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Working Paper

2007-09

Propositions for the building of a quantitative Austrian modelling: an answer to Prof. Rizzo and to Prof. Vriend

Rodolphe BUDA

UMR 7166 CNRS

Université Paris X-Nanterre
Maison Max Weber (bâtiments K et G)
200, Avenue de la République
92001 NANTERRE CEDEX

Tél et Fax : 33.(0)1.40.97.59.07
Email : secretariat-economix@u-paris10.fr

Université Paris X Nanterre

Propositions for the Building of a **Q**uantitative **A**ustrian **M**odelling: An Answer to Prof. Rizzo and to Prof. Vriend

Rodolphe Buda*
Economix UMR 7166 CNRS, University of Paris 10†

April 1, 2007

*The author would like to thank here the anonymous referee for his remarks and advises.

†200, Avenue de la République, 92001 NANTERRE Cedex - FRANCE - Tel. : 01-40-97-77-88 Fax.: 01-47-21-46-89 - e-mail : *rodolphe.buda@wanadoo.fr*

Summary

In this paper, we try to promote the building of a Quantitative Austrian Modelling (QAM). QAM must be viewed as a complementary quantitative prolongation of the Austrian methods and as a complementary approach to the already existing quantitative approaches - especially we would like here to answer to the appeal of Prof. N.J.Vriend [61]. As we explain it in the first part, our approach resulted from a critical view of the econometric procedures by Austrian methods and, from a theoretical instrumental study of the econometric models. We define the main properties to quantitative approaches and especially to the QAM. In the second part, we present QAM principles and equations (of the `AUSTRIAN` *model), and justify it according to the classical Austrian point of view. The QAM could be viewed as an answer to Prof. M.J.Rizzo [49] about the relationship between the Praxeology and the Econometrics. Indeed, according to its properties, even if QAM won't be able to recreate any observable data, it could give a consistent pattern where the other quantitative approaches could fit. Especially, QAM could help, we hope so, to answer the question we asked about the quality of the econometric behavioral equations [8], in providing two levels of data, from where we could extract a relationship useful to correct observable econometric data. QAM is in building.*

Résumé

Ce papier propose de faire la promotion d'une modélisation autrichienne quantitative (en anglais QAM). Cette modélisation doit être considée comme un prolongement de la méthode autrichienne et comme une modélisation complémentaire de celles déjà existantes - en particulier, nous aimerions répondre ici à l'appel du Professeur N.J.Vriend [61]. Comme nous l'expliquons dans la première partie, notre approche est autant le résultat d'une vision critique - basée sur la méthode autrichienne - des procédures économétriques, que d'une étude instrumentale des modèles économétriques. Cette étude nous a conduit à définir les propriétés des approches quantitatives en générale et de la QAM en particulier. Dans la seconde partie, nous présentons les équations (du modèle `AUSTRIAN`*) et les ancrages de la QAM à la tradition autrichienne. Nous mettons en évidence le lien qu'elle permet d'établir entre la Praxéologie et l'Econométrie, répondant en cela, nous l'espérons, au souhait du Professeur M.J.Rizzo [49]. Bien qu'elle ne permette pas de retrouver de données observables, la QAM peut fournir des résultats qui peuvent être rapprochés de ceux obtenus par les autres méthodes quantitatives, en particulier l'économétrie. Ainsi, grâce à ses deux niveaux de résultats de simulation, la QAM devrait permettre de contribuer à améliorer la qualité des équations économétriques de comportement [8]. Cependant, le travail accompli n'est qu'une première étape.*

Key-words : Austrian Economics - Agent-based Computational Economics - Methodological Individualism - Quantitative approaches - Econometrics - Micro-Macroeconomic Bridge

JEL Classification : B41, B53, C5, C63, C87, C88
Austrian Classification : AE1, AE3, AE5, AE9, AE14

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0 - Introduction

During the seventies, the keynesian econometric modelling reached the top level of its use, then since it decreased. The main way used by econometricians to solve the problem is obviously based on statistical ground. However, in a previous paper [8], we suggested that the solution should be to rebuilt the behavioral econometric equation, in involving a methodological individualism point of view. This paper describes the links we found between the Econometric modelling and the Austrian Approach to get econometric equations better, and finally the track for the building of a quantitative modelling based on an Austrian approach.

The first part explains how we was led from an instrumental to an individualism approach to analyze the econometric problem - during Pr.Rizzo [49] considered that Econometrics could be used to provide some quantitative historical results (or rules) to the Praxeology.

In the second part, we present the classification we obtained from the different quantitative modelling methods, hence we built a new one - an Austrian one - we called Quantitative Austrian Modelling (QAM). We present properties and the expected results of such modelling, used in the same time with econometrics. Pr.Vriend [60] wished that Austrian Economists and Agent-Based Computational Economics Economists to work together. We hope QAM answer to these wishes.

I - The Critique of the Econometric Procedures

Our purpose was initially to get better econometric models. We firstly consider the problem of accuracy - so we worked to multidimensional models - then we considered the problem of the specification of the behavioral econometric equations. That implied we had to consider that problem according to a new point of view - different than statistical one. The individualism methodological point of view seemed to be appropriated to this purpose. Such an approach already used by the Agent-based Computational Economics [57]. However, our purpose - to get news specification of behavioral econometric equations - led us to analyze the problem according to a praxeological point of view. The final question was to conciliate the econometric models - aggregated - with the individual models ; in other words, the generalization of the individual procedures. Thus we presented a first quantitative modelling typology.

1. The computational tools of the Keynesian Method Approch

The instrumental analysis of the econometric problem led us to a new question. Is the choice of algorithm neutral according to a theoretical point of view ?

a - Instrumental point of view of the econometric models

An intuitive method to get econometric models better consists to disaggregate the sample[1]. We worked to multidimensional models - multi-periodical, multi-sectoral, multi-regional models[2].

i - Large Scale (Multidimensional) Modelling

The disaggregation of the models involves that we encounter new instrumental problems. When econometrician-developer has to manage large scale sample, he usually encounters problems of resource's limits. When we develop multi-dimensional systems, we could think we only have to transpose the classical algorithms to all the dimensions of the model[3]. The resolution of multi-dimensional models is longer than mono-dimensional one too[4].

---

[1]- See [47, 2] for an overview of the computational method for macro-econometric models.

[2]- We indeed have built a multi-dimensional economic modelling software, `SIMUL`. The typical problems of the econometrics software implementation: `SIMUL` usually can quickly estimate and solve multi-dimensional econometric equations systems. It only needs an instruction for such an equation by equation according to $Y_t^{r,s} = X_t^{r,s}.a^{r,s} + \varepsilon_t^{r,s}$. `SIMUL` is divided into some modules. Mainly, one module manages econometric estimation procedures, another manages the data bank and another manages the resolution of the systems. For an overview of `SIMUL` software, see [9, 12].

[3]- Unfortunately, the limits of resources, especially the data memory one, prevents this easy transposition. The developers already know, some languages don't manage data-memory efficiently. Even if the memory of computers increases, the size of the data-memory of such language is limited to 640 Ko - e.g. : Turbo-Pascal. M.S.Khanniche & S.H.Yong had developed an algorithm ("A Solution to Memory Limit of DOS Based Large Finite Element Programs", *Advances in Engineering Software*, 21, 1994, pp.99-112.), but we have developed another one. We don't explain here the algorithmic problems linked to this program. See [13] and our paper "From hyper-matrix to vector: an Alternative Method to Manage DOS Data-Memory Shortage", *Working Paper GAMA*, University of Paris 10, 9 p., 2003.

[4]- So, we have developed new faster algorithms, which decreases the size of iterations during calculation. We especially developed an algorithm for two dimensional aggregation calculation - see [12] and our paper "Two Dimensional Aggregation Procedure : An Alternative to The Matrix Algebraic Algorithm", *Working Paper GAMA*, University of Paris 10, 26 p., 2005.

ii - High Accuracy Calculation

Even if a very few of papers specify[5] that problem, the econometrician-developer has to study the problem of accuracy calculation[6] - to increase accuracy of the models[7], even if this correction never would reach perfection.

