CENTER FOR OPERATIONS RESEARCH & ECONOMETRICS

UNIVERSITE CATHOLIQUE DE LOUVAIN

Report from the Research Director

for the period July 1, 1977 to June 30, 1978

Contents

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1. INTRODUCTION

At the start of the academic year 1977-78, CORE moved from Leuven to Louvain-la-Neuve into its new building. After the experience of this year, it seems that our new place is still better adapted to CORE's research activities than the old one. In spite of the difficulties associated with the change, our new environment has coincided with the development of closer contacts among CORE members and other members of the Scientific Community of Louvain. We take this opportunity to thank the University and all people concerned for having organized this transfer in such good conditions.

The beginning of this academic year has also coincided with a change of the officers responsible for the daily management of CORE. During the academic years 1975-76 and 1976-77, CORE was managed by G. NEMHAUSER as Research Director and A. BARTEN and V. GINSBURGH as co-directors. The new staff thanks the old one for the excellent job accomplished during that period.

This change of staff did not imply a reorientation of CORE's general activities, i.e., research activities in Econometrics, Mathematical Economics and Mathematical Programming, and in related areas including Applied Probability and Statistics, Game Theory and Economic Theory.

Research results are communicated through seminars, discussion papers and reprints. The discussion papers that appeared during the period covered by this report give a good indication of current research interests at CORE. The reprints are the outcome of research carried out at CORE that has been published in journals, proceedings, etc.. In the period covered by this report 40 reprints were issued.

Next to the three weekly seminars at which CORE members and invited outsiders present their current research, a number of specialized seminars were organized this year. In Mathematical Economics, a seminar on Shapley Value was held in February, March and April 1978, directed by Professor R. AUMANN from the Hebrew University of Jerusalem. Another specialized seminar on Dynamic Systems in Economics was jointly organized with the Math. Department of the University. In Econometrics, a series of lectures was given by A. PAGAN on "Information in ARMAX Systems". Furthermore, the summer workshop of the Econometric Society took place at CORE in June 1978. A seminar on Nondifferentiable Optimization was jointly organized by J.-Ph. VIAL from CORE and colleagues of the Facultés Universitaires Notre-Dame de la Paix, Namur.

In the beginning of this academic year, our permanent staff was widened with two new permanent members, Cl. d'ASPREMONT and J.-F. MERTENS. Both of them were old figures at CORE : Cl. d'ASPREMONT was a visiting faculty member in 1974-75, and J.-F. MERTENS was at CORE between 1969 and 1973. During the next academic year, our president J. DREZE and co-director L. WOLSEY will be on leave.

Previously informal activities have now been institutionalized. Due to the difficulty of recruiting new permanent faculty members, the visitors policy is a central issue for renewing CORE's intellectual environment : a so-called "Visitors Committee" has been constituted to define and undertake this policy. On the other hand, the computing aspects of CORE activities have grown considerably and are expected to increase further in the coming years : a special committee has been appointed to handle matters related to these activities.

Many research plans have been elaborated for the next coming years. In particular, CORE has introduced a research project to be financed by the Belgian government in the framework of Belgian Scientific Policy. The project is designed to facilitate the development of operational aspects / applications of theory developed at CORE, such as software for Bayesian analysis, codes for large scale mathematical programming, economic modelling, etc.. This project has been accepted by the University and has been submitted for approval to the Government. In addition, an extension of the Energy Contract with the Belgian government, supervised by Y. SMEERS, has been asked and approved, and two new contracts with E.E.C. have also been signed.

The present document is organized as follows. Section 2 deals with Personnel matters. Section 3 gives abstracts of Discussion Papers which are listed chronologically in Section 4, together with Reprints, other publications and editorial activities. Section 5 gives the details of the seminar program and workshops organized at CORE. Short visits to CORE that are not part of the regular visitors' program are mentioned in Section 6. Visits by CORE members to other institutions are listed in Section 7. Section 8 presents CORE members' activities at meetings and conferences. Section 9 ends with the institutional aspects.

2. PERSONNEL

2.1. During the academic year 1977-78, the research staff of CORE consisted of

- *Faculty members* of the Université Catholique de Louvain (UCL), the Katholieke Universiteit te Leuven (KUL), the Université Libre de Bruxelles (ULB), the Facultés Universitaires Saint-Louis, Bruxelles, and the Facultés Universitaires Notre-Dame de la Paix, Namur.

