\delta$  parameter can be interpreted in this way (Metcalfé, 1998 : p. 49). If  $\delta$  is high, the switching speed is high and, consequently, the price dispersion is low. At the limit, when  $\delta = \infty$ , we fall back on the classical idea of a pure and perfect competition, with no price dispersion: if a firm sets a price higher, it will instantaneously lose its market share and be driven out from the market. *A contrario*, when  $\delta = 0$ , each firm is in a *de facto* monopoly position and exploits a consumption niche. Thereby price dispersion is (and remains) high. Between these two limit-values, there exists a continuum of market configurations, each of which being characterized by a degree of competitive pressure. In a later paper, Metcalfé (2002 : p. 114) remarks that the interpretation of the  $\delta$  coefficient can be linked with the informational dimension of markets: ‘[The product market selection coefficient  $\delta$ ] is our measure of the information disseminating efficiency of the market institutions’.

We can note that, since the parameter  $\delta$  plays no role in the determination of the average unit price, the change of the value of this parameter only affects the variance of the unit prices of

the firms of the population: a “loose” selection environment would allow firms with very different efficiency levels to survive longer.

Another result can be deduced if we posit that the competition is perfect and that the supply of external funding is perfectly elastic for each firm (with no regard for its growth rate and/or market share). Equation [1], which represents the dynamic of competition, that is, the ongoing redefinition of the structure of market shares, can thus be rewritten:

$$\frac{ds_i}{dt} = s_i \Delta [\bar{h}_s - h_i] \quad [3]$$

Since  $\sum s_i = 1$ , one of the equations of this system can be deduced from the others. The simple and intuitive principle we reach is that ‘the market share of firm  $i$  is *always* increasing whenever that firm has lower unit costs than the population average, and conversely. The velocity with which the competitive process takes place depends on the market selection coefficient and it is clear, for example, that competition works more rapidly the more perfect is the market’ (1998: p. 59). We clearly see that the value of  $\Delta$  does not influence the direction of selection, but only its velocity.

Fisher’s “Fundamental Theorem” provides a synthetic vision of these structural changes in analyzing the average level of adaptation of the population (Andersen 2004, Metcalfe 1994). Adaptation designates the relative reproductive success of an individual, a firm or a species: an entity is relatively better adapted than the entities which compose a population if its growth rate (its reproduction rate) is superior to the average growth rate of the population. Adaptation is the result of the interaction between the constituting entities of the population and the properties of the environment.

This theorem precises the relation between the evolution of the adaptation of the individual entities of a population and the evolution of the average adaptation of the population perceived in its globality. According to this theorem, (1) selection improves the average adaptation of the population and (2) the growth of the population is proportional to the variance (that is, the variety) of the adaptation of the population<sup>viii</sup>. Using our previous notations, we can define the average adaptation of the population to its environment as  $g = \sum s_i g_i$ . Using [2], the evolution of this average adaptation is given by:

$$\frac{dg}{dt} = \sum \frac{ds_i}{dt} g_i = \sum s_i (g_i - g) g_i = V_s(g) \quad [4]$$

with  $V_s(g)$  the variance of growth rates of the surviving firms. In the same way, this theorem can be defined with the average unit cost  $\bar{h}_s$  :

$$\frac{d\bar{h}_s}{dt} = \sum \frac{ds_i}{dt} h_i$$

Given the definition of  $s_i$  given by [1], we can reformulate the preceding equation by

$$\frac{d\bar{h}_s}{dt} = \sum s_i (g_i - g) h_i$$

Using  $g_i$  as expressed by [2] and if  $V_s(h)$  designates the variance of the unit costs of the surviving firms, we get :

$$\frac{d\bar{h}_s}{dt} = -\Delta V_s(h)$$

[5]

this formula makes appear that the rate at which decreases the average unit cost negatively depends on two factors: (1) the variance of the unit costs of the surviving firms and (2) the intensity of the market selection pressure. This corresponds to what we stated earlier: the value of  $\Delta$  only influences the speed at which decreases the average unit cost. This cost is thus not a stable parameter throughout the process, but a variable whose evolution depends on the variance of the unit production costs of the surviving firms and on the selection pressure.

We can notice that the concept of dynamic replication and the Fisher's Fundamental Theorem both imply an optimality principle: at the term of the selection process, only the firms whose unit production cost is minimal survive. So, even if the firms follow suboptimal rules of thumb (i.e., do not have a rational behavior, in the maximization sense of the term), the end of the selection process is the adoption of the optimal routine<sup>ix</sup>: entities become maximizers despite of themselves. 'Whether or not individual characteristics are based on optimizing behavior, the evolution of the population as a whole reflects an optimizing principle. The pattern of structural change that flows from the replicator dynamic maximizes the rate of change of average population characteristics, relative to any other possible pattern of structural change in that population' (Foster et Metcalfe, 2001: p. 8).

Indeed, the replication concept enunciates that, if the adaptation of a firm is superior to the average adaptation of the other firms, the relative share of the selection trait of this firm (namely, its production routines, which are the causes of its cost advantages) increases. Consequently, the most efficient firm's market share –in our simplified case with onyl one selection trait, the firm whose unit production cost is the smaller- increases up to

(asymptotically) unity. In turn, Fisher's Theorem enunciates that, through time, natural selection pressure makes that the average adaptation degree of a population increases up to the level of the most adapted entity (Witt 2006): selection thus becomes synonymous with the increasing of the productivity of the population.

In the terms of evolutionary game theory, under the accepted assumptions (notably, the one for which firms have an invariant behavior throughout the selection process), the pure strategy which characterizes the most efficient firm(s) is an "evolutionarily stable strategy" (or ESS). During the monotonic selection process, strategies whose payoff is superior to average payoff have a growth rate superior to the average growth rate of the population (that is, their  $s_i$  increases) and the strategies which are strictly dominated by pure strategies are iteratively eliminated, the velocity (i.e., the efficiency) at which runs the iterative selection process being influenced by the unit cost dispersion and by the institutional parameters. At the end of the selection process, there is no routines combination whose efficiency would be superior to the surviving firms (on the relation between dynamic replicator and ESS, see Fudenberg et Levine 1998, Chap. 3 et Hofbauer et Sigmund 2002, Chap. 6 et 7, Weibull 1995, Chap. 3). Only through innovation, for example, in the form of new factors combinations or new organization methods, would it be possible to compete with anew.

