

**ORGANIZATIONAL LEVELS
AND TIME SCALES IN ECONOMICS**

Bernard WALLISER
Ecole Nationale des Ponts et Chaussées – CERAS

January 2003

In economic theory, two main **organizational levels** are abstractly defined by specific entities (and the outputs they produce) :

-at individual level, several basic agents take some actions in a rational way, under the influence of the states taken by a physical environment called 'nature' and of the signals taken by a social environment symbolized by 'institutions' of several kinds;

-at collective level, agents' actions, nature's states and institutions' signals interfere to give rise to global phenomena of several types : distributional (distribution of agents' actions), relational (network between basic agents) and emergental (original collective entities).

Agents are individuals like consumers or already social groups like firms ; institutions (assumed to coordinate the agents) are physical like markets or conceptual like money.

In economic theory, two main **time scales** are defined as concern the links between variables (each variable being attributed to some entity):

-at short term (within a period), some present conjectural variables (for instance present prices) adjust to each other, given the past conjectural variables (past prices) as well as past structural variables (past equipments) considered provisionally as fixed ;

-at long term (between two periods), the present structural variables (for instance present equipments) adjust themselves to the preceedingly adjusted conjonctural variables (present prices) as well as to the past structural variables (past equipments).

Moreover, the former objective time scales may be simulated by two corresponding subjective time scales when agents are able to expect the future path of the system.

The organizational levels and the time scales are independent in principle, since the individual variables can be classified in short term and long term ones and the same is true for the collective variables. However, in practice, one observes a fuzzy relationship between the two taxonomies of variables, since the individual variables adjust rather at short term while the collective variables react rather at long term. The paper aims at making such a relationship more precise through the various equilibrium notions usually considered in two main economic fields. *Exchange theory* is devoted to the confrontation on (competitive) markets of purely reactive and specialized agents, i.e. producers and consumers ; *game theory* is devoted, at a higher level of generality, to strategic interactions between undifferentiated players without mediation of institutions.

In a first part, the paper describes four steps in the history of economic thought as concerns the interweaving of levels and the treatment of time. In a first section, time is frozen and agents' actions adjust instantaneously in order to give rise to a one period equilibrium. In a second section, objective time stays fixed while subjective time spreads out and defines an intertemporal equilibrium. In a third section, while subjective time vanishes, objective time becomes sequential and leads to discriminate short and long term equilibria. In a fourth section, objective and subjective time are mixed, and agents' adaptive actions may converge towards an asymptotic equilibrium.

In a second part, the paper considers the epistemological positions held in economics about methodological individualism in relation with time. In a fifth section, the distinction between methodological individualism and methodological holism is reexamined in the light of the foregoing framework. In a sixth section, two related problems are considered, emergence of institutions and social conditioning of agents. In a seventh section, the distinction between microeconomics and macroeconomics is involved with the so called aggregation problem. In an eighth section, the transition from theoretical models to empirical models leads to modulate the number of organizational levels and time scales.

1. Frozen time

In economic theory, three entities are usually considered in order to explain some social phenomena, each endowed with specific behavior rules :

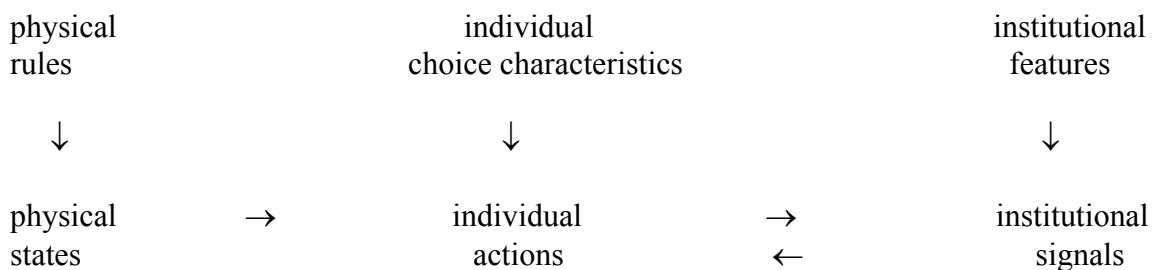
- agents, eventually of several types, choose their actions in a rational way after observing their environment, in accordance with three choice characteristics : opportunities (which delimit their action sets), beliefs (which allow to expect the effects of their actions), preferences (which evaluate the consequences of their actions);
- nature, gathering all physical and technological factors, take states in an autonomous and mechanical way, according to a deterministic or stochastic rule;
- institutions, symbolizing various social mediating devices, emit signals in a more complex way, according to institutional rules relating them to individual actions.

Any agent follows a deliberation process from observations to actions ruled by two complementary forms of **rationality** which concern specific characteristics (Walliser, 1989):

- instrumental rationality deals with the adequation realized between the alternative means available to him and the goals pursued by him;
- cognitive rationality deals with the adequation realized between the information gathered by him and the beliefs formed by him.