  Anton P. BARTEN
  Volker BÖHM
  Claude d'ASPREMONT
  Guy de GHELLINCK
  Jacques H. DREZE
  Victor GINSBURGH
  Willy GOCHET
  Jean JASKOLD GABSZEWICZ
  Maurice MARCHAND
  Jean-François MERTENS
  Michel MOUCHART
  Louis PHLIPS
  Jean-François RICHARD
  Léopold SIMAR
  Yves SMEERS
  Henry TULKENS
  Jean-Philippe VIAL
  Jean WAELBROECK
  Laurence A. WOLSEY

- *Senior Research Associates*

Etienne LOUTE
Frans SPINNEWYN
Hans TOMPA

- *Research Associates*

Roland BLOMME
Jean-Paul BULTEAU
Guy CARRIN
Benoît CULOT
Gonzague d'ALCANTARA
Pierre DEHEZ
Anne-Marie de KERCHOVE
Philippe GILLE
Jean-Claude KOEUNE
Luc LONGREE
François LOUVEAUX
Silvio OLIVIERI
Erik SCHOKKAERT
Henri SNEESSENS
Freddy TOMICKI
Geneviève TOMICKI-LOICQ
Marinette VIAL-SCHOENMACKERS

- *Visiting Faculty Members and Research Fellows*

Robert J. AUMANN, Department of Mathematics, The Hebrew University of Jerusalem.

David AVIS, Department of Operations Research, Stanford University.

Stefan CRUCEANU, Institute of Mathematics, Rumanian Academy of Sciences.

Bengt HOLMSTRÖM, Graduate School of Business, Stanford University.

Pierre HUARD, Electricité de France, Paris.

Gerald H. KRAMER, Cowles Foundation for Research in Economics, Yale University.

Heinz MÜLLER, Department of Economics, University of California at Berkeley.

Adrian R. PAGAN, Department of Statistics, Australian National University.

Robert PARKS, Department of Economics, Washington University, St. Louis.

Steven SLUTSKY, Department of Economics, Cornell University.

Jorgen TIND, Institut for Operationsanalyse, Aarhus University.

Michel TRUCHON, Département d'Economique, Université Laval.

Kumaraswamy VELUPILLAI, Nationalekonomiska Institutionen, vid Lunds Universitet.

Asad ZAMAN, Department of Economics, Stanford University.

- *Graduate Students*

Frederico de CARVALHO, Institut des Sciences Economiques, Université Catholique de Louvain.

Mussalam KHAYAT, Institut des Sciences Economiques, Université Catholique de Louvain.

Tomasikila KIONI, Institut des Sciences Economiques,
Université Catholique de Louvain.

2.2 Two new Faculty appointments have gone into effect during the period covered by this report : Cl. d'ASPREMONT and J.-F. MERTENS.

Cl. d'ASPREMONT, after obtaining a Ph.D. in mathematical economics at Stanford University, came to CORE as visiting faculty member in 1974. During this academic year, he was appointed as Chargé de Cours Extraordinaire at UCL and joined the permanent staff of CORE.

As announced in last year's report, J.-F. MERTENS has come back to CORE. He was appointed Research Professor in the Department of Mathematics at UCL in 1971. He later visited the Department of Statistics at the University of California at Berkeley, as associate professor. After a two years' leave he now has returned to UCL Math Department.

2.3 During the academic year 1978-1979, two CORE faculty members will be on leave : J. DREZE will be on sabbatical leave and L. WOLSEY will go to the London School of Economics under a senior visiting fellowship from the Science Research Council.

2.4 CORE will miss V. BÖHM who will leave to take up a chair at the University of Mannheim. He joined CORE in 1974 and taught at the Economics Department of ULB.

2.5 The following visiting Faculty members and Research fellows will be in residence at CORE for all or part of the 1978-1979 academic year :

Roy BERGSTROM, Department of Mathematics, University of Illinois at Urbana-Champaign.

Hsueh-Cheng CHENG*, Department of Economics, University of Southern California.

Luc DEMERS, Department of Mathematics, University of Ottawa.

Nicholas M. KIEFER*, Department of Economics, University of Chicago.

Lynn McLINDEN*, Department of Mathematics, University of Illinois at Urbana-Champaign.