According to Metcalfe, this simple modelization of the selection process by replication clarifies one of the most famous of Hayek's theses according to which the market process is a discovery procedure: 'Since the replicator dynamic seeks the boundary of the selection set, it simultaneously discovers the lowest cost producer and we can make precise the Hayekian idea of a market discovery process [...] The behaviour of firm one [the firm with the minimal unit cost  $h_1$ ] comes to dominate the industry because it is its behaviour which is best adapted to the prevailing environmental circumstances (*op.cit.*, p. 60).

### ***3. Replication and Ignorance***

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As has been shown, the central idea on which relies the concept of the dynamic replicator is that the rate of change of the market shares structure of a firms population depends on the prior distribution of the firms characteristics –their routines, as causes of the labor productivity differential- around the mean of the selection trait in the population (Foster et Metcalfe, 2001 : p. 7). In the last analysis, only those firms which integrate the routines combination enabling the greater labor productivity, will be selected. Thus, replication

essentially mean continuation and inalteration of the considered selection traits all along the process.

This accepted, let us go back to the conclusion drawn by Metcalfe, according to which the frequentist approach which is the heart of the dynamic replication principle, allows to accurately explain the Hayekian conception of the market process. Considering the terms used by Metcalfe, we can suppose that he refers to the *Competitiiton as a Discovery Procedure* paper (1968 [1978]) (CDP in what follows). This paper aims at deepen our understanding of the fundamental issue of the economy and, more generally, of social sciences, that Hayek articulated 40 years before (1937 : p. 33): how is knowledge acquired and communicated?

Even if CDP can be read independently from the other texts Hayek dedicated to this question of the dispersion and communication of knowledge (for example 1937, 1945, 1946, 1975), the nature of the issue and of the argumentation of CDP can only be fully appreciated in the light of them.

CDP is guided by a major idea: the market process is a precious procedure of economic coordination, since it makes smoother the discovery of knowledge hitherto ignored by individuals. From the first page of Hayek's paper, we can indeed read that 'it would be pointless to arrange for competition, if we were certain beforehand who would do best' (p.: 179). If agents were not ignorant –in the sense this term is defined by Austrian economics– that is, (1) if the passing of time would not be accompanied by the change of knowledge, (2) if knowledge would not be dispersed and (3) if it had a univocal meaning for all individuals, the market process would be of no value as a individuals plans coordination procedure.

The recognition of the individuals' ignorance is at the heart of the Austrian conception of the market process (see for example O'Driscoll et Rizzo 1985). Every author belonging to the Austrian school defend a similar conception (among others, Kirzner 1973, Lachmann 1986, Mises 1949), according to which the driving force of the market process is the discovery by the agents of profit opportunities which were hitherto unnoticed and unexploited: individual learning is thus a central aspect –even perhaps the fundamental aspect– of the Austrian conception of the market. The role of the market in an universe of ignorance is to guide the actions of individuals, this guiding being facilitated by the diffusion of useful knowledge.

Contrary to the generally endorsed conception of competition, the essential “function” of the market is thus of a cognitive nature; despite its importance, the allocative function is only secondary or, at least, a function subordinated to the cognitive one. It is the same for all the institutions on which depends a capitalist economy: we can judge of the efficiency of the institutional arrangment of an economy according to its ability to diffuse and favor the

creation of knowledge, not, for example, according to its ability to reduce transaction costs (cf. the classical works of Alchian et Demsetz 1972, Demsetz 1968, Williamson 1985). More precisely, for Austrian economics, the reduction of transaction costs can be seen as one of the consequences, and not as the cause, of the existence of institutions; in other words, the Austrian theory of institutions is not a functionalist theory. Even if this proposition is, in our opinion, a logical extension of the Austrian analysis of institutions, it does not explicitly appear in the literature or is simply [basically] rejected<sup>x</sup>. That is nevertheless on this proposition that implicitly relies Koppl's thesis (2002). What he calls "Big Players" are institutions which have the power to discretionarily distort the market mechanisms without being themselves affected by these modifications. For example, the intervention of central banks on the money market tends to distort the reliability of the signals transmitted to agents and, thus, to diminish the 'probability of non-failure of their expectations' (Hayek, 2007 : p. 367)<sup>2</sup> and to increase the probability to bear losses. To use Koppl's terminology, the rupture of the anonymous character of the interaction between a *Big Player* and other economic agents is at the origin of the discoordination of their expectations and of inefficiencies and herding. The only means they have to increase this probability of non-failure is then to acquire costly informations about the past behavior of this institutions, informational basis from which will be refined the prediction models of its future behavior. In a way, agents have to bear transaction costs to restore the quality of their model of interpretation of the signals transmitted through the skewed institutional framework. Thus, (1) we can detect a causality relationship between institution and transaction cost, although the sense of the causality is reversed in comparison with the one of neo-institutional economics and (2) this causality can more easily enlighten by an *a contrario* reasoning: *ceteris paribus*, the unforeseeable change of the legitimately expected behavior of an institution compels individuals to quickly modify their behavior by acquiring new and costly informations which would have been useless otherwise.

The particular pattern of resources allocation of an economy can not be understood without a concomitant study of its institutions: 'For a competitive society, the question [is] not how we can "find" the people who know best, but rather what institutional arrangements are necessary in order that the unknown persons who have knowledge specially suited to a particular task are most likely to be attracted to that task' (Hayek, 1946: p. 95). The resources allocation and the factors of production's earnings result at the same time from the market process and from

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<sup>2</sup> [I dont have the English version of LLL, so the translation may be false]

the institutional order, the latter determining the conditions of operation of the former. Can we find this essential cognitive dimension in the approach developed by Metcalfe?

### **3.1 Unit Cost and Accumulation**

The analysis in term of dynamic replication underlines that the rate of growth of the relative frequency of a selection trait in a population –the most efficient routines- is determined by  $[\bar{h}_s - h_i]$  as [3] makes clear: the rate of growth of the firm  $i$  through the accumulation of its means of production is directly correlated to the absolute difference between the payoff of the strategy which defines  $i$  and the average payoff of the population, the speed of adjustment depending (1) on the size of this payoffs difference and (2) on the institutional characteristics synthetized by the  $\delta$  and  $\Delta$  parameters.