From all these previous instrumental questions, a new question appears : *Is the upper level of disaggregation should be the individual one ?* However, that choice would not resolve our problem, because the individual and the disaggregated equations should not be the same one.

b - The Fundamental Diagnostic of the econometric problem

i - Lucas' Critique

The problem consists to ask the following general problem, already noticed by R.Lucas [36] : *How to correct the behavioral econometric equation ?* The diagnostic we suggested [8] - a self-evident proposition in a sense - was, that econometric behavioral equations suffer of a lack analogical representation of the economic behavior. These equations are more aggregated to correctly represent the actual economic behaviors[8]. Thus, we aimed our work at a better representation of the markets[9]. Even if the Lucas's critique was not based on Austrian grounds, L.M.Lachmann [30] and then T.Basse [4] advised to introduce it into the Austrian topics, and more generally to

---

[5]- The *Handbook of Computational Economics* [2] don't specify it, but let's quote M.E.Jerrell, "Interval Arithmetic for Input-Output Models with Inexact Data", *Computational Economics*, 1997, 10(1), pp.89-100.

[6]- We indeed know that the representation of the number by the computer - the famous floating-point arithmetics - is imperfect. We developed a multi-precision arithmetics - the `GNOMBR` library software. See our paper "Macroeconomic Modelling Accuracy's Control Tool : `GNOMBR`", *Working Paper GAMA*, University of Paris 10, aug., 21 p. (+ `GNOMBR` software), 1996.

[7]- The main use of such arithmetics for macroeconomic or econometric models, is to decrease floating point error diffusion, but not to increase the number of significant digits of results. For a interesting overview of the computer's arithmetics problem, see M.Daumas & J.M.Muller (Eds), *Qualité des calculs sur ordinateur - vers des arithmétiques plus fiables ?*, Paris, Masson, Informatique, 1997, 164 p.

[8]- The econometric equations suffer of their of the weakness of explanation [18].

[9]- Let's quote the originally work of M.Allais [1] who have built a macro-account from summing of micro-account, in using differential calculation. This work get very clearly a bridge between the individual to the global level. However, we didn't follow this path to built a modelling independent to national account theory.

apply econometric procedures only to historical investigations[10]. M.J.Rizzo [49] and more recently, R.Batemarco [5] think that the gap between Theoretical models and Econometric models could be resolved by praxeological method. Moreover, Econometrics could be used to give historical (but not prospective) economic rules and M.J.Rizzo (*ibid.*) think that Econometric could help praxeological method to set its principles with their empirical (quantitative) results.

ii - The Theoretical Neutrality of the Economic Algorithms

Until the birth of computational economics [2, 57], the economic calculation search and the mathematics search (especially the numerical analysis) were separated. But the assumption of algorithmic neutrality must be left now. Firstly, is there a continuum between the disaggregated level models and hypothetical individualized models ? - see [12]. Unfortunately, we know that paradoxically, the accuracy result of the econometrics models does not continuously increase when the disaggregation level increases. Thus, two assumptions: 1° that means that there is an optimal level of disaggregation ; or (not exclusively) 2° that means that we can't keep the same specification of the equations with the disaggregation level and the individual level.

Secondly, calculation of the solution needs some algorithms. Let's consider now, we previously explained that we sometimes choose between algorithms, or we have to change algorithms according to technical difficulties. Is the choice of algorithm significant or not ? Does algorithm's change imply another solution ? It seems to be obvious that another algorithm should give the same solution as the referent algorithm. It's even one of the criteria of the development of new algorithms. However, it seems that, in fact, the more complex is the level of representation of the model, the more important is the choice of the algorithm[11]. The Austrian methodology gave us some tools of analysis of this problem ; especially the Austrian representation of the Market. We firstly aim our study at the building of a simulation model of market. But we need to built an experimental model of market too to provide a validation of the simulation results.

[10]- "[...] *econometrics in fact can be a very helpful research tool for economists studying historical events.*" [4].

[11]- We know that the solution of the equilibrium calculation by a centralized process is different than a parallel (decentralized) one - see [44].

2. The Individualism Method Approach

a - A Simulation-Experimentation approach of the problem

We developed two complementary tools to simulate the market process. This path did't led us to conclude directly. However we obtain some conclusions about the limits of calculation in economics.

i - Simulation Market Models

A first step [12] to build a market's simulation model consists to represent some operators on a same market under imperfect competition[12] without any auctioneer. That means that all agents can't make their transactions at the same time[13]. The main default of such these models was the poor representation of the information flows, and the bargaining. Furthermore, it was a model of pure exchange, without production[14].

> `SINGUL` is a very short period model with only one good. The agents can't keep quantities of this good over the level they indeed need. So, they can't speculate. `SINGUL` simulates the behavior of the N total number of agents. For each agent `SINGUL` calculates the initial patrimony (1) - see complete equations set in Appendix 1 -, initial actual commodities level (2), wished commodities level (3), "mind price" - it's a kind of hidden price : if the agent wants to buy the good, he won't pay more than a maximum price ; if the agent wants to sell the good, he won't to be paid less than a minimum price - (4) and (5), and the negotiation margin which determines the interval of transaction.
> The i-the agent meets a total number of P_i other agents. Their ranks are selected by random choice among N-1 ranks. The i-the agent negotiates the price of one unit of the good. At the beginning of the simulation, if the difference
> $$\Delta_i^t = ActualLevel_i^t - WishedLevel_i^t$$
> is negative, positive (resp.) then the agent is seller, buyer (resp.). When the difference becomes equal to zero, then the agent leaves the market.

---

[12]- We developed `MEREDIT` based on the exchange of commodities and information imperfection. See our paper "An Essay of Communication between Agents Modelling : `MEREDIT`", *Working Paper GAMA*, University of Paris 10, nov., (+ `MEREDIT` software), 1994. We assumed false or true data endowment to be compared with a general true data matrix. But we left this assumption because of its lack of subjectivism.

[13]- Iterations start from 1 to N where N represents the number of agents of the economy.

[14]- We built another centralized and without auctioneer model. This one was without information management, but with a better representation of goods supply, demand and bargaining, the model `SINGUL` [10]. Such a model was proposed according to a walriasian comparison by P.Albin & D.K.Foley, "Decentralized, Dispersed Exchange Without an Auctioneer", *Journal of Economic Behavior and Organization*, 18, pp.27-51, 1992.

> During the negotiation (9, 10) between the two agents i-the and j-the, they won't be motivated with the same strength (given by the α parameter).
>
> $$\alpha_{i,j}^t = \frac{|\Delta_j^t|}{|\Delta_i^t| + |\Delta_j^t|}$$
>
> Then price is calculated according to this difference of motivation[15]:
>
> $$Price_{i,j}^t = \alpha_{i,j}^t.Price_i^t + (1 - \alpha_{i,j}^t).Price_j^t$$
>
> One of the two agents, who has got the greater difference, will accept the price condition of the other agent more easily. But the conclusion of transaction happens only if the price belongs to both negotiation intervals. Neither agent knows the negotiation margin of his partner[16]. The model calculates to simulation run modes: a *stiglerian* one (agent meets all his partner and chooses the best one, if reciprocity is true), and the *simonian* one (agent deals with any partner, at each times the conditions are filled).

Such simulation models can't be validated by econometric procedures. Moreover, we would be wrong in trying to correct econometric equation with other econometric tools.

ii - Experiment Market System

Experimental validation appears to be the best one[17]. We present now the `ECHANGE` software [10, 13] designed to validate the `SINGUL` model.

> `ECHANGE` software can (will be able to) run under two modes on a network system. The teacher e.g., can lead the system with the pilot mode and his pupils (or students) use operator mode but the pilot is not an auctioneer. `ECHANGE` simulates the transactions : the operator nor really buys the goods neither do these goods really exist. The exchanges take place over a short period (we assume a daily period) and the goods have been chosen among the leisure of the pupils.
> Each operator exists for the other one through his advertisement(s). At each period, the operator can write advertisements and/or answer to one (to buy and/or sell). They have to pay for information (advertisements).