Leonard MIRMAN, Department of Economics, University of Illinois at Urbana-Champaign.

Renzo ORSI, Facolta di Economia, Universita di Modena.

Zvi ROSBERG*, Department of Statistics, The Hebrew University of Jerusalem.

Norman SCHOFIELD, Department of Government, University of Texas at Austin.

Andras SIMONOVITS**, Institute of Economics, Hungarian Academy of Sciences.

Yair TAUMAN*, Department of Statistics, Tel Aviv University.

Timo TERÄSVIRTA*, Department of Statistics, University of Helsinki.

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*holds a CORE fellowship
**holds a CORE-Ford fellowship.

2.6 *Other items*

J. DREZE was elected "Foreign Honorary Member" by the American Academy of Arts and Sciences.

G. KRAMER was elected as President of the Public Choice Society and as Fellow of the American Academy of Arts and Sciences.

J.-F. RICHARD was appointed Secretary of the European Standing Committee of the Econometric Society.

H. TULKENS was elected as member of the Steering Committee of the Institut Belge de Finances Publiques.

L.A. WOLSEY was elected member of the Council of the Mathematical Programming Society.

3. RESEARCH ACTIVITIES

The first three parts of this section, organized by major areas of research, give abstracts of the discussion papers that appeared in the period covered by this report. The fourth subsection discusses ongoing research projects at CORE that are sponsored by outside agencies in the form of grants or contracts.

3.1. *Operations Research*

J.K. HO and E. LOUTE, A comparative study of two methods for staircase linear programs (7801).

> This paper considers the important class of large-scale staircase linear programs arising from dynamic or multi-stage models. The two major approaches to large LP's : problem decomposition and basis factorization are discussed. Two methods for staircase LP's , one from each approach, that have recently been developed and implemented, are compared in both algorithmic and data structural aspects. Computational results on an empirical comparison are presented. The study demonstrates that both special techniques can be more efficient than the direct simplex approach. It also identifies certain classes of problems for which a particular technique is especially promising.

F.V. LOUVEAUX, A solution method for Multistage Stochastic Programs with Recourse with application to an energy investment problem (7806)

> We consider a Multistage Stochastic Program with Recourse, with discrete distribution, quadratic objective function and linear inequality constraints. We show that under reasonable assumptions, solving such a program is equivalent to solving a nested sequence of piecewise quadratic programs and we extend

*The numbers in parentheses refer to the publication numbers given in Section 4.1 below.

the algorithm presented in Louveaux ("Piecewise convex programs", to appear in *Mathematical Programming*, 1978) to the multistage situation. Finally, we consider the application of the method to an Energy Investment Problem and report on the results of numerical experiments.

J.-Ph. VIAL, Sphero-convex sets (7810).

A new notion is presented which strengthens the notion of strict convexity. We give two alternative definitions of sphero-convexity. Then, we study the problem of maximizing a linear form $< x, p >$ over a strictly convex and compact set C and prove that the solution point $x(p)$ is a Lipschitz continuous function of p, where p is a normed vector in the Euclidean space R^n, if and only if C is sphero-convex.

W. GOCHET and Y. SMEERS, A modified reduced gradient method for a class of nondifferentiable problems (7811).

The class of nondifferentiable problems treated in this paper constitutes the dual of a class of convex differentiable problems. The primal problem involves faithfully convex functions of linear mappings of the independent variables in the objective function and in the constraints. The points of the dual problem where the objective function is nondifferentiable are known : the method presented here takes advantage of this fact to propose modifications necessary in the reduced gradient method to guarantee convergence.

G. CORNUEJOLS, Degree sequences of random graphs (7818).

Consider the graphs whose vertices are labeled $v_1, \ldots, v_n$. There are $2^{\frac{n(n-1)}{2}}$ such graphs. The purpose of this study is to derive properties of degree sequences that are satisfied by almost all graphs, i.e., properties that are satisfied by a number N of graphs such that $N / 2^{\frac{n(n-1)}{2}} \longrightarrow 1$ as $n \longrightarrow \infty$. For almost all graphs we give the value of the maximum vertex-degree. This corrects an error that appeared in a paper of Erdös and Wilson. The main results of our paper are properties of the tails of the degree sequence that are satisfied by almost all graphs. The fact that almost all graphs have a unique vertex of maximum degree follows as a consequence.