If cognitive rationality allows the agent to expect accurately the consequences of his actions on his environment by using his information and prior beliefs, instrumental rationality allows him accordingly to choose the best actions to implement by confronting his opportunities and his preferences.

The interrelation between agents, nature and institutions is given by the following scheme where, in a single period, physical states act on individual actions without feedback while institutional signals and individual actions are mutually determined:



With such a configuration, an **equilibrium state** is defined as a fixed point (conditional to the state of nature) of the loop linking individual actions and institutional signals, hence as a rest point in the absence of outside perturbations. A first question asks how equilibrium variables can be simultaneously defined, a sort of paradox since agents choose individually their actions by observing the signals in the same time that they contribute collectively to fix the signals. A second question asks if there exists some equilibrium state compatible with agents' behaviour and institution's functioning, and in case of multiple equilibria, how one specific equilibrium is selected. The two former problems of simultaneity and multiplicity can only be solved by exhibiting (as seen later) a concrete process followed conjointly by the agents and the institution and able to converge towards some equilibrium.

In *exchange theory*, the standard example is given by the « Walrasian equilibrium » between producers, consumers and the 'market', considered as an institution symbolized by the Walrasian auctioneer (Arrow-Debreu,1954). Each producer, allowed with a production

function (linking technically his factors and products) and a profit function (defining the generated profit), chooses his demanded inputs and offered outputs by optimizing his profit, after observing their prices. Each consumer, allowed with a budget constraint (restricting their consumption basket by their revenue) and a utility function (defining the satisfaction given by some basket), chooses the demanded goods by optimizing his utility, after observing all prices. The Walrasian auctioneer fixes the prices of the goods by equalizing their offers and their demands, hence the prices appear as institutional signals simultaneously observed and determined by the agents.

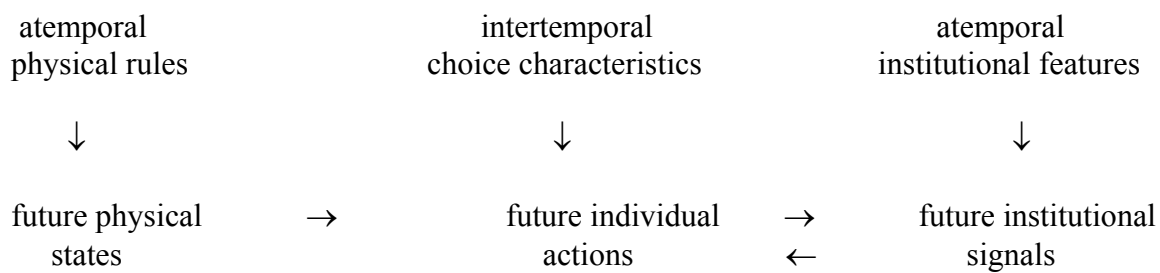
In *game theory*, the standard example is given by the « Nash equilibrium » between players, determined by an implicit and fictitious institution symbolized by the Nashian regulator (Nash,1951). Each player, endowed with a utility function depending directly and strategically on all players' actions, defines a best response to others' actions by optimizing his utility function under his constraints. The Nashian regulator searches for an equilibrium which is a fixed point of the loop defined by mutual best responses, hence a configuration from which no player has interest to deviate unilaterally when already achieved. Here, there is no specific institutional variable common to all players, since players have bilateral relations without a mediating entity, but the profile of players' actions fulfils formally a similar function of (multidimensional) public signal.

2. Spread out time

Agents, nature and institutions are now involved in a sequence of similar interactive situations, the agents' characteristics being adapted in consequence (sequentially interdependent opportunities, intertemporal preferences). Each agent exploits his cognitive rationality in order to expect the future path of the system, i.e. the future states adopted by nature, the future signals emitted by institutions and even the future actions taken by the other agents. He exploits his instrumental rationality in order to choose an optimal strategy, a strategy being defined as the action he will use in all possible circumstances according to nature's observed states and others' past actions. Once chosen before the first occurrence of the successive situations, the actions are implemented by the agent as they result from the chosen strategy, without needing to be reevaluated as new information is coming in.

Moreover, the agent is not omniscient and faces two forms of **uncertainty**, 'factual uncertainty' concerning past actions, states and signals, 'structural uncertainty' concerning others' choice characteristics or nature's law. For tractability reasons, uncertainty is domesticated in three steps : structural uncertainty is reduced formally to a factual one, factual uncertainty is summarized in a subjective probability distribution, probability distribution is assumed to be common knowledge among agents. To reduce his uncertainty, each agent revises his prior belief each time he receives some new message, either some external information about the true state of nature or some observation of another's implemented action. But here again, he is assumed to expect before the beginning of the play the future revisions he will make for all possible messages, and to choose his strategies accordingly before implementing the corresponding actions.