---

[15]- Sometimes, the buyer's "mind price" is greater than the seller one. We assume, only one of the two partners understands this fact and then agrees with the price of his partner.

[16]- The algorithm of partner's choice is a Gale-Shapley one - See L.S.Gale & D.Shapley, "College Admissions and the Stability of Marriage", *The American Mathematical Monthly*, 69(1), p.9-15, 1962.

[17]- Even if L.Mises [41] didn't advise experiment in economics, V.L.Smith thinks the experimental economics as it appeared in the sixties could be used according to Austrian economics methods "*Experimental economics, created in the 50 years since Human Action, is kind to the Austrians in enabling us to demonstrate that the spontaneous order, operating through property right institutions, exhibits the desirable characteristics that the Austrians claimed for it.*" [54].

The goal of each operator (pupil) is to maximize his utility (in buying or selling some goods) with his liquid assets. Before the exchanges, each operator answers to a questionnaire to define his utility function (proportions of goods to hold at each period). Initial endowments of goods are calculated to present an excess quantity of one good, so that all operators would be sellers of one good, at least. There is no point in the operators speculating because they don't realize their periodical aim - prominence principle. ECHANGE software calculates the classification of the operators at each period - insatiability and dominance principles -, and at the end of game - it considers the final level of liquid assets too[18].

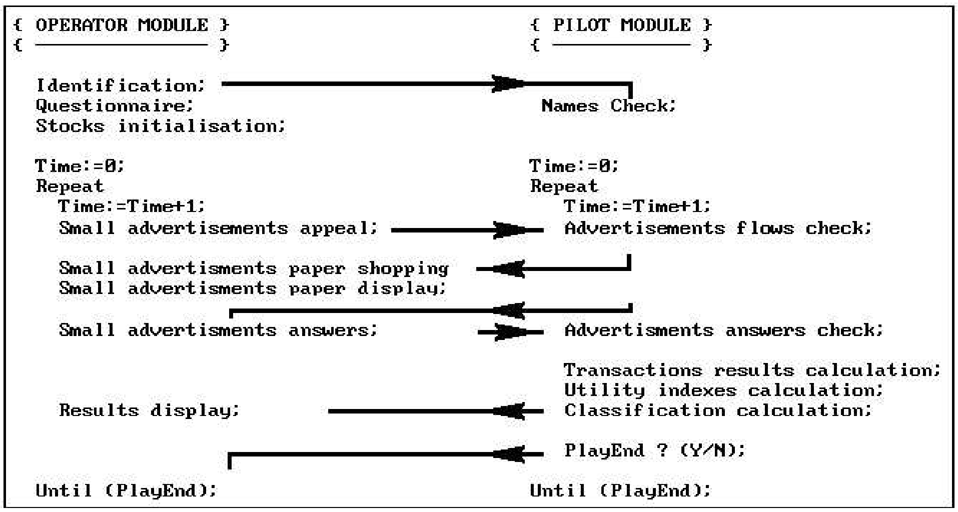

Fig.1 - ECHANGE General Algorithm

The ECHANGE software has already been used to organize five experimental market exchanges, but the data has not been analyzed yet. Furthermore, another release should be developed with a simulation run mode. Hence we could compare the experimental results with some simulation results obtained with the same initial data of the experiment[19].

b - A First Conclusion About the Limits of Calculation

i - Generalization of the Simulation Market Model

When we develop an individual model according to our purpose - build a econometric equation correction tool -, we have to resize it. Two problems appear now. Firstly, *is the generalization of the* SINGUL *model possible ?*

[18]- About the experiment design, see [53].

[19]- Some important results about rationality have been obtained by such path [21] - see [19] for other results and an overview.

and by the way, *how to introduce the production process ?* Secondly, *What are the limits of calculation in economics ?* This last question implies another question: *For whom have we to make economic calculation ?* There are three answers. The answer of macroeconomics is *the State*, the Austrian one is *individual* (managers already make economic calculation), and the economic searcher one is *economic science could need it.*

Economic calculation already exits at the individual level and built the market itself. When agent uses this calculation procedure, he neither uses nor needs the whole information of the economy [25, 26]. As soon as we want to get modelling with the whole information, we encounter problems with data availability and treatment.

ii - Typology of Modelling Representations

According to the quantitative point of view, we have to aggregate the model and/or the results. Thus we lose a lot of information. We encounter problems with the census of the transaction[20]. Even if we would have got this information, or if we use representative sample data, we encounter arithmetics computer problem which decreases the accuracy of the results[21]. According to the qualitative point of view, we have to decrease the complexity of the real world. Thus, some relationship would disappear during aggregations [43]. Especially, we encounter the famous Quételet paradox[22]. Furthermore, the aggregation is debatable, especially the homogeneity assumption[23] [11]. Thus, our temporary answer was, `SINGUL`-Generalized modelling was impossible. However, we'll see in the second part, that the impossibility is actually not a complete one.

If we observe the evolution of economic calculation modelling - see Table 1 -, we can notice that the first macro-econometric model's builders developed

[20]- The data census problem is a human one too - see Appendix 2 and [48].

[21]- About the quantitative problems, see Appendix 2 and our paper R.Buda (1996, *op.cit.*).

[22]- The new entity obtained after aggregation usually have no longer same properties as his individuals. For a general point of view, see the Paradox of Quételet (1835) ; see too C.W.J.Granger, "The Effect of Aggregation on Non-Linearity", *Working Paper University California San Diego*, Aug., 1989, 25 p.

[23]- The products indeed are still transforming during the period of observation - this problem is known by statisticians when they try to calculate price indexes. This transformation can be slow or chaotic, but anyway the product is no longer the same from the beginning to the end of the period. Such samples data of products can't be aggregated because, the homogeneity hypothesis is now wrong - exists inheritance relationship between the different goods.

very aggregated and mono-computer procedures, then they progressively disaggregated them.

Table 1: **Typology of Modelling Representations**

Computers	**Aggregation Level:** *Very Strong*	*Weak*	*No*
Only One	Mono-dimensional Macro-econometric Modelling	Multidimensional Macro-econometric Modelling	-
A Few	Market Socialism (I)		-
A Lot Of	-	Market Socialism (II)	ACE, AL, QAM
One Per Agent	-	-	*Market itself* (*)

(*) If we consider operators as calculators in the market.

The Market socialism (I) - Lange-Lerner Model [32, 33, 34, 35] - and then the Market Socialism (II) - Cockshott-Cottrell Model [15, 16, 17] - disaggregated and decentralized a lot the procedures. Finally, Agent-based Computational Economics (ACE), Artificial Life (AL) [55] procedures and the QAM we'll present in the second part reach individual level of modelling with a lot of computers - about our general approach, see Fig.2.

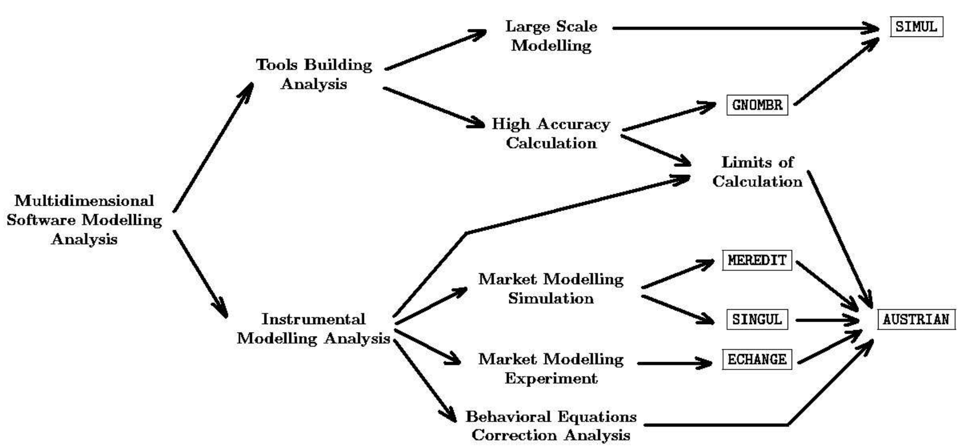

Fig.2 - From Tools Building to Instrumental Analysis

II - An Austrian Answer to the Econometric Problem : the QAM

In this second part, we develop a reasoning *ad absurdum*. We assumed one can develop a Quasi-Perfect Quantitative Model (QPQM), so that we make appear the properties of the currently Quantitative Modelling and these of a new one, the QAM.