G. CORNUEJOLS, G.L. NEMHAUSER and L.A. WOLSEY, Worst-case and probabilistic analysis of algorithms for a location problem (7824).

We consider a location problem whose mathematical formulation is $\max\{z(S) : S \subset N, |S| = K\}$, where $z(S) = \sum_{i\in I} \max_{j\in S} c_{ij}$ and $C = (c_{ij})$ is any non-negative $m\times n$ matrix with row index set I and column index set N. We show that any procedure which uses matrix C only to calculate values of the function $z(S)$ cannot, with a number of values polynomial in n, guarantee to find an optimal solution. However when C is the edge-vertex incidence matrix of a graph, we show that if n is suitably large and K is fixed or does not grow too rapidly with n, the K vertices of largest degree nearly always constitute an optimal solution.

J. TIND and L.A. WOLSEY, On the use of penumbras in blocking and antiblocking theory (7827).

E. Johnson has recently shown that the concept of a penumbra leads to a simple geometric description of the blocker and antiblocker of a given set. Here we develop some basic results on penumbras which permit us to slightly generalize and simplify results on their relationship to blocking and antiblocking theory. In addition, motivated by the obvious symmetry of our results, we examine the effect of reversing the blocking and antiblocking operations.

S. CRUCEANU, Duality and optimality for some extremal problems described by convex multi-valued mappings (7829).

In a duality framework, optimality conditions for the following problem : "maximize a linear function over the image set corresponding to a specified point by a convex multi-valued mapping" are derived.

The approach closely related to the concept of a bifunction (Hamiltonian) is used to construct necessary extremum conditions for general multi-period convex programming problems.

G.L. NEMHAUSER and L.A. WOLSEY, Maximizing submodular set functions : formulations, algorithms and applications (7832).

We consider integer programming formulations of problems that involve the maximization of submodular functions. A location problem and an integer quadratic program are well-known special cases. We give a constraint generation algorithm and a branch-and-bound algorithm that uses linear programming relaxations. These algorithms are familiar ones except for their particular selections of starting constraints, subproblems and partitioning rules. The algorithms use greedy heuristics to produce feasible solutions, which, in turn, are used to generate upper bounds. The novel features of the algorithms are the performance guarantees they provide on the ratio of lower to upper bounds on the optimal value.

D. AVIS, A note on some computationally difficult set covering problems (7833).

Fulkerson *et al.* have given two examples of set covering problems that are empirically difficult to solve. They arise from Steiner triple systems and the larger problem, which has a constraint matrix of size 330×45 has not yet been solved. In this note, we show that the Steiner triple systems do indeed give rise to a series of problems that are probably hard to solve by implicit enumeration. The main result is that for an n variable problem, branch-and-bound algorithms using a linear programming relaxation, and/or dynamic programming require the examination of at least $2^{\sqrt{2n/3}}$ partial solutions.

3.2. *Mathematical Economics*

D.F. BRADFORD, The incidence and allocation effects of a tax on corporate distributions (7738).

To study the effects of "double taxation" of dividend income (first at the level of the corporation, then at the shareholder level) this paper analyses a model with a tax on all corporate distributions to equity owners and no other taxes.

Contrary to the common view, the tax is shown to have no substitution effect and, in particular, no effect on the corporate choice between debt and equity (via retained earnings) finance. Wealth effects of changes in the tax rate are shown to be important, and in certain cases to constitute the only incidence effects. A novel general equilibrium model of market evaluation of equity under rational expectations is developed for the analysis.

C. HENRY, On the free rider problem in the M.D.P. procedure (7739).

Does the fact that participants in a Malinvaud - Drèze - de la Vallée Poussin procedure are motivated to misreport their preferences, impinge this mechanism to reach its objective, i.e., an efficient provision of public goods ? The answer is shown to be no when the revisions along the procedure are made continuously, provided the participants have a Nash-type behaviour when evaluating their self-interest. This result of John Roberts is extended here to situations requiring constraints on the plausible lies.

In a discrete version of the procedure a more general question is subsequently considered : how to manage the procedure in order that, under acceptable behavioural assumptions, it does converge to an efficient provision ? Both a system of assumptions and a way of managing are proposed which ensure the desired property.