The interrelation between agents, nature and institutions can now be summarized in the following scheme where everything is instantaneously expected for all future periods, the implementation of actions and signals which faithfully follows being not represented :



An equilibrium is again stated as a fixed point of the loop between the future actions and future signals on all future periods, with either each period defining an autonomous loop or all periods being interrelated and treated together. In case of uncertainty, an equilibrium is moreover a fixed point for each player between his actions and his beliefs, present beliefs being revised according to past actions while future actions are adapted to present beliefs. Such an equilibrium happens to be ‘dynamically consistent’, in the sense that it has not to be reevaluated as time is unfolding, since all contingencies have already been correctly envisaged at the very beginning of the game. It reduces the long term objective (realized) future to a short term subjective (simulated) future, but such a ‘belief equilibrium’ among agents turns into an ‘action equilibrium’ as time unfolds and actions are implemented.

In *exchange theory*, when only probabilistic uncertainty about nature is involved, a « rational expectations equilibrium » can be defined not constructively but formally by three rather demanding conditions about price signals (Muth,1960). First, the agent has a perfect specification of the system in which he is going to act with other agents, especially about the way the market fixes real prices by gathering offers and demands (depending on expected prices). Second, the agent observes without bias all past relevant variables of his environment, especially the past values of the prices of all goods as well as the past states of nature influencing them. Third, the agent is a perfect statistician who computes from the former sources of information the best estimation of the future value of the price signal (for instance by minimizing the square value of error).

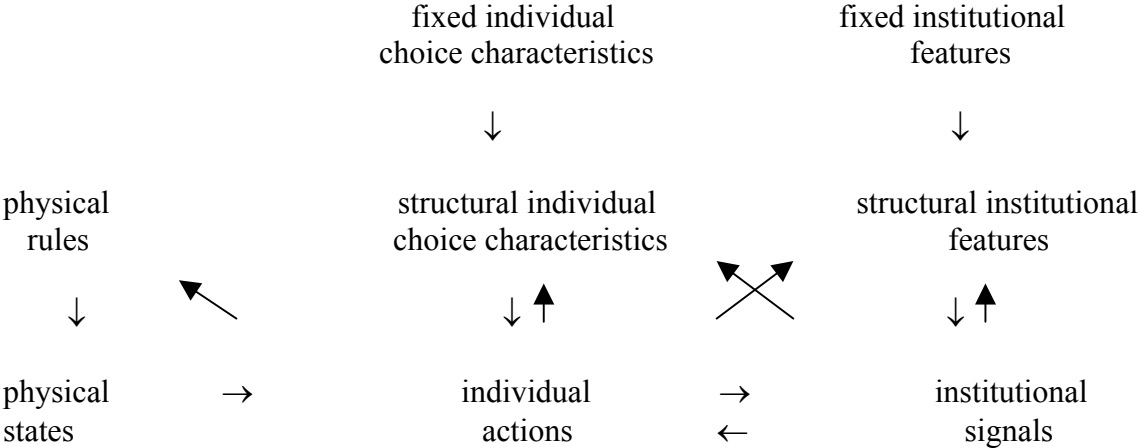
In *game theory*, for extensive-form games (defined by a game tree), several equilibrium notions were defined by the modeller and may be computed by the players themselves (Selten, 1968). Without uncertainty, the « subgame perfect equilibrium » is obtained by a ‘backward induction’ procedure : the last player plays his best response to all past moves, the preceding one plays his best response expecting the opponent’s future one, and so on. With uncertainty, concerned with the other’s probabilized type (summarizing his choice characteristics), the « Bayesian perfect equilibrium » includes moreover the revision of the other’s type when other’s action is observed. These abstractly defined equilibrium notions receive epistemic justifications, when considering sophisticated players endowed with even more demanding beliefs such as common belief about game structure, player’s rationality or player’s independence.

3. Sequential time

In sequential time, the structure of the system is no more fixed but adjusts from period to period, and the agents act myopically by making their choice by reference only to the expected effects of actions on the ongoing period. Several time scales lexicographically ordered may be considered, but practically only two time scales are explicitly introduced, which are symbolized by three types of variables endowed with different speeds of evolution. At short term (within each period), variables of a first group adjust simultaneously to each other under the influence of all others, considered as temporarily or definitively time invariant. At long term (between two periods), variables of a second group adjust under the effect of the past (first and second group) ones and in the general frame determined by variables of a third group, which are fixed for all periods.

More precisely, the agents' actions, the nature's states and the institutional signals form together the conjectural level and act on some more fundamental features, previously fixed. The agents' opportunities and preferences are decomposed into fixed variables (analytical form of the utility function or of the action set) which frame structural ones (parameters of the utility function or of the action set) also influenced both by actions and signals ; the agents' beliefs evolve even more naturally through observations, but the belief revision rules are again considered as fixed. In the same way, the institutional features are decomposed into fixed ones (generic frame) and structural ones (specific rules) influenced by actions and signals. The nature's states are themselves determined by environmental rules influenced in a retroactive way by individual actions.