1. The Quantitative Approachs of Modelling

a - The QPQM Approach and Classification of the Quantitative Modelling

Let's assume one can get a QPQM. Lets consider the answer he resolved to reach it.

i - An Absurd Approach to describe the Properties of Quantitative Models

Such a model should represent a whole economy (best field of representation property), describing agents and transactions individually (best level of representation property), accurate "at the nearest cent" (best accuracy property). Furthermore, the variables and the result must be realistic at least (real property) or actual - with a very little difference from the actual data - (actual property)[24] hence we can obtain the main properties of the quantitative modelling - see Table 2.

Table 2: **Quality Criteria of Quantitative Models and Theories**

	Significance	Kinds
Field	Represented areas	global/partial
Level	Level of disaggregation	aggregated/disaggregated/individual
Accuracy	At near cent	weak/average/strong/exact
Realism	Could result be observed ?	no one/weak/strong/
Actually	Is result conform to reality	not/near/observed

ii - Classification of Modelling

The different kinds of quantitative methods and theories appeared in the twenties, can be now analyzed according to our criteria - see Table 3.

[24]- For more details, see Appendix 2.

The theoretical models have got a weak accuracy, because they stylize reality, and are often aggregated. Then, the econometric models are realistic and actual - it depends on the quality of the data sample -, but have got a weak accuracy[25] [43].

Table 3: **Essay of Quantitative Techniques and Method's Typology**

	Field	Level	Accuracy	Realism	Actually
Literal theory	**Global**	*Aggregated*	*No one*	*No one*	*Not*
Math. theory	**Global**	*Aggregated*	*Weak*	*No one*	*Not*
Econometrics	**Global**	*Aggregated*	*Average* (1)	*Weak*	*Near*
CGEM	**Global**	*Disaggregated*	*Average*	*Weak*	*Near*
Microsimulation	**Global**/*Partial*	*Disaggregated*	*Average*	*Good*	*Near*
Agent-Based (2)	**Global**	*Disaggregated*	*Average*	*Weak*	*Near*
Agent-Based (3)	*Partial*	**Individual**	**Very strong**	*Good*	*Near*
Experiment	*Partial*	**Individual**	**Exact**	**Strong**	**Observed** (4)
Austrian	**Global**/*Partial*	**Individual**	*Unintelligible* (5)	**Strong**	*Not*

(1) - But higher in Micro-econometrics.
(2) - With econometric calibration.
(3) - With experimental or game theory's calibration.
(4) - Analogue of a widest reality.
(5) - But locally exact.

According to the mode of calibration, Agent-based Computational Economics models are partial, disaggregated, realistic, actual and strong accuracy if it's an experimental one[26], or whole, disaggregated, realistic, not actual and average accuracy if it's an econometric one[27]. The experimental

[25]- We have to assume that econometricians have got the same assessment method's to validate their models, that is not always true - see R.Carbone and J.S.Armstrong, "Evaluation of Extrapolative Forecasting Methods: Results of a Survey of Academicians and Practitioners", *Journal of Forecasting*, 1, pp.215-17, 1982.

[26]- About mixed methods between experiment and artificial life, see J. Duffy, Learning to speculate: Experiments with artificial and real agents, *Journal of Economic Dynamics and Control*, 25, pp.295-319, 2001.

[27]- About the micro-simulation model calibration, see C.F.Citro and E.A.Hanushek (Eds), *Improving Information for Social Policy Decisions: The Uses of Micro-simulation Modeling*, Vol. I, Review and Recommendations, Washington D.C.: National Academy Press, 1991. About the artificial life calibration, see K.C.Clarke, S.Hoppen and L.J.Gaydos, "Methods And Techniques for Rigorous Calibration of a Cellular Automaton Model of Urban Growth", *Working Paper University of Salzburg*, 1998.

models are individual, with an exact accuracy, realistic and actual, but never global. QAM is an **individual** - each individual is described -, **global**[28], **realistic** - by experimental validation of the equations - but **not actual** - because we can't calibrate the real-world parameters of economies[29] :

> "*Economic equations describe only an imaginary condition that differs from the actual condition and that can never be realized.*" (L.von Mises [42])

globally unintelligible - because we don't try to aggregate individual results - **but locally exact** ones.

b - Relevance of the Quantitative Approach Translation

i - Quantitative Translation of the Austrian Topics

Austrian economics usually never uses mathematical (differential calculation, statistics etc.) except arithmetics and logic. However, we think that the QAM could introduce a systematical use of arithmetics in the Austrian logic analysis, especially to investigate its main topics (equilibrium, institutions, etc.). We'll examine the original location of the QAM among the other quantitative approaches.

QAM as an Austrian consistent deduction prolongation tool : Austrian economists usually deny the interest of the mathematical formulation in economic and social science [40, 24, 42]. However we think QAM follows the principles of Austrian economics. Indeed, QAM uses neither differential equations nor econometric procedures. Furthermore, QAM must neither be used to make predictive nor historical simulations. QAM exists to help investigation of economic and social mechanisms described by the Austrian economics. QAM uses a lot of modules which simulates individual behaviors. Each module simulates an agent during its action - according to a praxeological point of view. Each one indeed follows his own purpose (constitution of a basket of commodities, production of goods etc.) - according to the subjectivism principle. Each one looks for information and commodities in his environment in contacting other agent, during simulation - according to a catallaxical point of view. A lot of demonstrations of L.Mises, F.Hayek or most of Austrian

[28]- In using an internet implementation, like the program of prime factorization of large integers led to test the safety of the RSA public key against the attempt of cracking [51].

[29]- ACE modelling implies a step of validation, by calibration - see M.C.Kathleen, "Validating Computational Models", *Working Paper, Carnegie Mellon University,* Sept., 1996, 40 p.

economists, are based on the logic[30] but the conclusion is often undetermined: "*... when the variable x increases, it involves the variable y decreases, but in the same time the increase of z involves the increase of y, so that we can't conclude.*". We think that QAM could help the Austrian economists to leave such indetermination.

QAM as investigation tool of Austrian topics : Whatever the accuracy degree of the representation no model would be able to simulate the whole reality. Building a model means we have to choose to simplify some mechanisms or to hide some other considered (or assumed) insignificant. However, we think that QAM has reached an interesting level of individual representation so that, QAM could help us to get a better understanding of market mechanism, spontaneous order[31], institutions genesis, hayekian production process, or equilibrium tendencies[32]. QAM could help to show the mechanism of incitives during a market socialism procedures[33]. However, we think that QAM interest is not only inside the Austrian economics thought.

ii - The Links between Econometrics, QAM and Experiment

The different approaches of the economic science didn't work totally independently each other. There are some links between the different approaches.

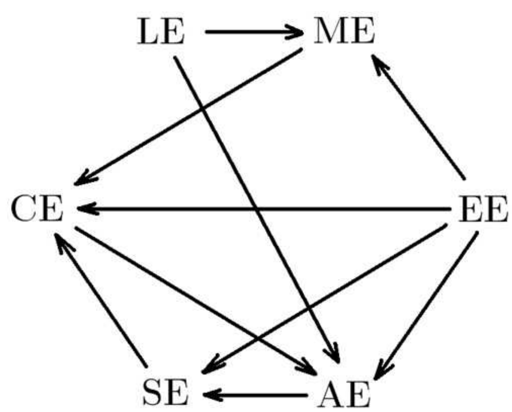

Fig.3 - The Links Beetween the Different Approches

[30]- About Austrian economics, L.Mises [41] denied the qualification of literarily economics to substitute it by the term of logician economics.

[31]- Especially the lag between the perception of a change by the agents and the reallocation of the resources implied by this change.