L. PHLIPS and P. PIERAERTS, Substitution versus addiction in the true index of real wages (7740).

A static utility maximization approach to the measurement of real earnings (such as Pencavel's in the *American Economic Review*, March 1977) exaggerates the gain in real wages. The same is true in a dynamic approach when the Fisher-Shell index, focusing on current tastes, is used and goods consumed are addictive. To the extent that addiction (i.e., habit formation) is properly taken into account, as is the case in our "cardinal" index, the gain in real wages (over the period 1939 - 1967) is in the same ballpark as the one indicated by the currently used Laspeyres-type BLS index numbers.

J.-F. MERTENS, A note on the characteristic function of supergames (7741).

The α- and the β-characteristic functions of a supergame coincide.

J.-F. MERTENS and S. ZAMIR, Minmax and maxmin of repeated games with incomplete information (7742).

We prove that in two-person zero-sum infinitely repeated games with incomplete information the Min Max is Vex Cav u (dually for Max Min) for the model used by Mertens (The Value of Two-person Zero-sum Repeated Games with Lack of Information on Both Sides, *International Journal of Game Theory*, *1*(4), 217-227, 1971/72). This is a result proved by Stearns (A Formal Information Concept for Games with Incomplete Information. Report to the U.S. Arms Control and Disarmament Agency. Washington, D.C. Final Report on Contract ACDA/ST-116, prepared by Mathematica, Princeton, N.J., September 1967, Chapter IV, 405-433) and Aumann-Maschler (Repeated Games with Incomplete Information. A Survey of Recent Results. *Idem*, ..., Chapter III, 287-403) for the particular case where the types of the two players are independent and where all letters of the information matrices H^I and H^{II} are different.

A. ZAMAN, Optimal exploitation of monopoly on an exhaustible resource (7743).

An n+1 country model is studied where one country has a monopoly on an exhaustible resource and the other n need it as an essential input to their production functions. It is shown that as long as the importing countries are not permitted to store the import, their optimal import strategies do not depend on future prices. More precisely, the optimal quantity of import at time t does not depend on the prices after time t except possibly in an indirect way. This result holds in great generality and establishes a tight connection between possibilities of storage and responses to anticipations of inflation.

It is also shown that the optimal price stream for the monopolist has lower prices over an initial time segment than

the prices that would prevail under perfect competition. This occurs under the assumption that the elasticity of output with respect to the exhaustible resources is low.

M.L. HELLWIG, On the validity of the intertemporal capital asset pricing model (7744).

The paper analyzes asset market equilibrium in continuous trading. Merton's derivation of the Lintner-Sharpe capital asset pricing formula from the assumption that investment opportunity sets are constant is shown to be incorrect unless the supply of each risky asset is inversely proportional to its price. For constant asset supplies, the Lintner-Sharpe formula is incompatible with limited liability regulations, as in the single-period model. Constant asset supplies are shown to be the most appropriate specification for industries with restricted entry and pure profits.

L. PHLIPS, Intertemporal price discrimination and sticky prices (7745).

The maximization of discounted profits leads to the textbook marginal-revenue-equal-marginal-cost rule, on the assumption that the firm is not threatened by potential entrants and never produces for inventory. Otherwise, this rule is abandoned. It is shown that potential entry leads to a marginal-revenue-below-marginal-cost rule, while the possibility of building up inventories (voluntarily!) leads to the intertemporal price discrimination rule, which, in turn, has to be amended when entry enters the picture; with or without entry, this rule provides a formal rationalization for normal costing.

Equilibrium conditions for a group of firms, i.e., an industry, are derived, using the intertemporal discrimination rule and assumptions about the degree of collusion. These conditions can be written as linear estimating equations, with regression coefficients explicitly linked with parameters representing market structure and cooperation. These links are compatible with the available empirical evidence and help to explain price stickiness over time. In particular, they imply that, in more concentrated industries, cost increases are less fully transmitted and changes in demand are more fully transmitted into prices than in less concentrated industries.

J.-F. MERTENS, Values and derivatives (7802).

A formula in terms of derivatives gives a value on a rather large space of games.

Cl. d'ASPREMONT and J.H. DREZE, On the stability of dynamic processes in economic theory (7803).

The notion of stability in the sense of Lyapunov is applied to economic dynamic processes of the Champsaur-Drèze-Henry type.