Thereby, when we use the dynamic replicator tool, we must necessarily know these absolute payoffs, that is, the unit cost of production of the firm  $i$  and the average unit cost of production of the firms which compose the population, in order to point out at the same time the *orientation* of the selection and also, and particularly, the *speed* of the selection, the institutional parameters being given. If a mere ordinal ranking of the payoffs would allow us to establish the orientation of the selection, it would not be sufficient to establish its speed. We are going to show that this simple relation  $[\bar{h}_s - h_i]$ , relation which is at the heart of [3], relies on debatable conceptions of knowledge and learning.

Considering that the  $h_i$  are given is just another way to put into words the constant returns to scale hypothesis. Their fixity prohibits (1) that the accumulation of factors of production would have any influence on the productive efficiency of the firm and (2) the introduction of the possibility that the firms could learn to better use their materials from accumulated experience and refinement of their production routines, possibility on which relies the concept of learning curve ever foreseen by Adam Smith (Arrow 1962, Wright 1936, Yelle 1979). In our opinion, this fixity hypothesis implicitly depends on the twin assumptions of capital goods homogeneity and of invariability of the knowledge possessed and managed by firms all along their life, what is (1) in complete opposition with the Austrian theory of capital (Hayek 1941 [2007], Lachmann 1956 [1978], Lewin 1999) and (2) is not without posing elementary epistemological questions.

If, in conformity with the Austrian vision on capital, we reject the first assumption of factor homogeneity, the questions (1) of factorial complementarity (synergy effects), (2) of indivisibilities of the production sets and (3) of increasing returns, must be (re-)introduced in the analysis of economic evolution<sup>xi</sup>. The articulation of these three dimensions of the capital

accumulation constitutes the major project of Lachmann's work on capital, where he often emphasizes that, if we accept as our starting hypothesis the heterogeneity in use of the factors of production (capital and labor), the simplistic vision of capital accumulation as a mere duplication of factors to a homogenous stock must be rejected in favor of a structural vision of capital focusing on the evolution of the factors composition inside firms and, by extension, between firms. To use his own terms, we have to establish a clear-cut distinction between, on the one hand, the homogenized vision of capital, for which accumulation is perceived as capital widening and, on the other hand, the structural vision, for which accumulation is perceived as capital deepening. Remark further that this latter conception in terms of structure is more in line with the Schumpeterian thesis of creative destruction than the former conception in terms of stock<sup>xii</sup>. Lachmann binds these elements together as follows:

'The capital structure will thus change since the capital coefficients change, almost certainly towards a higher degree of *complexity*, i.e. more types of capital items will now be included in the combinations. The new items, which either did not exist or were not used before, will mostly be of an *indivisible* character. *Complementarity plus indivisibility* are the essence of the matter. It will not pay to install an indivisible capital good unless there are enough complementary capital goods to justify it. The accumulation of capital does not merely provide us with the means to build power stations, it also provides us with enough factories to make them pay and enough coal to make them work. Economic progress thus requires a continuously changing composition of the social capital. The new indivisibilities account for the increasing returns. The introduction of new indivisible resources, feasible only when the volume of complementary capital reaches a certain size, will as a rule also entail a change in the composition of this complementary capital, with the result that some of these capital goods will have to be shifted to other uses while others, which cannot be shifted, may lose their capital character altogether. Thus the accumulation of capital always destroys some capital'.

One could obviously assess that these questions of indivisibilities and increasing returns bring forth no particular difficulty for a neo-Schumpeterian approach, since it suffices to interpret the accumulation of heterogenous goods as an innovation, in the Schumpeterian sense of the word, which temporarily disturbs the smooth working of the selection process. Even though it

is conceivable, we can nevertheless doubt of the credibility and of the internal coherence of this *ad hoc* proposition.

If we posit that heterogeneity and indivisibilities characterize investments thus, every investment should be seen as an innovation. Yet, capital accumulation being a direct consequence of the normal working of the selection process, as is reflected by the parameter  $f$ , it would mean that, by nature, the selection process is itself creator of these disturbing “innovations”. These innovations would thus not be the consequence of the firms’ creativity, but one of the consequences (an unexplained by-product) of the mere working of the selection process. This proposition is formally untenable since, as has been shown, the concept of replication is presented as a system of differential equations which simulates the selection mechanism, without integrating any mutation variable. *Selection and mutation are thus formally distinguished* (Weibull 1995, Hofbauer et Sigmund 1998). Consequently, the above proposition according to which the market selection engenders by itself a mutation movement is logically unacceptable.

If the selection process is not a monotonic process, we cannot claim that it tends toward a configuration characterized by an optimality property which respects Fisher’s principle. The replicator principle would thus lose its determinism for an “*open ended*” dimension, more in conformity with the Austrian theory of the market process. In addition, the absence of monotony would blur the notion of adaptation. Above (cf. page 8), we have indicated that “an entity is relatively better adapted than the entities which compose a population if its growth rate (its reproduction rate) is superior to the average growth rate of the population”. In presence of indivisibilities and increasing returns, an entity can be relatively less adapted (i.e., can have a unit cost of production superior to the average unit cost of the population and a growth rate inferior to the average growth rate of the population) than the other members of the population at  $t_0$ , but become relatively more adapted –following this definition –at  $t_1$ . To put it another way, in presence of production indivisibilities and increasing returns, the evolution of the relative frequency of a routine can not anymore be seen as systematically monotonic. If a selection mechanism is supposed monotonic, it is unconceivable that the relative frequency of an entity increases and then decreases.

Thus, we cannot see accumulation as an automatic aspect of the behavior of a firm, but as a decision involving its survival and its future. The replication approach does not take into account this projective dimension, since the investment decisions mechanically (i.e., functionally) depend on the past and present results of the firm: the neglect of expectations in

the analysis of the accumulation of factors of production disregards the central question of their formation under uncertainty which is a corollary question to the integration of individuals' ignorance.

The second assumption (fixity of knowledge) means that the object of replication is the content of the firms' routines, i.e., the experience, capabilities and accumulated knowledge<sup>xiii</sup>. Drawing on the classical proposition exposed by the philosopher David Hull<sup>xiv</sup> (1988 : p. 408) that the replicator is defined as an 'entity that pass on its structure largely intact in successive replications', Metcalfe (2005: p. 410) clearly states that '[production units] have built in copying mechanisms to ensure that production can take place tomorrow, the day after and so on in a way that preserves a particular pattern of activity. What is copied, transmitted over time and used is the firm's knowledge and skill, scientific, technological and managerial –a template to maintain its capability; in Nelson and Winter's terms (1982), the "collectivity of routines"'. The principle of replication is thus not accompanied by the synchronic evolution of what is being replicated: knowledge replication and its evolution are uncoupled and diachronic processes.