The interrelation between agents, nature and institutions involves now short term influences (plain arrow) and long term ones (thick arrow) :



With such a configuration, two nested equilibrium notions can be defined, ordered in a lexicographic way, since the (unique) long term equilibrium results from a whole sequence of (one period) short term equilibria. A short term equilibrium takes place within each period by mutual adjustment of actions and signals, given the present choice characteristics and institutional features which are provisionally unchanged. The long term equilibrium happens asymptotically, when the structural individual characteristics and institutional features have converged, under the constraint of the corresponding fixed properties and the influence of the successive actions and signals. Hence, the long term equilibrium is defined constructively by the process followed by the short term ones, while the short term equilibrium remains defined formally without concrete process leading to it.

In *exchange theory*, one considers for instance an ‘endogenous’ evolution of the consumer’s preferences, which are no more exogenously given to him but vary through time (Peleg-Yaari, 1973). At short term, each consumer chooses his consumption basket according to his ongoing preferences, assumed to be dependent only on the presently consumed goods, hence he expresses a short term demand. At long term, the consumer’s preferences evolve due to exogenous factors (age), to his past actions (addiction) and eventually to past signals (advertising), hence his behaviour evolves too and may converge towards a long term demand. Other endogenous evolutions of characteristics can be considered, especially as concerns the action set of a producer, the implementation to-day of a more flexible equipment allowing to-morrow a larger set of possible equipments.

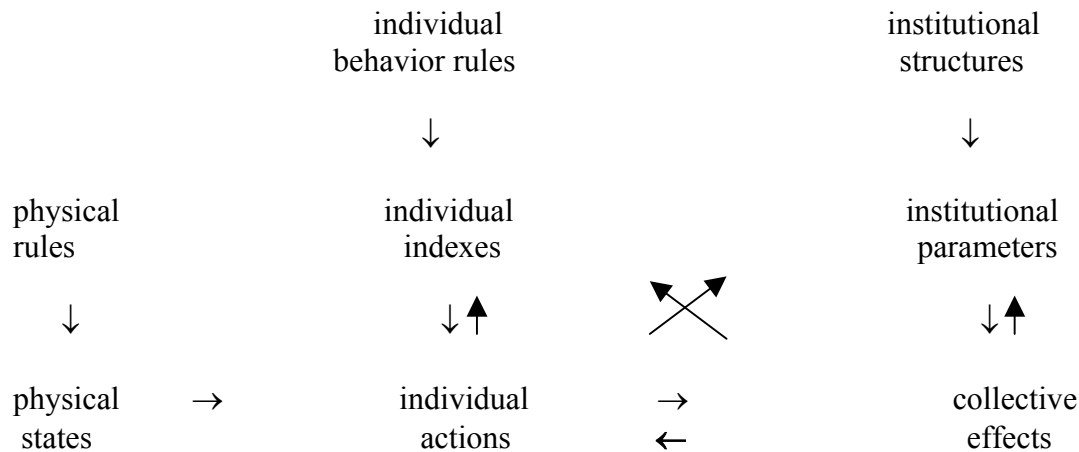
In *game theory*, one considers for instance an ‘endogenous’ evolution of the players’ interaction network, which is no more exogenously given but is changing through time (Schelling,1971). At short term, each player meets the opponents situated in his private interaction context, eventually by a sampling procedure, and chooses his best action in response to the sorted out opponents’ actions. At long term, each player sees his interaction context modified, due to exogenous factors (emergence of new players) or past actions (selection of players having provided to him performant previous interactions), leading progressively to a long term interaction network. Other endogenous evolutions arise, especially for players’ beliefs revised between two periods according to new messages, as was considered in a previous section, but assumed to be expected rather than experienced by the agents.

4. Adaptive time

The actor’s rationality becomes now severely bounded, due to his limited computational and informational capabilities, and leads to several alternative formulations of an adaptive behaviour to the context (Simon,1959). Cognitive rationality is bounded, since the agent has only partial information about his environment and contents with rather myopic expectations about the surrounding system or even no expectations at all. Instrumental rationality is bounded, since the agent no longer looks for an « optimizing » action, but contents with some « satisficing » one nevertheless seeking the good with regard to his objectives and past observations. The whole process, taking place in objective time with some remaining subjective expectations, can be summarized in four principles, knowing that agents stay endowed with given opportunities and preferences (Lesourne et alii, 2002).