Cl. d'ASPREMONT, J. JASKOLD GABSZEWICZ and J.-F. THISSE, On Hotelling's "Stability in Competition" (7807).

The purpose of this note is to show that the so-called *Principle of Minimum Differentiation*, as based on Hotelling's 1929 paper "Stability in Competition" is invalid.

S. SLUTSKY, Equilibrium under α-majority voting (7808).

This paper defines a class of α-majority voting rules under which, for some α, $0 < \alpha < 1$, an alternative is socially at least as good as y iff the number of individuals who prefer x to y is at least $\alpha/(1-\alpha)$ times the number who prefer y to x. Simple majority rule is $\alpha = 1/2$ while α near 0 and 1 are two types of unanimity rules. For all elements in this class, in a multi-dimensional policy space, the paper gives necessary and sufficient conditions on the pattern of gradients of individuals at a point for the point to be a voting equilibrium. These conditions generalize both the sufficient and necessary conditions given by Plott for simple majority voting.

J.L. GUASCH and A. WEISS, On self-selection strategies (7809).

This paper studies the use by a firm of selection devices as a means of screening applicants for a job. A selection device consists of tests with an application fee. A self-selection strategy is a wage offer and an application fee such that only the workers with the required ability apply. Existence and optimality of a self-selection strategy are studied under different assumptions on the behaviour of the applicants toward risk and on their perception of the probabilities to pass the tests.

H. MÜLLER and U. SCHWEIZER, Temporary equilibrium in a money economy (7813).

Clower's concept of a non-pure money economy is worked out in detail. We use a model including transaction costs, several media of exchange and a system of markets. We emphasize the role of money as a medium of exchange. As a consequence, consumers have to face a set of monetary constraints which, typically, cannot be replaced by an overall budget equation thus contrasting sharply with an Arrow-Debreu world. Finally, a proof of existence of temporary equilibrium in a money economy is given in an appendix.

M. TRUCHON, Pareto optimality and competitive equilibrium with public goods : A note on a recent paper of Groves and Ledyard (7815).

Giving a static representation of the Malinvaud-Drèze-de la Vallée Poussin procedure for the provision of public goods, Groves and Ledyard have recently asserted and offered a proof that a competitive equilibrium of this static model could not be Pareto optimal, which seems a direct contradiction of a result of Drèze and de la Vallée Poussin. The purpose of this note is to clarify this paradox.

B. HOLMSTRÖM, Moral hazard and observability (7816).

The role of imperfect information in a principal-agent relationship subject to moral hazard is considered. A necessary and sufficient condition for imperfect information to improve on contracts based on the payoff alone is derived, and a characterization of the optimal use of such information is given.

R.P. PARKS, Comments on "Some effects of taxation and collective goods in postwar U.S.A. : A tentative appraisal" (7817).

Gevers and Procst (Some Effects of Taxation and Collective Goods in Postwar U.S.A. : A Tentative Appraisal, *Journal of Public Economics*, forthcoming, 1978) obtain a remarkable result

that a median optimal allocation is also a majority rule equilibrium for a certain utility function over tax rates and public good allocations. Here it is shown why the result holds in terms of Plott's conditions for a majority rule equilibrium. Specifically, we show that for the utility function used by Gevers-Proost, all individuals have gradients which lie along the same line. A more general utility function is then presented which has this characteristic.

G.H. KRAMER, Existence of electoral equilibrium (7823).

It is well-known that in the multidimensional version of the Hotelling-Downs model of electoral competition, in which the candidates compete by choosing strategies belonging to some multidimensional issue or policy space, a pure strategy equilibrium generally does not exist. Moreover, because of the presence of discontinuities in the payoff function, an equilibrium in mixed strategies is not assured either. It is shown here, however, that if the electorate is large, the mixed-strategy electoral game nevertheless does have a value. If the game is symmetric in the sense that both candidates' strategy sets are the same, there exists a mixed-strategy equilibrium. If the strategy sets differ, at least one of the candidates has an optimal mixed strategy, though the other candidate may have no strictly optimal strategy, but only ε-optimal strategies with finite support.

Cl. d'ASPREMONT and H. TULKENS, Commodity exchanges as gradient processes (7826).