Following the philosopher Bruno Latour (1995), we can question the underlying epistemology of this "diffusionist" conception of knowledge, which implies the neutrality of the replication process on the object of the replication. Latour demonstrates that such an invariance approach is particularly unadapted when applied to the study of the propagation of a knowledge content. If there is pure and simple replication, the moment of the transfert of the routines' content is not problematic, like the moment of the photocopy of a paper document is not problematic for what is written. However, when we introduce the possibility of the *interpretation* of the knowledge transferred to individuals and of their *combination* with those they ever possess and master, there is no invariance anymore, but a cumulative and self-alimented process of which we cannot *a priori* assert that it tends toward an asymptotic position of univocity of the knowledge contents and of transfert neutrality: the reception of new knowledge is interpreted in the light of the previous knowledge, and their interpretation triggers in its turn a propagation of new knowledge, and so on. Diffusion and innovation cannot be perceived as two independent and diachronique phenomena and do not respect the temporal sequence "innovation followed by diffusion". This dichotomy is tenable only if we assume the transfert's neutrality. In Latour's words: 'Les individus ne sont pas des conducteurs, ni même des semi-conducteurs, mais des *multi-conducteurs*, et en plus de cela ils sont imprévisibles [...] Est-il possible de maîtriser le destin d'un énoncé alors qu'il résulte du comportement de tous ces alliés si volages ?' (1995 : p. 250) [you should read French].

Nevertheless, if, as above, we maintain that the combination of replicated knowledge is only an aspect of innovation, we cannot accept the Fisher's principle anymore.

### **3.2 Average Cost and Population**

Considering that  $\bar{h}_s$  can be measured relies on two conditions which, even if they appear trivial and innocuous, are essential. First, we have to assume that it is possible (and easy, i.e., costless) to identify the number of entities which constitute the population, that is, the population size. If this first condition is fulfilled, the second condition is that we can know the prior distribution of unit production costs, that is, the characteristics of the entities which constitute the population. Let us study these two conditions successively.

At first sight, the first condition does not seem to be very restrictive since, as noted above, a population is merely defined as the set of entities facing the same selection pressures. In our opinion, this definition is actually not restrictive, but only under the hypothesis of homogeneity of the produced good. For example, observation is sufficient to indicate without any difficulty if a farmer belongs to the corn producers' population or to the cocoa's. However, if we introduce a slight degree of heterogeneity in the produced good, this classification loses its obviousness. For example, it is already more delicate to indicate empirically if an editor of economics books belongs to the same population as an editor of comics. We can confidently conjecture that Marvel and Routledge do not perceive themselves as potential competitors.

We have ever touched upon this first difficulty when has been introduced the  $\delta$  coefficient. We have seen that, when the market structure is characterized by  $\delta=0$ , every producer is a monopolist who exploits a consumption niche, this niche being the result of (1) the consumers' reluctance to switch suppliers or (2) characteristics of the supplied good (in case of heterogeneity). Price dispersion is then high and persists all over the process. In such a situation, we can ask if the different firms still belong to the same population. The position of the authors who adopt population thinking methods is on this point fragile and ambiguous. As Andersen states (2003: p. 2): 'The fruitfulness of the concrete demarcation of the population under study is largely an empirical matter that cannot be solved *a priori*'. In other words, even if they are essentially built on this idea of demarcation, population thinking and replication do not rely on a solid set of methodological principles on which would be established a taxonomy of economic entities. This constitutes a further illustration of the imperfection of the biological metaphor: it is indeed much easier to establish taxonomies and classifications in this discipline than in economics, where the studied entities (1) can deeply evolve on

relatively much shorter time-scales than those proper to biological evolution or (2) be defined by characteristics which cannot easily be identified with those of other entities.

Yet, this imperfection is a serious challenge, since the very first step of a population way of thinking is evidently to establish what is the population studied. If the taxonomy of entities (i.e., the indication of the criteria thanks to which an entity is classified into a population) relies mainly on the identification of the nature of intensity of the selection constraints to which they are subjected, the modification of these constraints implies *ipso facto* the parallel modification of the basis on which selection operates, that is, a redefinition of the size and – possibly- of the characteristics of the entities composing the population<sup>xv</sup>.

The second condition without which  $\bar{h}_s$  cannot be measured is that we can know the initial distribution of the unit production costs. As has been pointed out, this second condition necessitates that we are able to identify beforehand the population on which this distribution is defined. As indicated, this is not without problem if we release the good homogeneity hypothesis. Beyond this first question, the fact of knowing the initial distribution of unit costs amounts to knowing the characteristics proper to the entities of the population relative to the considered selection trait.

Form an Austrian point of view, the specification of market conditions, of the number and relative performance of the competitors, is neither a trivial, nor an automatic, step of economic action, but an important aspect of the entrepreneurial discovery process, without which would not be detected the reasons that can explain the level and the persistence of the price variance and, consequently, the existence of profit opportunities<sup>xvi</sup>.

The position consisting in taking as given what has to be discovered (in this case, the  $h_i$  and  $\bar{h}_s$ ) through the market process precisely corresponds to the position criticized by Hayek as soon as 1937 and then rejected by the Austrian school: agents' ignorance –in the Austrian sense of the word- simply do not play any role in a replication analysis.

A further step in this way leads us to a simple and, at the same time, potentially demolishing, question: who has this knowledge set? To use Hayek's words: 'Datum means, of course, something given, but the question which is left open [...] is to whom the facts are supposed to be given' (1937: p. 39).

If this knowledge is only possessed by the modelisator, the assumptions can be seen as mere analytical conveniences which allow to define of the concepts, to make more their articulation and the proofs more tractable, and to determine what can be the position(s) toward which the model asymptotically tends. If we accept this point, the learning procedures by which agents

acquire themselves those knowledge throughout the process still have to be precised. The manner learning is conceived in a population thinking approach is bitterly different from that endorsed by the Austrian theory of the market process: in the former, learning consists in the monotonic elimination (in the exclusion from the population) of the least suited relative to an average criterium of suitability; for the latter individuals' learning consists in pushing back their ignorance barriers in refining their interpretation schema et in acquiring, by observation, imitation, experience, creation or through market transactions, new knowledge (Witt 2008).