[32]- QAM doesn't belong to misesian, hayekian, lachmannian or rothbardian economists in Austrian economics thought. QAM is a general Austrian tool. About an overview of the similarities and differences between the main Austrian economists, see S.Longuet, *Hayek et l'école autrichienne*, Paris, Nathan, 192 p., 1998.

[33]- This point seems has been left by the market socialism renewers [16, 17].

The topic is obviously too large to be described into some words, but we can highlight the following links between the different approaches. Literarily economics (LE) appeared in antique era[34] provides to the mathematical economics[35] (ME) concepts, analysis or mechanisms which are mathematically translated. Computational economics[36] (CE) is mainly the discretization of the ME[37]. Our QAM (AE) is partially inherited from the CE and validated by the experimental economics[38] (EE). Especially, N.J.Vriend [62, 61, 59, 58] worked on the game theory design representation of markets. He has developed some models based on hayekian principles (spontaneous order, information contagions, interactive adaptative agents) and wished that Austrian economists join ACE [60]. EE and econometrics[39] (SE for statistical economics) are linked since the technical of simulation and experiment have been simultaneously used.

All approaches we recalled, however developed some methods independently each other. They sometimes have connections to progress, but they are fundamentally independent according to their methods. Such an independence provides to each approach some validation tools from the other one. In other words, the method of one approach could be relevant if the method (an obviously independent one) of another approach gives the same result. That's the reason why, we finally think that, as we'll show it below, *AE could help SE.* Paradoxically, one of the main quantitative progress we assign to the QAM, is indeed the correction of the econometric behavioral equations.

Quantitative data and reality : For many reasons, the reality has been and will never be completely "caught" by any modeler[40]. Even if modeler would go into the field of his analysis, he could mistake or misunderstand an important data he however should have to keep. For example, *a man is walking on the street*, which data we have to keep ? He comes from the market and has just bought foods ; he falls on the street, the major is responsible because, the floor was not safe, he saw advertising on a wall, and so on. This simple example shows us that, no quantitative modelling, could reach the

[34]- We could say that the LE was the initial form of economic science appeared under the name of political economy.

[35]- Appeared between XVII and XIX-th centuries.

[36]- Appeared at the end of the XX-th century.

[37]- QAM isn't such a discretization of mathematical economic theory.

[38]- Appeared in the second part of the XX-th century.

[39]- Appeared in the first part of the XX-th century.

[40]- A subjectivist - [31] - bias exists into the observation of the modeler himself.

perfect level of realism. However, all approaches don't suffer from this lack of realism according to the same degree - see Fig.4. The EE is obviously the nearest approach from the reality - but the observation is not exactly the reality, only an analogy[41]. Then, because of it individual level and its calibration according to statistical data, CE is the following nearest approach from the reality. QAM (AE) according to its individual modelling level, comes after in the reality's proximity order, because we explained QAM does'nt try to describe directly the reality. Then SE because of its aggregation modelling level, comes after. Finally, LE and ME because of their abstraction analysis level, can't represent observable facts.

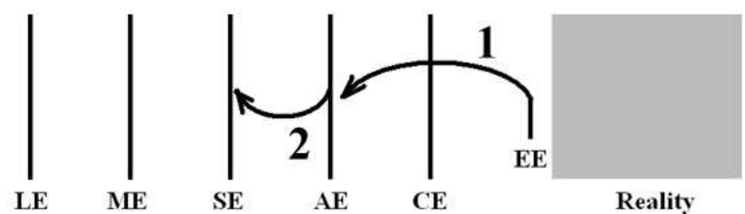

Fig.4 - Proximity to the Reality and the EE-QAM-SE Use

2. Presentation and Expected Contribution of The QAM

a - AUSTRIAN model : a first release of the QAM

i - Equations of the Model

`AUSTRIAN` a total endogeneous individual model [14]: With `SINGUL` model we did'nt resolve the endogeneouzed production problem ; `SINGUL` was only a commodities exchange simulation model. Given the production process method, the question was the following : *how to allocate factors to each producer ?* We had to leave the mathematical calibration. It would mean to solve a too big system of equations or to leave the global property. We had to leave experimental calibration too. It would mean to collect a too big data sample in a very quick time. Random calibration was left too, because the system would lose its coherence. We finally solved the system in starting it at the assumed earliest era of the Mankind. At the begin of the simulation, we indeed assumed that economy gets only a very short set of primary goods,

[41]- Unfortunately the reality that ME would try to describe could be different than the EE one. Moreover, about behavior, the link between EE and Economic Theory (EE-ME and EE-LE) is not an univoque one - see [52].

that each agent produces alone[42]. The dynamics of the system is given by the differential ability of each agent. Each agent progressively produces more goods than it needs so that, excess of goods for most of them appears. Thus the conditions of exchange appeared. The main disadvantage of this way is the probable long time to lead simulation to industrial economy. However, we don't try to simulate our actual economy. It's more important to validate the behavioral equation by experiment, than to validate the outcomes from these equations. According to an individual level, it could be quasi impossible to get a simulation which would lead us to our real one[43]. The main advantage is the complete endogenous process of the simulation. The starting economy is a no monetary one, but progressively a common good is chosen to be the money. In other words, after a lot of periods, the simulation should make appear a money[44]. Hence the economy should become a monetary economy, after it was a barter economy. Furthermore `AUSTRIAN` simulates flows of commodities, payments and information ; the system itself creates it goods (a new combination of inputs gets a new good), money and information.

Description of the main equations[45]: `AUSTRIAN` is an individual level simulation model[46]. Each agent is a human being, not only a producer - producer eats every time, so he could be viewed as a consumer too -, not only a consumer[47]. After the primary economic era, the simulation reaches an industrial era where the number of goods is more important and production organization is developed. The endowment of the t period of simulation are given by the previous period[48].

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[42]- Each agent produces only one, two or three goods, among ten or twelve available in the economy.

[43]- Given an economy of ten millions of people one million of goods, in doing such a simulation, we estimated the probability to reach our industrial state could be approximatively to 1 per $10^{1000000000}$, if we don't try to reach each step - see Appendix 2.

[44]- The current simulation only run under a barter economy, but we assume that a particular good could be choosen by agents, and become the money of the economy. We have to make simulation to answer definitively.

[45]- The following equations are not yet implemented into the current model, because we're always working on the technical change problem.

[46]- The program is available. Contact me by e-mail.

[47]- `AUSTRIAN` model, like the ACE Model [56], : starts at a primary ere of the economy, but in `AUSTRIAN` model individuals are not assigned exclusively consumer or producer.

[48]- In fact, it's difficult to talk about period. During the large simulation, a lot of computers will simulate each agent. The transactions between two agents will depend on the availability of them. Each of them will live at least three different period during a day : leisure, work, sleep periods.

$$
\begin{array}{rcll}
\texttt{AUSTRIAN} & : & \textit{An Essay of Quantitative Austrian Model} & \\
P_k^j & = & \inf_{d=1}^{D} \left(P_d^j\right) & (1) \\
C_i & = & \sum_{j=1}^{J} \alpha_j \cdot P_k^j \cdot B_i^j & (2) \\
P_s^n & = & \inf_{e=1}^{E} \left(P_e^n\right) & (3) \\
W_z^m & = & \inf_{f=1}^{F} \left(L_f^m\right) & (4) \\
V_j & = & \sum_{n=1}^{N} \beta_n \cdot P_s^n \cdot B_j^n + \sum_{n=1}^{N} \gamma_m \cdot W_z^m \cdot L_j^m & (5) \\
P_j & = & V_j + F_j & (6) \\
P_{b,s} & = & \eta_{b,s} \cdot P_s + (1 - \eta_{b,s}) \cdot P_b & (7)
\end{array}
$$

Each agent looks for his own purpose. Consumers[49] look for their best utility[50] and managers for their best profit. During transactions, a process of bargaining can appear - exchange is based on the subjective use-value given by each agent to the commodities ([41],pp.119-26). At each period, consumer i tries to get a set of goods B_i^j - according to his own tastes[51]. Each consumer i tries to find the good at the lowest price. When consumer looks for B^j, he compares prices of the D producers (or dealers) he can ask. Then he chooses the good B^j from k that price is lower **(1)**. For each period, the cost of consumption for the consumer i is given by **(2)**. Each manager i tries to get maximum profit. When manager tries to produce the good B^j, he looks for K_n^j capital-input and L_m^j which are the lowest price. When manager contacts the E providers of the K_n input, he chooses the s provider, which gets him lowest price input[52] **(3)**. According to the same ground, he chooses z worker among the F workers, which gives him lowest price labor **(4)**. Price P^j of B^j that the manager get on his market is composed by cost-price V^j and profit margin F^j - according to the management's behavior **(5)** and **(6)**.