The purpose here is to make explicit the sense in which two dynamic processes, due to Malinvaud and others, (whose solutions determine an efficient allocation for a given economy) are related to the gradient projection method known in the non linear optimization literature. The connections we establish derive from simple observations on first order characterizations of efficient allocations; they also lead to the formulation of another process, that applies to a classical welfare maximization problem; finally, they provide a common basis for an a priori justification of each of the three processes involved, which supplements the intrinsic properties that they can be shown to have.

B. HOLMSTRÖM, Groves scheme on restricted domains (7828).

It is proved that Groves scheme is unique on restricted domains which are smoothly connected, in particular convex domains. This generalizes earlier uniqueness results by Green and Laffont and Walker. An example shows that uniqueness may be lost if the domain is not smoothly connected.

A.T. DENZAU and R.P. PARKS, Deriving public sector preferences (7830).

Many analyses of the public sector use preferences which are defined on public sector allocations. We relate these preferences to the primitive preferences defined on the consumption space. Many properties of consumption preferences are inherited by derived public sector preferences but not all. We also question whether public sector preferences can be independent of prices with a negative conclusion. Also different definitions of derived public sector preferences are related.

A.T. DENZAU and R.P. PARKS, Existence of voting-market equilibria (7831).

We show the existence of an equilibrium in a model where private goods are allocated by markets and public goods are allocated by majority rule voting. The result extends Slutsky's (A Voting Model for the Allocation of Public Goods : Existence of an Equilibrium, *Journal of Economic Theory 14*(2), 299-235, 1977) result in allowing for public bads (negative prices) and non-strictly convex preferences.

3.3. *Econometrics*

J.-P. FLORENS and M. MOUCHART, Reduction of Bayesian experiments (7737).

For a given prior distribution, a Bayesian experiment may be analyzed as a probability on the product of the parameter space and the sample space. A reduction of the experiment is obtained either by marginalization or by conditionalization. A σ-field on the parameter space (or sample space) is sufficient (resp. ancillary) if it determines a reduction by marginalization (resp. conditionalization) without loosing relevant information.

The main object of this paper is to analyze sufficiency and ancillarity in reduced experiments. This is a natural framework to investigate situations with, e.g., exact restrictions on the parameter space, nuisance parameters or decomposition of the sampling process. We also analyze minimal sufficiency on both spaces and apply these concepts to a Bayesian approach to the identification problem.

H. SNEESSENS, Inflation : An infectious disease ? (7804).

The impact of foreign economies on domestic inflation may be direct (a direct effect on prices) or indirect (through aggregate demand). The former effect is the concern of the paper. Introducing it into the price equation forces to strong implicit assumptions about its mechanism. Four possible specifications are tested on data drawn from nine industrial countries; this leads to the tentative conclusion that foreign inflation is not as infectious as generally believed. The direct effect seems to be a one year effect which does not start a wage-price spiral and works through the price of traded goods only.

V. GINSBURGH and I. ZANG, Price taking or price making behavior in export pricing (7805).

In almost all econometric studies on export price behavior, prices are deduced either from full cost equations or are supposed to be the result of a weighted average of domestic costs and world prices. In this paper, we propose an alternative formulation in which the exporter may choose to base his price on cost considerations *or* on prices charged by his competitors.

The empirical results, computed for several EEC countries and the United States, give support to this assumption.

A.R. PAGAN, Some simple tests for non-linear time series models (7812)

This paper utilizes the score test to derive some simple statistics for testing for a non-linear component in a time series. The statistic can generally be computed from the residuals of an ARIMA model by the use of a least squares regression program. Two examples of its use are given.

A.R. PAGAN, A unified approach to estimation and inference for stochastically varying coefficient regression models (7814).

The paper is concerned with estimation and inference for regression models with stochastically evolving coefficients. Little work has been done to establish the large sample properties of the maximum likelihood estimators of the parameters of such models, and the paper derives a set of sufficient conditions for the maximum likelihood estimators to be consistent and possess a limiting distribution. Under these same conditions, a simple method for generating initial parameter estimates is shown to have a consistent estimator, and the two step estimator formed from these initial values is found to have the same limiting distribution as the maximum likelihood estimator.

The discussion of inference in varying coefficient models is divided into ways of pre-specifying suitable models for the coefficients and more formal tests that certain parameters are zero. For the former, a procedure equivalent to the use of autocorrelation function for determining ARIMA models is suggested, while the latter is solved by the use of the Lagrangean multiplier statistic.