The conception of learning in a frequentist approach directly follows from the characteristics given to the population's entities: if we assume that their characteristics are fixed –or “genetically pre-programed”- thus learning is quite simply identified with the iterative elimination of the suboptimal programs<sup>xvii</sup>. Firms do not *adopt* new behavioral rules. Population learning is thus identified with the increasing of the relative frequency of the optimal rule, that is, with the propension of the population structure to tend toward the optimal structure that only the modelisator can specify. In other words, population learns, not the entities which compose it. The conclusion drawn by Fudenberg and Levine (1998 : p. 52) thus seems to be particularly accurate: ‘Evolutionary models are generally cast in terms of the behavior of an entire population and are vague about the individual behavior that leads to this population dynamic’.

If only the agents' knowledge plays a functional role in the working of the selection process, we have on the contrary to admit that this knowledge set is the fact of the agents subjected to the selection. However, if the agents knew the two conditions we have just described, the selection process would simply be neutralized. If all the firms were able to identify in the same way the population to which they belong and knew the initial distribution of unit costs, thus every firm knows that every other firm knows that they belong to the same population and what are the efficient characteristics of the different production routines. Population size and composition would thus be common knowledge, in the game theoretic sense of the concept. So, what would be the incentives for a firm to enter a population while knowing beforehand that its unit production cost is and will remain above the average unit cost of the population? This average unit cost would not be a variable coming from the selection process anymore, but a datum: it would be equal to the unit cost of the firm(s) whose production routines are and will remain the most efficient. By definition if all these elements are common knowledge, there is no adjustment by the market process, since every agent knows that all the other agents know that there is nothing to discover.

#### 4. Conclusion

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We have established that the market process analysis developed by the Austrian school cannot be identified with the one developed by the neo-Schumpeterian approach. The origin of this conclusion is essentially methodological. The monotonic selection process which characterizes the latter conflicts with the “open ended” vision of the former, where the market process is articulated with the theory of capital and the agents’ ignorance. In a replication perspective, learning is not identified with the agents’ conscious pursuit of pushing back the limits of their ignorance.

Furthermore, our position compels us to reject one of the major conclusions drawn by Metcalfe: Fisher’s theorems, and the optimality principles they involve, do not correspond to the Austrian vision of the working of the market process. Even if there is still no consensus on this point within the Austrian school, we can ask ourselves if the notion of optimality (whatever its form) is compatible with Austrian economics. As for us, we do what Everett and Langlois (1994 : p. 38) have called an “evolutionary skepticism”, according to which ignorance, i.e., the *a priori* impossibility to completely determine the past, present, and future, conditions of action, the agents’ preferences, their knowledge or their efficiency, bans any form of analysis founded on this notion of optimality. It is possible and legitimate to use the optimality criterion when the modelisator and the agents know everything that have to know (endowments, preferences, technologies, states of the world and so on). If this is not the case, this concept is inadequate. To use Savage’s (1972) famous distinction, this notion seems to be more fitted to the analysis of “small” worlds rather than “large” worlds.

## References

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- Alchian Armen, 1950, *Uncertainty, Evolution, and Economic Theory*, The Journal of Political Economy, Vol. 58, No. 3.
- Alchian Armen et Demsetz Harold, 1972, *Production, Information Costs and Economic Organization*, The American Economic Review, Vol. 62, No. 5.
- Andersen Esben Sloth, 1994, *Evolutionary Economics. Post-Schumpeterian Contributions*, Londres : Pinter Publisher.
- Andersen Esben Sloth, 2003, *Population Thinking and Evolutionary Economic Analysis*, Draft of Postscript for the Japanese edition of “Evolutionary Economics: Post-Schumpeterian Contributions”.
- Andersen Esben Sloth, 2004, *Population Thinking, Price’s Equation and the Analysis of Economic Evolution*, Evolutionary and Institutional Economics Review, Vol. 1, No. 1.
- Arrow Kenneth, 1962, *The Economic Implications of Learning by Doing*, The Review of Economic Studies, Vol. 29, No. 3.
- Arthur Brian, Ermoliev Yuri et Kaniovski Yuri, 1987, *Path-Dependent Processes and the Emergence of Macrostructure*, European Journal of Operational Research, No. 30, in Brian Arthur (ed.), 1994, *Increasing Returns and Path Dependence in the Economy*, Ann Arbor : The University of Michigan Press.
- Arthur Brian, Durlauf Steven et Lane David (eds.), 1997, *The Economy as an Evolving Complex System II*, Reading : Addison-Wesley.
- Baird Charles, 2000, *Alchian and Menger on Money*, Review of Austrian Economics, Vol. 13, No. 2.
- Benaïm Michel, Schreiber Sebastian et Tarrès Pierre, 2004, *Generalized Urn Models of Evolutionary Processes*, The Annals of Applied Probability, Vol. 14, No. 3.
- Blume Lawrence et Durlauf Steven (eds.), *The Economy as an Evolving Complex System III, Current Perspectives and Future Directions*, New York : Oxford University Press.
- Boulding Kenneth, 1981, *Evolutionary Economics*, Beverly Hills : Sage Publications.
- Butos William, 2003, *Knowledge Questions: Hayek, Keynes and Beyond*, Vol. 16, No. 4.
- Castaldi Carolina et Dosi Giovanni, 2004, *The Grip of History and the Scope for Novelty: Some Results and Open Questions on Path Dependence in Economic Processes*, LEM Working Papers Series.
- David Paul, 2001, *Path Dependence, Its Critics, and the Quest for “Historical Economics”*, in Pierre Garrouste et Stavros Ioannides (eds.), *Evolution and Path Dependence in Economic Ideas: Past and Present*, Cheltenham : Edward Elgar.
- David Paul, 2007, *Path Dependence – A Foundational Concept for Historical Social Sciences*, Cliometrica-The Journal of Historical Economics and Econometric History, Vol. 1, No. 2.
- Demsetz Harold, 1968, *The Cost of Transacting*, Quarterly Journal of Economics, Vol. 82, No. 1.
- Edwards Anthony, 1994, *The Fundamental Theorem of Natural Selection*, Biological Reviews of the Cambridge Philosophical Society, Vol. 69, No. 4.
- Ewens Warren, 1989, *An Interpretation and Proof of the Fundamental Theorem of Natural Selection*, theoretical Population Biology, Vol. 36, No. 2.
- Foss Nicolai, 2000, *Austrian Economics and Game Theory: A Stocktaking and an Evaluation*, Review of Austrian Economics, Vol. 13, No. 1.
- Foster John et Metcalfe Stanley, 2001, *Modern Evolutionary Economics Perspectives: An Overview*, in John Foster et Stanley Metcalfe (eds.), *Frontiers of Evolutionary Economics –Competition, Self-Organization and Innovation Policy*, Cheltenham : Edward Elgar.
- Fudenberg Drew et Levine David, 1998, *The Theory of Learning in Games*, Cambridge (Mass.) : The MIT Press.
- Hanusch Hornst et Pyka Andreas, 2007, *Elgar Companion to Neo-Schumpeterian Economics*, Cheltenham : Edward Elgar.
- Hayek Friedrich, 1937 [1948], *Economics and Knowledge*, in. *Individualism and Economic Order*, Chicago : The University of Chicago Press.
- Hayek Friedrich, 1941 [2007], *The Pure Theory of Capital*, Chicago : The University of Chicago Press.
- Hayek Friedrich, 1945 [1948], *The Use of Knowledge in Society*, in. *Individualism and Economic Order*, Chicago : The University of Chicago Press.
- Hayek Friedrich, 1946 [1948], *The Meaning of Competititon*, in. *Individualism and Economic Order*, Chicago : The University of Chicago Press.
- Hayek Friedrich, 1968 [1978], *Competition as a Discovery Procedure*, in. *New Studies in Philosophy, Politics, Economics and the History of Ideas*, Londres : Routledge.
- Hayek Friedrich, 1975 [1978], *The Pretence of Knowledge*, in. *New Studies in Philosophy, Politics, Economics and the History of Ideas*, Londres : Routledge.
- Hayek Friedrich, 2007, *Droit, Législation et Liberté*, Paris : PUF/Quadrige.