The interaction principle makes explicit, in some interaction neighbourhood where each agent meets the others, if they meet randomly or not, in an anonymous or personalized way, two by two or in groups. The information principle makes precise, in some information neighbourhood where each agent gathers observations, if the data are sampled or not, with random or prior criteria, in individualized or already aggregated form. The evaluation principle makes precise how each agent gathers and synthesizes the preceding information in specific indexes : other’s past frequency of actions, own’s past mean or summed utility of actions. The decision principle shows how each agent chooses an action in response to the preceding indexes : strict or perturbed best response to other’s past actions, probabilistic response enforcing own’s actions with best past performances.

The interrelation between agents, nature and institutions implies again short term effects (choice of actions) and long term ones (adjustment of indexes) :



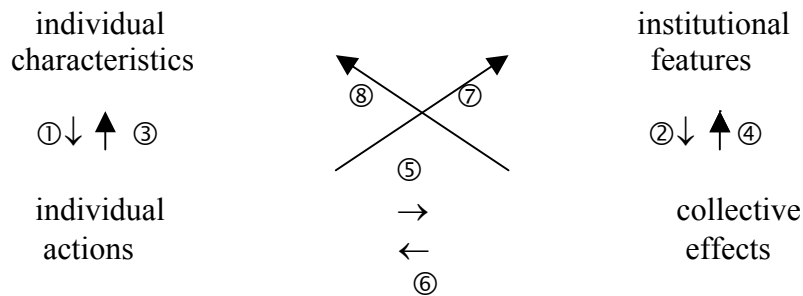
At short term, the system adopts some social state no more interpreted as an equilibrium, since each agent chooses his ongoing action independently of the others' present actions or present global phenomena. But at long term, the dynamical path of the system may be seen as a concrete process converging eventually towards an asymptotic state interpreted as an equilibrium since all agents appear duly coordinated in that state. The simultaneity problem (previously considered) is solved : agents' actions follow agents' observations at next period, hence the present social state is perfectly (even if sometimes randomly) determined by the past. The multiplicity problem is solved too : even if the process may not converge (cyclical or chaotic attractor), if it converges (ponctual attractor), it converges towards a social state selected by initial state, context and history.

In *exchange theory*, one considers for instance a labour market where employers and employees are matched two by two randomly after search processes and negotiate a short-term contract under bounded rationality (Lesourne, 1991). At any period, each employer (employee) proposes (accepts) a task at a given reservation wage and a contract is mutually accepted at some intermediate wage as soon as the respective wages are compatible. At next period, if the employer (employee) was unable just before to find an employee (employer), he increases (decreases) his reservation wage, and is matched again to an employee (employer). If that self-organizational process is without friction, the wages converge towards the unique competitive equilibrium wage, but otherwise (with research or negotiation costs), multiple wages or even cyclical paths may appear.

In *game theory*, two main learning processes are generally considered, according to decreasing cognitive capabilities ascribed to the agents, more and more compensated by the constructive work of time (Fudenberg-Levine,1998). In epistemic learning, each player observes the other's past frequency of actions, transforms it in a probabilistic belief about other's future action and chooses a best response to such a belief at each period. In behavioral learning, each player observes the past utility obtained by each implemented action, computes an index of the past performance of each action and chooses an action with a probability increasing with its index. Some classical equilibrium notions may then receive dynamic justifications as asymptotic states of such a process, especially the pure Nash equilibrium for a large class of games or the subgame perfect equilibrium for a restricted class.

5. Individualism vs holism

When considering two organizational levels and two time scales, the relations between individual and collective levels can be exhaustively enumerated in the following scheme :



In that scheme, nature has been omitted since it acts always in the same way : it influences the agents' behaviour and institution functioning at short term and may be influenced back mainly at long term. Moreover, there is no direct influence of individual characteristics on institutional features (or the other way around) since institutions are assumed not to act structurally on agent's behaviour, but only through operational variables they emit. Two extreme epistemological positions (Agassi, 1960) deny the existence of links between the individual and the collective levels, each level being respectively self-contained (influences ⑤,⑥,⑦and⑧ are void). Strong holism asserts that the social level is the only one to be meaningful (influences ② and ④ only) while strong individualism asserts that the individual level is the only one that makes sense (influences ① and ③ only).

Strong methodological holism considers that there are no relevant individual entities, hence that the social phenomena can only be explained by some other social facts while looking for internal consistency. Adopted in sociology by Durkheim or in anthropology by the structuralists, such a position has no great influence in economics where the agents are always singularized, except perhaps in the physiocrats' work. *Strong methodological individualism* considers that there are no relevant collective entities, hence that the so called social phenomena can always be analyzed as a superposition of individual entities and actions. Unknown in sociology except for some microsociologists, such a position is followed neither in exchange economics where prices are already collective variables nor in classical game theory where equilibria are not achieved by purely individual means.