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[49]- We'll use the terms of *consumer* and *manager* (resp.) but the correct term should be *individual as consumer* and *individual as manager* (resp.).

[50]- We replaced the program $Max\ U$ under income constraints with the program $Min|Sc - Sd|$ under income constraints - Sc and Sd (resp.) for current stock and wished stock (resp.). `AUSTRIAN` don't simulates a general or a partial equilibrium *a priori*. The Austrians don't agree all on this question.

[51]- Each agent translates his own welfare by a specifical basket of good.

[52]- Capital-input is evaluated per unit, and labor-input per worked hours.

The bargaining process between buyer and seller **(7)** to determine the prices is the same as the `SINGUL` model.

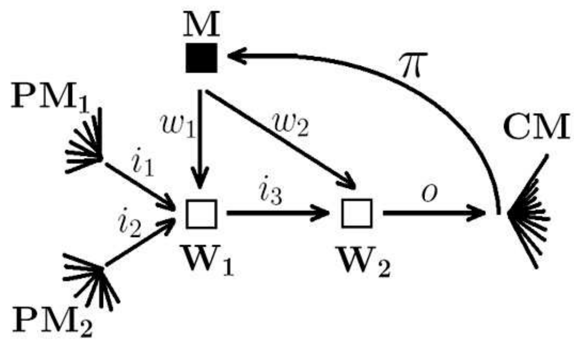

Fig.5 - Network Production Process

ii - Future Developpement of the Model

The technical change in the economy: The organization of production is given by a networks pattern. Firm is managed by a manager (**M**) - see Fig.5 - who learnt or discovered a production process. Fig.5, his firm produces the output o from input three inputs i_1, i_2, i_3 worked by two workers $\mathbf{W_1}$ and $\mathbf{W_2}$ (reps.) who receive wages w_1 and w_2 (reps.). Inputs come from the providing market $\mathbf{PM_1}$ and $\mathbf{W_2}$ and output is sold to customers market **CM**[53]. The technical change implies a new good or a change of process - complete one or just a substitution of one or more of the inputs[54]. All the goods sold return a profit π to the manager.

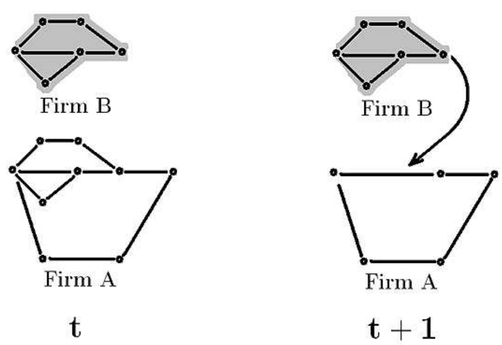

Fig.6 - Providing Relationship Between Firms

[53]- See Fig.6 where *Firm A* and *Firm B* (resp.) produce the same good, intermediate and final (resp.). If *B* has got a lowest cost than *A*, *B* becomes provider of *A*.

[54]- In the model, we represented the goods and the needs to simulate all cases resulting of a technical change: the new good satisfies just the old needs or the old needs and more.

Information is an endogenous variable in the model[55]. All information used in the model is necessarily available in the model or provided from it[56]. Some agents are "conscious" of a fact (e.g. the price of some commodities), some others compute data to obtain an information and so on[57].

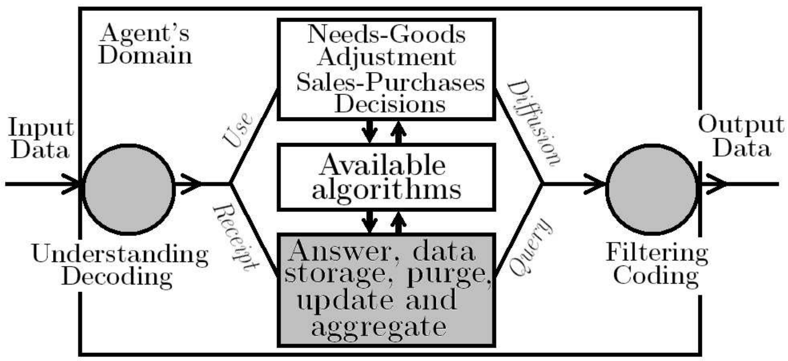

Fig.7 - Agent Communication Process in AUSTRIAN

The agent receives and decodes according to his knowledge the data from other agents - see Fig.7. He manages data storage (aggregate, update, purge and so on) and uses some of them to make its sale and purchase's decisions. His level of calculation - available algorithms - depends on his knowledge[58]. He transfers complete or filtered data to other agents according to the results he expects for him. This management is very important in the model, and must be very richly led to keep the realism of the model - about information and data accuracy, see [43]. The dynamics of the model would be provided by the managers. Some networks appear (e.g. between workers in their firm and the manager) which are organizations or institutions. The manager collect

[55]- In the current release, the information is only given by the price and the quantities. However, we already developed another simulation model to study this problem in a particular case of closed system - a classroom - to analyze the data flow problem. See our paper "Learning-Testing Process in Classroom - An Empirical Simulation Model", *Working Paper GAMA*, University of Paris 10, 17 p. (+ CLASSROOM software), 2006.

[56]- In the walrasian model there is a contradiction when we assume that prices give information about market (quantity, agents etc.) and in the same time, information is free and easy access. Furthermore, we don't see how information can transmitted between agents when we leave the classical assumption of pure and perfect competition. The way leads us to a paradox underlined by I.Kirzner [28], in which agents already know the information they are looking for.

[57]- CE economists use genetic algorithms [22] and the dilemma of the prisoner game approaches [3, 38, 39, 62] to represent communication, learning and beliefs

[58]- The algorithms should be built with the data (the knowledge) accumulated by the agent. This level of modelling is yet more difficult. Now, the agent is able to use new complex algorithms according to his level of knowledge.

all the time technical (which can update his own production technique: how to produce a particular good ?) and trade information (which help him to calculate the better quantity and prices of his products)[59].

Furthermore, we could represent justice problems. We could indeed simulate robberies - transfer without any compensation of goods with a decrease of the health capital of the victim -, murders - health capital of the victim decreases to zero - and so on. This network could be observed also in terms of "rules" [27].

b - The Parallel Use of AUSTRIAN with Econometrics

i - Ceteris Paribus Assumption Examination

QAM is based on a massive parallel simulation. It means that each agent is represented by an independent program which runs on a computer - `SINGUL` was a processional program. All computers are linked by a network[60]. At last, the choice of periodical step must be done very attentively.

> "*All such balances and statements are virtually interim balances and interim statements. They describe as well as possible the state of affairs at <u>an arbitrarily chosen instant</u> while life and action go on and do not stop. It is possible to wind up individual business units, but the whole system of social production never ceases.*" ([41],p.214)[61].

If we choose a too long periodical step then the simulation could be very long, if we choose a too short periodical steps, then the cohesion of the system is broken. Now, the `AUSTRIAN` model is only implemented on mono-processor computer and can only simulate the primary economic ere.

QAM neither tries to make retro-simulations nor obtain whole results. QAM simulation must not be used like econometric one. It means, econometric simulation consists in testing the effect of the variation of a variable to the whole system, but, because of its endogenous form, such simulation is impossible with QAM. Furthermore, because of its inertia, when a large simulation is running, we can't stop it so easily like an econometric one. That implies particular properties of its simulations.

We could indeed leave the *ceteris paribus* assumption usually used in the econometric models. In using econometric and QAM models, we could

[59]- L.Lachmann [31] proposed to make difference between additive information and complementary information.