- Hodgson Geoffrey, 1999, *Evolution and Institutions. On Evolutionary Economics and the Evolution of Economics*, Cheltenham : Edward Elgar.
- Hofbauer Josef et Sigmund Karl, 2002, *Evolutionary Games and Population Dynamics*, Cambridge : Cambridge University Press.
- Horan Barbara, 1994, *The Statistical Character of Evolutionary Theory*, Philosophy of Science, Vol. 61, No. 1.
- Hull David, 1988, *Science as a Process: An Evolutionary Account of the Social and Conceptual Development of Science*, Chicago : The University of Chicago Press.
- Hull David, Langman Rodney et Glenn Sigrud, 2001, *A General Account of Selection: Biology, Immunology, and Behavior*. Behavioral and Brain Sciences, Vol. 24., No. 2.
- Kirzner Israel, 1973, *Competition and Entrepreneurship*, Chicago : The University of Chicago Press.
- Kirzner Israel (ed.), 1982, *Method, Process and Austrian Economics: Essays in Honor of Ludwig von Mises*, Lexington : D.C. Heath.
- Klein Peter et Selgin George, 2000, *Menger's Theory of Money: Some Experimental Evidence*, in. John Smithin (ed.), *What is Money ?*, London: Routledge.
- Koppl Roger, 2002, *Big Players and the Economic Theory of Expectations*, New York : Palgrave MacMillan.
- Koppl Roger, 2006, *Austrian Economics at the Cutting Edge*, Review of Austrian Economics, Vol. 19, No. 4.
- Lachmann Ludwig, 1956 [1978], *Capital and Its Structure*, Kansas City : Sheed Andrews and McMeel.
- Lachmann Ludwig, 1959, *Professor Shackle on the Economic Significance of Time*, Metroeconomica, Vol. 11.
- Lachmann Ludwig, 1971, *Ludwig von Mises and the Market Process*, in *Capital, Expectations, and the Market Process. Essays on the Theory of the Market Economy*, Kansas City : Sheed Andrews and McMeel.
- Lachmann Ludwig, 1976, *From Mises to Shackle: An Essay on Austrian Economics and the Kaleidic Society*, Journal of Economic Literature, Vol. 14, No. 1.
- Lachmann Ludwig, 1986, *The Market as an Economic Process*, New York : Basil Blackwell.
- Langlois Richard et Everett Michael, 1994, *What is Evolutionary Economics ?*, in Lars Magnusson (ed.), *Evolutionary and Neo-Schumpeterian Approaches to Economics*, Boston : Kluwer Academic Publishers.
- Latour Bruno, 1995, *La Science en Action*, Paris : La Découverte.
- Lewin Peter, 1999, *Capital in Disequilibrium*, Londres : Routledge.
- Lewin Peter, 2001, *The Development of Austrian Economics: Revisiting the Neoclassical Divide*, Review of Austrian Economics, Vol. 14, No. 4.
- Littlechild Stephen, 1989, *Three Types of Market Process*, in Richard Langlois (ed.), *Economics as a Process*, New York : Cambridge University Press.
- Loasby Brian, 2001, *The Evolution of Knowledge*, DRUID Conference.
- Loasby Brian, 2003, *The Cognitive Basis of Institutions: An Evolutionary Perspective*, in. Ernst Helmstädter (ed.), *The Economics of Knowledge Sharing, A New Institutional Approach*, Cheltenham : Edward Elgar.
- Magnusson Lars, 1994, *Evolutionary and Neo-Schumpeterian Approaches to Economics*, in Lars Magnusson (ed.), *Evolutionary and Neo-Schumpeterian Approaches to Economics*, Boston : Kluwer Academic Publishers.
- Magnusson Lars (ed.), 1994, *Evolutionary and Neo-Schumpeterian Approaches to Economics*, Boston : Kluwer Academic Publishers.
- Menger Carl, 1976, *Principles of Economics*, Grove City : Libertarian Press.
- Menger Carl, 1996, *Investigations Into the Method of Social Sciences*, Grove City : Libertarian Press.
- Metcalfe Stanley, 1994, *Competition, Fisher's Principle and Increasing Returns in the Selection Process*, Journal of Evolutionary Economics, Vol. 4, No. 4.
- Metcalfe Stanley, 1998, *Evolutionary Economics and Creative Destruction*, The Graz Schumpeter Lectures, Londres : Routledge.
- Metcalfe Stanley, 2002, *On the Optimality of the Competitive Process: Kimura's Theorem and Market Dynamics*, Journal of Bioeconomics, Vol. 4., No. 2.
- Metcalfe Stanley, 2005, *Evolutionary Concepts in Relation to Evolutionary Economics*, in Kurt Dopfer (ed.), *The Evolutionary Foundation of Economics*, Cambridge : Cambridge University Press.
- Mises Ludwig E. von, 1949, *Human Action. A Treatise on Economics*, Auburn : Ludwig von Mises Institute.
- Nelson Richard et Winter Sidney, 1982, *An Evolutionary Theory of Economic Change*, Cambridge (Mass.) : Harvard University Press.
- Nelson Richard, 1995, *Recent Evolutionary Theories About Economic Change*, Journal of Economic Literature, Vol. 33, No. 1.
- O'Driscoll Gerald et Rizzo Mario, 1985, *The Economics of Time and Ignorance*, Londres : Routledge.
- Poirier Dale, 1988, *Frequentist and Subjectivist Perspectives on the Problems of Model Building in Economics*, The Journal of Economic Perspectives, Vol. 2, No. 1.