When the entities are accepted at the individual level as well as at the collective level, these not only internally connected (influences ① and ③, ②and ④), but mutually linked at lower scale (influences ⑤ and ⑥). Four more elaborated methodological positions are defined according to the acceptance or not of relations involving the upper level, either from individual to social (influence ⑦) or from social to individual (influence ⑧) :

⑦	⑧	yes	no
yes		crossed interactionism	weak individualism
no		weak holism	autonomous interactionism

Weak methodological holism asserts the social level to be prominent, i.e. collective effects are able to modify the individual features while individual actions have no influence on the institutional features. For instance, it assumes that the agent's characteristics are socially conditioned, a usual position in sociology which was seldom shared in economics where such a potential influence is at best treated as exogenous. *Weak methodological individualism* asserts the individual level to be prominent, i.e. individual actions are able to determine institutional features while social phenomena have no bite on the individual characteristics. For instance, it assumes that the institutions are designed (consciously or not) by the agents, a position generally denied by sociology, but sometimes considered by economics for some specific institutions.

Autonomous methodological interactionism considers that both levels are on an equal foot, symbolized by autonomous individuals and institutions which interfere only at lower time scale through their actions or signals. Unusual in sociology, it is reflected in economics by the market mechanism where the agents and the market coexist from the beginning of time and are related through the equilibration of offers and demands by prices. *Crossed methodological interactionism* considers that individuals and institutions are able to influence indirectly the others' features, without real existence anteriority or influence anteriority of one over the other. In economics, it is symbolized by evolutionist game theory, where the players' characteristics are influenced by some social effects, while institutions are long term consequences of individual actions.

6. Economic epistemological positions

Starting from autonomous interactionism, a first evolution in economics was to achieve weak methodological individualism, hence to explain all social phenomena from individual actions, especially the coordinating institutions and the interrelating networks. However, these social entities or links can be obtained by agents endowed with more or less sophisticated rationality principles, giving rise to corresponding forms of methodological individualism. 'Perfect individualism' states that the agents have strong cognitive and instrumental rationality, hence are able to fully expect the social effects they produce at short and long term by their deliberate and voluntary actions. 'Bounded individualism' states that the agents have limited instrumental and overall cognitive rationality, hence may face ex ante unforeseen social effects and may even not attribute ex post these effects to their ongoing actions.

The endogenous emergence of economic institutions has been studied essentially for two main global institutions, markets and money, both in charge of coordinating the agents' exchanges. With perfect individualism, markets are voluntarily designed by some specialized agents (new financial markets) while money is explicitly created by specific institutions (king's money, credit cards). With bounded individualism, markets are unexpected devices (Smith's invisible hand) emerging through unintended actions (Hayek's selection process) while money results from spontaneous actions selecting convenient means of exchange (shells, silver). However, more local institutions can likely be considered such as firms or syndicates, both creating coalitions of agents for more efficiency, initiated by an initial germ and growing by association of interested agents.

It is possible to combine sequentially the two approaches, by considering that an institution emerges in two phases, eventually under the influence of already mature institutions at higher level. In the 'formation phase', the institution emerges from the actions of boundedly rational agents learning through time or imitating one another and materializes an asymptotic equilibrium showing some regular pattern. In the 'naturalization phase', the institution is recognized as such by the agents and becomes an explicit entity, hence influences the agents' actions which reinforce it since it precisely corresponds to an equilibrium. The process may be completed by a 'legalization phase' where the institution receives from some representative authority a legal recognition and is protected if necessary by material constraints or financial incentives and sanctions.

Starting now from weak individualism, a second evolution of economics is to accept crossed interactionism, hence to take into account some influences of society on actors' behaviour, especially through social and ethical channels. Here again, global phenomena and especially institutions act on agents endowed with more or less sophisticated rationality principles, giving rise to corresponding forms of interactionism. 'Perfect interactionism' states that the agents have strong rationality, hence they are socially conditioned precisely through their choice characteristics, essentially their preferences and their beliefs. 'Bounded interactionism' states that the agents have plain behaviour rules linking some context to some action, hence they are conditioned by internalization of a newly experimented rule or by modulation of parameters of an already implemented rule.

The influence of institutions on agents' behaviour can be examined for two usual conceptual institutions, social norms and collective representations, which aim at coordinating agents without being of an economic nature. With perfect interactionism, social norms act on preferences through moral sanctions or ethical incentives while collective representations act on beliefs by educational training or media diffusion. With bounded interactionism, social norms act on behaviour rules by reinforcement mechanisms or mimetic contagion while collective representations act by imposing a dominant interpretation of the application domain of the behaviour rule. Some other social institutions can likely be considered, for instance churches or clubs, but their influence on participants' behaviours is even less precise since they mix various elements which need to be isolated.

It is again possible to combine the two approaches by considering that an institution modifies the agents' behaviour in two phases, eventually with the support of other institutions having complementary roles. In the 'enforcement phase', some types of behaviour are imitated from other agents since they seem performing or are simply imposed by external sources having sufficient physical or moral authority. In the 'internalization phase', these behaviours are consciously rationalized by the agents' (eventually adapted) preferences or are unconsciously considered as acceptable under constraints. But the conditioning process suggested by sociology stays difficult to translate into economic terms since the channels by which institutions act on behaviour are restricted to beliefs and preferences on one side, to actions and signals on the other side.