[60]- A LAN - Local Area Network - to test the model - or Internet to make the first simulation.

[61]- We underlined the idea we wanted to highlight.

better appreciate the actual weight of the *ceteris paribus* assumption. We could reach here the purpose of collaboration between Econometrics and Praxeology assigned by M.J.Rizzo [49].

ii - The Austrian Procedure of the Econometric Correction

Econometricians built models in choosing to link two or more variables from a sample data observed at the same time of each variable. We describe here the classical method of the OLS - Ordinary Least Square[62]. Econometric equation simplifies reality and assumes some global regularities exist between socioeconomic variables followed by each agent (if we consider by example the cross series data). Unfortunately, each agent doesn't follow exactly the global regularity represented by the estimated equation: the residuals vector ε will never be null, it's impossible[63] and unnecessary. So, the main path of the Econometrics consists in finding new procedures to extract as much information as possible from the residuals[64]. The problem becomes more complex as soon as the econometrician has to estimate simultaneously two (or more) equations into a model. That is the reason why one decided to consider economic variables like stochastic one and no more deterministic one[65]. Thus, econometric models became some virtual representation of reality. Another problem proceeds from the quality of the data used in the econometric equations. Unfortunately, econometricians can't control this point [43].

We think that QAM could help econometrician here. To achieve this purpose, we assume we make a large simulation with a QAM model (`AUSTRIAN`). At each simulation, the system is indeed able to provide two level of data[66]: the "*systemic data*" (parameters of the agents, level of stocks, currency, tasks, etc.) and the "*endogenous data*" (data that agent have exchanged together, true or false, complete or not, high frequency sampling or not, etc.)[67]. The

[62]- Given two variables Y and X observed at T periods (time series data) or observed for N agents (cross series data), econometrician uses OLS method to calculate the best equation which links the vectors Y and X. He finally obtain $Y = a.X + \varepsilon$ where a is a coefficient and ε "keeps" the part of information of Y which is not explained by X.

[63]- The probability of $a_1 = a_2 = \ldots = a_N$ can't be equal to 100%.

[64]- See R.Davidson & J.G.MacKinnon, *Econometric Theory and Methods*, Oxford, Oxford University Press, 2004.

[65]- A change introduced by T.Haavelmo [23] and studied by J.Marschak [37] too.

[66]- The modeler who would try to study these data should choose a sample data but could'nt study the complete data sample, supposed a large simulation.

[67]- In a previous study, we describe the mechanism of a pedagogical software - `OSCAR` for `O`util de `S`imulation de `C`omptes `A` `R`econstituer - devoted to the national account teaching. The software would calculate some data from a sample of data and from some

"*endogenous data*" have been obtained from the behavior of the simulated agents and these behaviors have been checked by experimental validation - Fig.8 the arrows (1) and (2) (resp.). So that, even if QAM is rather blind, we can assume that, as soon as we can find the relationship $f \ / \ s = f(e)$ between "systemic data" (s) and "endogenous data" (e), then we could apply it to the observed data (o). We could then calculate some corrected data (c) with the relation $c = f(o)$.

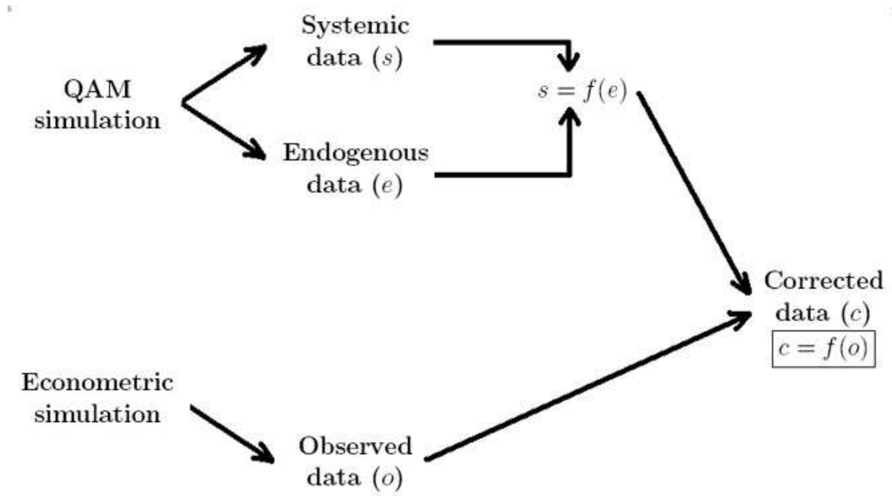

Fig.8 - An Austrian Econometric Correction Procedure

We indeed have assumed that the behavioral bias which has deteriorated the observed data of the econometrician who is making is econometric model, is the same which explain the difference between the systemic data and the endogenous data of the simulated agents of the QAM simulation[68].

well classical known statistical perturbations. Student would have to apply a correction to the available data according to the perturbations he assumes and the software would compare his outcomes to the actual sample data. Then it calculates a score. About our analysis, see our paper: "Pédagogie des comptes nationaux et esprit économique critique", Communication au VIIIè Colloque de l'ACN : Comptabilité nationale, Paris, 19-20 et 21 jan., *Document de travail Modem* 00(02), Université de Paris X-Nanterre, 10 p., 2000. This software is not developed yet.

[68]- Let's quote a previous experience proposed by [46]. G.H.Orcutt *et al.* has built three levels of models. Their micro-analytic model has served as a hypothetic "real world" and they obtain interesting results, but they can't definitively conclude. It seems to be better to build many quantitative models of different kinds, than a set of models belonging to the same kind to get gains in the quantitative representation. However, this modelling keeps the same kind of approach for each level.

III - Some Temporary Concluding Remarks

QAM is ambitious because it needs to use a lot of computers through a parallel simulation[69]. But QAM is reasonable, because QAM calculation is limited to the representation of some potential economies.

`AUSTRIAN` model is in building[70]. Firstly, we now work on a better specification of the individual agent data-management - more exactly to the translation into equations. Secondly, we are looking for the better kind of relationship we should built between the *systemic* and the *endogenous data*. But this question depends widely on the answer of the previous question.

Anyway, we think that, QAM could help Austrian economists in their analyzes and investigations, and QAM would provide too a large storage of two-level data which could be analyzed by econometricians, to adjust their own models and to reconciliate them with stylized theories - especially they could leave the ceteris paribus assumption.

As individual level of modelling, QAM reinforces the micro-macro bridge asserted (or assumed) by microeconomics but never improved, and seriously worked by the CE and would perhaps decrease the existing gap between Austrians and other economists - see [6, 7]. The "*communication failure between the Austrians and other economists*" ([6], p.44) could disappear if the Austrians would provide a quantitative answer to the quantitative question of the other economists. On the other hand, we could compare outcomes from the game theory design of the ACE with these from QAM.

Now, about the question of the respective domain of the ACE and the QAM, it seems that we can say, QAM uses some tools of the ACE and seeks mainly the same purposes. In a sense, we can say that QAM belongs to the ACE economic school. But, in another sense, QAM is not linked to equilibrium or games theory[71] that could be better to the Austrian analysis.

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[69]- Biologists and Mathematicians (resp.) have already such an experience of this procedure to analyze DNA and Prime numbers (resp.) - see [51].

[70]- The current model *AUSTRIAN* is implemented in Turbo-Pascal 7.0 and don't reach the monetary and industrial step of the simulation. It run on only one computer. Moreover the final release will be implemented in Java and will turn on Internet.

[71]- Especially to the microeconomic formulation - see [20] about such a modelling.

Finally, we think that paradoxically, QAM could help Austrian economists in their investigations about the limits of calculation in economics, especially about the renewed debate of the socialism calculation. Even if calculation abilities have significantly increased with the current computers, the socialist calculation renewers have not denied the problem of the incentives. QAM could help to investigate this question.