- Potts Jason, 2000, *The New Evolutionary Microeconomics –Complexity, Competence and Adaptive Behaviour*, Cheltenham : Edward Elgar.
- Price George, 1972, *Fisher “Fundamental Theorem” Made Clear*, *Annals of Human Genetics*, Vol. 36, No. 2.
- Saviotti Pier Paolo, 1996, *Technological Evolution, Variety and the Economy*, Cheltenham : Edward Elgar.
- Schlicht Ekkehart, 2000, *Aestheticism in the Theory of Custom*, *Journal des Economistes et des Etudes Humaines*, Vol. 10, No. 1.
- Schreiber Sebastian, 2001, *Urn Models, Replicator Processes, and Random Genetic Drift*, *SIAM Journal of Applied Mathematics*, Vol. 61, No. 6.
- Schumpeter Joseph A., 1954, *History of Economic Analysis*, New York : Oxford University Press.
- Schumpeter Joseph A., 1990, *Capitalisme, Socialisme et Démocratie*, Paris : Bibliothèque Historique Payot.
- Silverberg Gerald et Verspagen Bart, 1994, *Learning, Innovation and Economic Growth: A Long-Run Model of Industrial Dynamics*, *Industrial and Corporate Change*, Vol. 3, No. 1.
- Silverberg Gerald et Verspagen Bart, 2004, *Breaking the Waves: a Poisson Regression Approach to Schumpeterian Clustering of Basic Innovations*, *Cambridge Journal of Economics*, Vol. 27, No. 5.
- Sperber Dan, 1996, *Explaining Culture: A Naturalistic Approach*. Oxford : Basil Blackwell.
- Sperber Dan, 1996, *An Objection to the Memetic Approach to Culture*, in. Robert Aunger (ed.), *Darwinizing Culture*. Oxford : Oxford University Press.
- Vega-Redondo Fernando, 1996, *Evolution, Games, and Economic behaviour*, Oxford : Oxford University Press.
- Velupillai Kumaraswamy, 2000, *Computable Economics. The Arne Ryde Memorial Lectures Series*, Oxford : Oxford University Press.
- Velupillai Kumaraswamy, 2005, *Computability, Complexity, and Constructivity in Economic Analysis*, New York : Wiley.
- Velupillai Kumaraswamy, 2007, *A Computable Economist’s Perspective on Computational Complexity*, Trento University Discussion Paper, No. 23 [forthcoming in Barkley Rosser (ed.), *The Handbook of Complexity Research*, Cheltenham : Edward Elgar].
- Vromen Jack, 2007, *Generalized Darwinism in Evolutionary Economics: The Devil is in the Details*, Max Planck Institute Working Paper, No. 0711.
- Weibull Jörgen, 1995, *Evolutionary Game Theory*, Cambridge (Mass.) : The MIT Press.
- Williamson Oliver, 1985, *The Economic Institutions of Capitalism*, New York : The Free Press.
- Witt Ulrich, 2002, *How Evolutionary is Schumpeter’s Theory of Economic Development?*, *Industry and Innovation*, Vol. 9, No. 1/2.
- Witt Ulrich, 2006, *Evolutionary Economics*, in Lawrence Blume et Steven Durlauf (eds.), *The New Palgrave Dictionary of Economics* [Forthcoming].
- Witt Ulrich, 2008, *Observational Learning, Group Selection, and Societal Evolution*, *Journal of Institutional Economics*, Vol. 4, No. 1.
- Wright Theodore Paul, 1936, *Factors Affecting the Cost of Airplanes*, *Journal of Aeronautical Sciences*, Vol. 3, No. 4.
- Yelle Louis, 1979, *The Learning Curve: Historical Review and Comprehensive Survey*, *Decision Sciences*, Vol. 10, No. 2.

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<sup>i</sup> According to Foster and Metcalfe (2001), the act of birth of modern evolutionary economics can be traced back to the beginning of the 1980s, through Boulding’s (1981) and Nelson and Winter’s (1982) works. For Metcalfe (2005: p. 394), despite all its diversity, the evolutionary approach can be defined as follows: ‘‘An evolutionary argument based upon selection processes is concerned with explaining how the relative importance of specified entities within a well-defined population changes over time : why some are eliminated and others continue to survive, and yet others enter the population. Thus, the concern is ultimately with two phenomena: viability, and the differential growth of entities between which meaningful comparisons can be made. What is the criterion for meaningful comparison? It is that the entities are elements in the same population and thus subjected to common selective pressures’.

<sup>ii</sup> The proximity between the Austrian and neo-Schumpeterian perspectives has ever been underlined: ‘The view of the role of the competitive process held by Schumpeter and the modern neo-Schumpeterians is shared with economists who explicitly regard themselves as evolutionary. As Nelson and Winter, Langlois, Kirzner, and others have emphasized, this can, to some extent, be regarded as a return to Adam Smith and the classical tradition of political economy (Kirzner 1982). Moreover, this vision is strongly emphasized in the modern Austrian approach developed by Hayek, Mises, Kirzner and others. According to the Austrians, as well as the group that Littlechild has named the *radical subjectivists* which includes Shackle and Lachmann (Littlechild

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1989: p. 29), economic agents are uncertain, ignorant, and indeterminate of future states when they make their (economic decisions)' (Magnusson, 1994: pp. 3-4).

<sup>iii</sup> Among the authors assimilated or close to the neo-Schumpeterian current, we can identify for example Hanusch et Pyka (2007), Magnusson (1994), Nelson (1995), Saviotti (1996), Silverberg et Verspagen (1994, 2004), Witt (2002).