7. Micro and macro-analysis

Economics makes a traditional distinction between microeconomics and macroeconomics, but these two approaches cannot be plainly associated with the two former studied organizational levels, i.e. basic agents and collectivity. Both approaches consider the economic system as a whole, but differ by the fact that goods and agents are maximally decomposed in the first while they are **aggregated** in «compound goods» and «representative agents» in the second. The reason for the distinction is that it is quite impossible to deal practically with a lot entities or variables and it is much easier to construct empirical relations with aggregated variables. Hence, if microeconomics is essentially devoted to theoretical analysis (except for partial analysis of exchanges among a few agents), macroeconomics is essentially fitted for empirical analysis (except for already global phenomena like money).

The first aggregation problem concerns the quantities and prices of goods which are produced, exchanged or consumed by an agent or a set of agents, especially when these goods are qualitatively different. For an homogeneous good, the quantities can be simply added if they are used in a similar way (total consumption), but need to be more subtly combined if not (total production obtained algebraically by eliminating what is produced by some firms and consumed by others). For heterogeneous goods, the quantities are aggregated in value and not in volume, the total quantity being the weighted sum of the singular quantities obtained with relative prices as weights. Always for heterogenous goods, the prices are aggregated in a dual way (prices weighted by quantities), giving rise to various price indexes, which are in fact only defined in variation from one period to the other.

The second aggregation problem concerns the gathering of a set of basic agents under a representative agent of same type, who deals with aggregated variables in an aggregated environment (Kirman, 1992). An aggregation procedure defines the representative agent's behaviour which is equivalent to the conjunction of the individuals' ones in some specific context, for given aggregation rules for goods and revenues. On one hand, 'rationalistic aggregation' implies, for strongly rational agents, an aggregation procedure directly defined on their choice characteristics which are duly formalized, not only their opportunities, but also their beliefs and preferences. On the other hand, 'behavioral aggregation' implies, for agents with limited rationality, an aggregation procedure directly defined on their behavior rules, expressing in a short-cut how their actions are linked to signals and states.

The aggregation procedure concerns mainly the definition of aggregated consumers and producers in a competitive equilibrium framework, and is rigourously defined only under drastic and even unrealistic conditions. The consumers' utility functions and the producers' production functions can be perfectly aggregated only when agents have sufficiently similar characteristics and well dispersed resources. The consumers' demand functions and producers' offer functions can be rigourously aggregated, for a given price system of goods, only if agents' reactions to prices are identical and revenue distribution among agents smooth enough. The aggregation procedure is still harder to achieve when considering an imperfect competition context or taking into account more heterogeneous goods, even if it is sometimes replaced by approximate aggregation.

It must be noticed that the two agents' aggregation procedures may become close, since the aggregation of behaviour rules stemming from rational agents leads to an aggregate behavior which no longer appears as rationally grounded. More precisely, the individual demand function of a rational agent, linking the demanded quantities of goods to prices and revenue, obeys to some specific constraints known as Slutsky conditions. However, the total demand

function obtained by additive aggregation of goods no longer obeys to corresponding constraints and appears similar for agents endowed with more or less strong rationality (Debreu, 1974 ; Sonnenschein, 1973). Hence, at a macroeconomic level where aggregate agents are represented by behaviour rules, a lot of precise information concerning the individual agents' types of behaviour is lost in the averaging procedure.

A related problem is to examine how some randomness can be taken into account and interpreted at each organizational level and how such randomness may be transmitted from one level to the other. In microeconomics, randomness is usually explained by some intrinsic indeterminism in agents' behaviour, even if it is sometimes attributed to hidden psychological factors formally not taken into account. In macroeconomics, randomness results more convincingly from external shocks related either to technological change (random innovations) or to foreign trade influences (unexpected international crisis). But it is possible to state neither that the micro randomness is compensated by aggregation to give rise to a macro deterministic order nor that the macro randomness is absorbed by the agents who act more deterministically.

8. From theoretical to empirical analysis

Only two organizational levels were previously considered, but it is possible to consider more for practical applications, the successive levels being always considered as dealing with nested entities. Between micro and macro level, one sometimes considers a meso level of groupings of basic agents, grounded on qualitative as well as spatial criteria, such as syndicates, holdings or otherwise regions. A supra-macro level may be concerned by the exchanges taking place between several national economic systems and a infra-micro level by the multiple « selves » which are assumed to compete inside any individual agent. The considerations made so far continue to apply separately to each couple of contiguous levels, an original problem appearing only when some shortcuts exist between two non contiguous levels.