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Appendix 1 - The SINGUL Model

(i) Basic Equations of the Model

$$Patrim_i^t = \overline{Patrim_i^0} \tag{8}$$
$$Actual\_Level_i^t = \overline{Actual\_Level_i^0} \tag{9}$$
$$Wished\_Level_i^t = \overline{Wished\_Level_i^0} \tag{10}$$
$$Price\_Max_i = \overline{Price\_Max_i} \tag{11}$$
$$Price\_Min_i = \overline{Price\_Min_i} \tag{12}$$
$$Margin_i = \overline{Margin_i} \tag{13}$$
$$\alpha_{i,j}^t = \frac{|\Delta_j^t|}{|\Delta_i^t| + |\Delta_j^t|} \tag{14}$$
$$with \begin{cases} \Delta_i^t = Actual\_Level_i^t - Wished\_Level_i^t \\ \Delta_j^t = Actual\_Level_j^t - Wished\_Level_j^t \end{cases} \tag{15}$$

(ii) Equations of the Simonian Release

$$Transaction'sPrice \ : \ Price_{i,j}^t = \alpha_{i,j}^t.Price_i^t + (1 - \alpha_{i,j}^t).Price_j^t \tag{16}$$
$$if \ Price\_Max_{Buyer} < Price\_Min_{Seller} \tag{17}$$
$$sinon \begin{cases} Price_{i,j}^t = \psi.Price_i^t + (1 - \psi).Price_j^t \\ \psi = 0 \ ou \ 1 \end{cases} \tag{18}$$

a) $\Delta_i < 0$ (i Buyer) and $\Delta_j > 0$ (j Seller)

$$Price_i^t.(1 - Margin_i) \leq Price_{i,j} \tag{19}$$
$$Price_j^t.(1 - Margin_j) \geq Price_{i,j} \tag{20}$$
$$Price_i^t = Price\_Max_i \tag{21}$$
$$Price_j^t = Price\_Min_j \tag{22}$$

b) $\Delta_i > 0$ (i Seller) and $\Delta_j < 0$ (j Buyer)

$$Price_i^t.(1 - Margin_i) \geq Price_{i,j} \tag{23}$$
$$Price_j^t.(1 - Margin_j) \leq Price_{i,j} \tag{24}$$
$$Price_i^t = Price\_Min_i \tag{25}$$
$$Price_j^t = Price\_Max_j \tag{26}$$

(iii) Equations of the Stiglerian Release

If i Buyer and j Seller[73]

$$\begin{aligned} Price^t_{i,j} &= \inf_{P_{i-r}}^{h=1} (Price^t_{j,h}) && (27) \\ Price^t_{j,i} &= \sup_{P_{j-r'}}^{k=1} (Price^t_{i,k}) && (28) \\ r &= \begin{matrix} Rank(j) \\ \in \mathcal{C}_i \end{matrix} && (29) \\ r' &= \begin{matrix} Rank(i) \\ \in \mathcal{C}_j \end{matrix} && (30) \end{aligned}$$

(iv) Equations of Satisfaction's Level of the Transactions

a) i is Buyer

$$Satis_i = 1 - \left(\frac{Price^t_{i,j} - P_0}{P_{100} - P_0} \right) \tag{31}$$

$$with \quad \begin{cases} P_{100} = Price\_Max_i \\ P_0 = Price\_Max_i.(1 + Margin_i) \end{cases} \tag{32}$$

b) i is Seller

$$Satis_i = \left(\frac{Price^t_{i,j} - P_0}{P_{100} - P_0} \right) \tag{33}$$

$$with \quad \begin{cases} P_{100} = Price\_Min_i \\ P_0 = Price\_Min_i.(1 - Margin_i) \end{cases} \tag{34}$$

[73]- $\mathcal{C}_i$ is the classification of the partners of the agent i.

Appendix 2 - Impossibility and Uselessness of QPQM's Building

Let's assume one tries to build a Quasi-Perfect Quantitative Modelling procedure. According to our previous criteria, QPQM must represent individually (Individual criterium) transaction all agents (Global criterium) at the near cent (Accuracy criterium) according to reality (Realism and Actually criteria[74]). QPQM-Modeler would encounter the following problems.

Table 4: **Exhaustive Transactions Account**

$$
\begin{array}{ccc}
\text{Good } m & & \text{Buyer } j \\
 & & \\
\text{Seller } i & & \left[\begin{array}{ccccc}
d_{1,1} & & \cdots & \cdots & d_{1,N} \\
\vdots & & & & \vdots \\
 & \boxed{d_{i,j}} & & & \vdots \\
\vdots & & & \ddots & \vdots \\
d_{N,1} & \cdots & \cdots & \cdots & d_{N,N}
\end{array}\right]
\end{array}
$$

$d_{i,j}$ = transaction's data between buyer i/ seller j ($i \neq j$)

The problem of the census of transaction : Given N agents, M goods, T transaction number, A data storage array's number[75], and D the transaction's data number (price, quantity etc.)[76] we have :

$$T = \frac{M}{2}.N.(N-1) \tag{1}$$

$$A = D.T \tag{2}$$

Modeler must fill and update the A arrays (Table 4) periodically and quickly[77]. However, modeler would waste a lot of data resources. Indeed, nobody would be able to contact the whole $N-1$ agents of the economy, as soon as N is very large. If agent i lives three periods p in a day d_p^i (sleeping, working, and last one), and τ^i the average lapse of time during agent i makes one decision. Number of orders in a day is given by

$$O^i = d_p^i / \tau^i \tag{3}$$

where the units are second[78]. Considering that the lapse of time to make decision spends one second. From a technical point of view, each agent

74- If Actually criterium is observed, Realism one is *a fortiori* observed too.

75- Agent i deals on A goods with $N-1$ agents ; i can't sell and buy p good with j agent, in the same time.

76- If $D = 2$, $N = 10$ millions, and $M = 1$ million then $A = 19,999.998$ billions.

77- If tables aren't updated at time, they become useless.

78- If we assume $\tau^i = 1$ and $d_p^i = 8 * 3600$ (8 hours), we found $O^i = 24000$ orders a day.

could indeed program decisions so that order spends one second e.g. on the Internet[79].

Table 5: **Transactions Duration (Thousand seconds)**

		ω			
		1 sec (1)	1 min (60)	1 hour (3600)	1 day (86400)
T	10 min.	0.600	36	129 600	1 119 740 000
	30 min.	1.800	108	388 800	3 359 230 000
	1 hour	3.600	216	777 600	6 718 460 000
	5 hours	18.000	1 080	3 888 000	33 592 300 000

A transaction is an order and the response of the partner. Let's consider response to agent i spends the lapse of time ω^i - the human and mechanical handling[80]. All orders of agent i can't be treated simultaneously[81]. If k is the rank of the k^{th} order of the all orders a day of agent i, this order will be complete after T^i seconds[82] defined by the relation

$$T^i = (k-1) * \omega \tag{4}$$

Hence $\mathbf{T} \lessapprox \mathbf{25000}$ each day. If we get weakest assumption, we have to consider the lapse of time to make decision. It probably depends on the amount of the order. Thus, modeler could economize cells of arrays, but unfortunately, he doesn't know *ex ante* for each i agent who are his partners.

The problem of the census of the different states of an economy: At t, if each agent could contact all other agent, number of states of our economy[83] would be given by $\mathcal{S}_t = M.Q^{\frac{1}{2}.N.(N-1)}$, but in fact we have

$$\mathcal{S}_t = M.Q^{\frac{1}{2}.N.P_{max}} \tag{5}$$

where P_{max} is the maximum number of transaction's partners at t. Hence, if $M = 10$ millions, $Q = 1000$ and $N = 1$ million and if we assume $P_{max} = T$, then we find $\boldsymbol{\mathcal{S}_t = 10^{525.10^9}}$

[79]- The lapse of time to treat information spends from 7 to 15 seconds, according to the kind of human memory used : short or long run one. See R.L.Klatzky : *Human Memory*, San Francisco, Freeman, 1980. We don't speak here about human perception of the environment using 1/100 to 1/10 second.

[80]- We don't include shipping period because it only gets a lag.

[81]- If at t, i deals with j, j can't deal with k at the same time.

[82]- If we assume $\omega = 1 * 3600$ (one hour) the delay for the last order of agent i would be $L^i = 3600 * 24000$ seconds (more than 2 years)

[83]- All the combinations of the array's cells.