<sup>iv</sup> According to Andersen, population thinking, centered around the analysis of the evolution of the mean and frequency of a selection trait in a population, constitutes the unifying criterium of the different forms of evolutionary analyses. Thus, this approach is, by its very nature, "statistical". The way we use the term "frequency" should not be confused with the traditional acceptance of this term by the frequentist theory of probability. Only the theoretical principles called up to explain the evolution of the relative proportions of different strategies in a population are of interest for us, what allows us to use the terms frequency and proportion as synonymous. Our vision is thus far from the one of the frequency theory of probability that is generally described as follows: 'Frequentists interpret probability as a property of the external world, i.e., the limiting relative frequency of the occurrence of an event as the number of suitably defined trials goes to infinity. According to this view a "true" model or data generating process exists involving parameters which attain an objective existence' (Poirier, 1988 : p. 122).

<sup>v</sup> The link between routines and retention is clearly stated by Everett and Langlois (1994: pp. 21-2): 'The better routines (introduced first as innovations) are selected by the environment (comprising only the market in most of their analyses) and then propagated by replication (within a firm) and imitation (interfirm), leading to the differential survival (via profitability) of firms. Through the process of competition, the better rules survive'.

<sup>vi</sup> He goes on: 'Epistemic variations, and innovations are always epistemic variations, are constrained by cognitive frameworks; whether they be called paradigms, heuristics or business theories they guide thought and provide exemplars of good design' (*Ibid.*).

<sup>vii</sup> 'Innovation may require the breaking of some established connections, but the new connections must be adequate substitutes for the old in forming complementary relationships with some established patterns. The new ideas and the old may be incommensurable in the straightforward sense of not being partitions of a single structure of knowledge (and therefore not susceptible to standard economic analysis in terms of information sets), but successful novelty is carried by what Schlicht (2000) calls 'good continuity', which allows new knowledge to be connected to old' (Loasby 2003: p. 114).

<sup>viii</sup> Lots of commentaries and criticisms have been formulated against this theorem (see for example Edwards 1994, 2002, Ewens 1989, Price 1972). Fisher defined his theorem in these words: 'The rate of increase in fitness of any organism at any time is equal to its genetic variance in fitness at that time' (1958 : p. 37). Edwards offers another definition, which emphasizes (1) the underlying genetic pool of a population and (2) the deterministic aspect of evolution: 'The rate of increase in the mean fitness of any organism at any time ascribable to natural selection acting through changes in gene frequencies is exactly equal to its genetic variance in fitness at that time (1994 : p. 450).

<sup>ix</sup> Following Nelson and Winter (1982), we can remark the patent proximity between this conception of evolution with the one of Alchian (1950).

<sup>x</sup> For example, Langlois and Everett (*op.cit.*: p. 14) clearly state that the conscious research of the curtailment of transaction costs is the cause of the emergence of institutions: 'Money as a medium of exchange evolved because as traders sought to reduce transaction costs, they eventually came to accept those commodities that were highly valuable and highly marketable. Explaining the origin of money as such does not require an assumption of conscious collective action; rather, an assumption of individualistic pursuits is sufficient'. **This idea is built on a circular reasoning: how can agents appraise for the advantages of the adoption of a particular medium of exchange when, by definition, there exists no generally accepted unit of measurement?**

<sup>xi</sup> Even if it goes beyond our paper's object, a very important point for the Austrian theory of capital should be noted. These three properties of complementarity, indivisibility and increasing returns, *are not deduced from the theory of action*. Lachmann states it bluntly (1956 : p. 81): 'Böhm-Bawerk's thesis about the higher productivity of roundabout processes is an empirical generalization; it is not derived from the axioms of economic action. The same applies to our thesis about the typical changes of the capital structure as capital accumulates. There is no *a priori* reason to expect that a sufficient number of exploitable indivisibilities will always present itself, but the history of industrial countries over the last 200 years goes to show that they usually do'.

<sup>xii</sup> 'The initial stock of goods is neither homogeneous nor an amorphous heap. Its various parts complement each other in a way that we readily understand as soon as we hear of buildings, equipment, raw materials and consumers' goods [...] The stock of goods existing at any instant of time is a structured quantity or a quantity that displays structural relations within itself, that shape, in part, the subsequent course of the economic process' (Schumpeter, 1954 : pp. 631-2).

<sup>xiii</sup> The principle of replication evidently implies the principle of retention: 'Inheritance is to be conceived as the force that links patterns of behaviour across consecutive generations. It is, of course, a precondition for selection

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to be effective that inheritance be able to transfer behaviour across generations (at least some of its traits) in a sufficiently stable manner. Selection and inheritance are, in a sense, two sides of the same coin in any evolutionary model' (Vega-Redondo, 1996 : p. 2).

<sup>xiv</sup> In another text, Hull defends a still harder position according to which the notions of replication or inheritance can be assimilated to the notion of copy: 'Replication is inherently a copying process. Successive variations must in some sense be retained and then passed on' (Hull et al., 2001: p.514). From this conception of replication as copy, it becomes easy to introduce different forms of distortion, noise and mutation. For Sperber (1996, 2000), this vision of replication as "duplicata" does not permit to adequately take into account social, cultural or economic evolution, what drives him to accept a diametrically opposed conception in rejecting any notion of replication, whatever its form (for more details, see Vromen 2007).

<sup>xv</sup> In our opinion, a simple and general procedure would allow to establish whether an entity belongs to a population. This procedure would consist in studying the cross elasticities of demand with respect to price between the firms which hypothetically belong to a given population: if these elasticities are positive, we can deduce that these firms are competing and then, being subject to the same selection pressures, belong to the same population.

<sup>xvi</sup> The role of the acknowledgment of these causes in Kirzner's description of the "pure entrepreneur" (1973: pp. 41 and *suiv.*) is insufficiently underlined. It seems that the central question that the Kirznerian entrepreneur asks himself is "where" are the profit opportunities and, to a much lesser extent, "why" do they exist?

<sup>xvii</sup> The exist of the population is assimilated to the "death" of the routines combination of a firm. Nevertheless, routines' suboptimality is not the sole cause that can explain firms' exit. This very phenomenon can indeed be caused by innovation. By innovating, a firm can extricate itself from the selection pressures which used to circumscribe the population to which it belonged. Consequently, the phenomenon of population exit cannot be exclusively studied by the sole reference to the entities' differential growth rates. Innovation can also be as much at the origin of the entry as of the exit of a firm in/from a population. Thus, firms can exit from a population without passing away, but simply by living somewhere else.