Only two time scales were previously considered, but it is possible to consider more in empirical cases, the embedded scales dealing again with variables evolving at different speeds with asymmetric influences between them. For a firm, quantities adapt at short term, prices may adjust at middle term, quality of goods and technologies are revised at long term and the firm structure is even modified at ultra long term. Incidentally, rather than to specific variables, time scales may be defined as more and more extended periods showing different types of evolution for each variable. For macroeconomic policy, short term corresponds to one year (budget periodicity), middle term to three to five years (planning periodicity) and long term to about ten years ; in financial markets, the corresponding intervals are rather of one hour, one day (opening period) and one week.

On the empirical side , the observations collected by agents, statistical institutes or academic researchers are either basic data expressed in a quantitative form or already empirical regularities extracted qualitatively from them ('stylized facts'). Historical observations stem from the spontaneous functioning of the economic system, and are further aggregated by the National Accounting System at different scales (for instance, from hundred goods to only three ones). Experimental observations stem from laboratory experiments which develop more and more as concerns exchange theory (market mechanisms, auction procedures) as well

as game theory (negotiation processes, coalition formation). In fact, more and more individual data become available (with regard to aggregated ones) and data are available on longer and longer periods even if some are reconstituted (19th century corn prices).

On the theoretical side, theoretical models are transformed by deduction and specification into empirical models which are composed of testable relations and are associated with precise fields of application. All theoretical variables (utilities, expectations) are eliminated in order to keep only observable ones (quantities, prices), even if more and more variables become observable (series of expectations become available). Simultaneously, all non standard formalizations (for instance agent's optimization programs) are resolved to give rise to usual stochastic relations between variables which remain too often linear. However, these relations allow to treat simultaneously variables at different organizational levels, but it is harder to introduce more than three time scales since the observed variables are just indexed by the unidimensional physical time.

An empirical model is then confronted (globally or relation by relation) to (more or less pretreated) observations along two main procedures which appear as complementary and lead to modify or adjust it. In a projective way, a model is formally tested against the data and is confirmed or refuted in accordance with some statistical criteria, generally of a conventional kind (five per cent admissibility level). In an inductive way, a model is given in its analytical form (which is preserved in the process) and its parameters are simply estimated against the data by various statistical methods (statistical induction). However, it does not follow that a model refuted by observations is automatically revised since empirical violations need to be repeated many times to do so and since empirical arguments are completed by pragmatic ones (simplicity, operability) when validating a model.

Besides the preceding interpretation of randomness as intrinsic uncertainty, two more interpretations of stochastic terms are introduced in order to ensure a better fit between theoretical models and empirical relations. Stochastic factors are assumed to represent specification errors, concerning either the analytical form of a relation (such as linear approximation) or omitted variables in the relation (such as non economic factors). Stochastic factors are also assumed to incorporate measurement errors concerning the data, even if no error intervals are generally evaluated and published for basic data as well as aggregated data (except for sampling errors). In any case, all forms of randomness are mixed in an empirical model and it is possible in principle to compute the confidence interval of its results, but this is rarely done in practice and would lead to despairing values.

Bibliography

Agassi, J. (1960) : Methodological individualism, *British Journal of Sociology*, 11 :244-70

Arrow, K. - Debreu, G. (1954) : Existence of an equilibrium for a competitive economy, *Econometrica*, 22 :265-90

Debreu, G. (1974) : Excess demand functions, *Journal of Mathematical Economics*, 1 :15-23

- Fudenberg, D. - Levine, D. (1998) : *Theory of learning in games*, MIT Press
- Kirman, A. (1992) : What or whom does the representative individual represent ? *Journal of Economic Perspectives*, 6(2) :117-36.
- Lesourne, J. (1991) : *The economics of order and disorder*, Clarendon Press
- Lesourne, J. – Orléan, A. – Walliser, B. (2003) : *Leçons de microéconomie évolutionniste*, Editions Odile Jacob
- Peleg, B. – Yaari, M. (1973) : On the existence of a consistent course of action when tastes are changing, *Review of Economic Studies*, 24 : 56-68
- Muth, J. (1960) : Rational expectations and the theory of price movements, *Econometrica*, 29 :315-35
- Nash, J. (1951) : Non cooperative games, *Annals of Mathematics*, 54 :286-95
- Schelling, T. (1971) : Dynamic model of segregation, *Journal of Mathematical Sociology*, 1 :143-86
- Selten, R. (1975) : Reexamination of the perfectness concept for equilibria points in extensive games, *International Journal of Game Theory*, 4 :25-55
- Simon, H.A.(1959) : Theories of decision-making in economics and behavioral sciences, *American Economic Review*,49 :249-83
- Sonnenschein, H. (1973) : Do Walras identity and continuity characterize the class of community excess demand functions, *Journal of Economic Theory*, 6 : 345-54
- Walliser, B. (1989) : Instrumental rationality and cognitive rationality, *Theory and Decision*, 27 : 7-36