H. SNEESSENS, Inflation in western economies (7819).

The inflation phenomenon is analyzed through the dynamic behaviour of a three equation macroeconomic model. Endogenous variables are the interest rate, GNP and the inflation rate. The nominal money stock, assumed to be exogenous, plays a central role in determining the production level. The model is fitted

on data for Belgium, Western Germany, the United Kingdom and the United States. Simulation experiments emphasize how lagged and slow the effects of changes in the money stock and in the export level may be. At the opposite, the positive effect of import price changes on inflation quickly disappears.

T.S. BREUSCH and A.R. PAGAN, The Lagrange multiplier test and its applications to model specification in econometrics (7820).

Of the three major test statistics available from asymptotic theory, the Wald, Likelihood Ratio and Lagrangean Multiplier (LM) statistics, the latter has been least used in econometrics. This is surprising as it employs restricted estimates of the parameters, and there are a large number of cases in econometrics in which restricted estimation involves OLS or some variant of it. The paper exposits the theory behind the LM test and derives some special forms of it and illustrates these with some examples. Five illustrations are employed : testing for a liquidity trap; testing for autocorrelation, inference for the error components model; detecting time varying models of the Cooley-Prescott type and non-nested hypothesis testing. In each case a simple test statistic is derived that is easily constructed. The final section of the paper considers the $C(\alpha)$ test which would be employed when only consistent estimators of the parameters are easy to obtain, and investigates the use of the LM statistic as a control variate for stimulation studies.

A. ZAMAN, Estimation of the reciprocal of a normal mean (7821).

The MLE of the reciprocal of a normal mean has infinite variance in all finite samples. In view of this, several alternatives have been presented with the quadratic loss criterion in mind. A review of the results available for quadratic loss is provided (with a few simple extensions). The customary truncations of the MLE are seen to be inadequate corrections for the quadratic loss criterion, and a uniformly superior truncation is given. It is shown that an estimator based on the diffuse prior may be preferred to the MLE on the grounds that it is admissible and asymptotically more efficient. It is argued that the diffuse prior does not represent adequately a state of prior ignorance in this problem, and an alternative is presented. The inadequacy of the asymptotic efficiency criterion is also discussed.

Due to bimodal posteriors which arise in this problem, estimators based on quadratic loss have small probabilities of concentration around the true value of the parameter over some regions in the parameter space. Thus, it is useful to consider a 0-1 loss function. With this loss function a class of estimators is obtained which is qualitatively quite different from those obtained with quadratic loss. New support for the MLE is obtained in the light of this analysis, since it is shown to be Bayes versus an 'uninformative prior' and also almost admissible with respect to the 0-1 loss function.

J.-F. RICHARD, Statistical analysis of models with several regimes (7822).

We discuss a class of linear dynamic models with special regimes. Each regime is characterized by a different partitioning between "endogenous" and "exogenous" variables. The switching times may be unknown. As switching models are often part of large models we use limited information type procedures.

A.R. PAGAN, Detecting autocorrelation after Bayesian regression (7825).

The Bayesian Regression Program (BRP) developed at CORE seeks to provide users with the facility of Bayesian regression at reasonable computational cost. One of the items of output for most regression programs are test statistics for autocorrelation in the disturbances, and the present paper proposes a method whereby users could utilize BRP to obtain Bayesian analogues of the Durbin-Watson, d_4 and h statistics. Such information is of importance as it is well known that the second moments of the posterior distributions will be of incorrect magnitude in the presence of autocorrelation, so that valid inferences can only be made when there is no autocorrelation. An example is given of the method applied to the Durbin-Watson spirits data.

Research Memorandum

M. MOUCHART and J.M. ROLIN, A note on conditional independence (with statistical applications).

The object of this paper is to exhibit the role of conditional independence in the reduction of Bayesian experiments. General properties are first defined and their relevance for the concept of sufficiency and ancillarity (on both the parameter and the sample space) are made explicit. Then minimal sufficiency is analyzed in terms of projection of σ-algebras. Finally, further properties such as separable measurability and strong identification are defined and shown to offer powerful combinations with conditional independence in order to allow stronger reductions. In particular, Basu's previous results are generalized.

3.4 *Research Projects under Contracts*

Research teams of CORE have been involved in four sponsored research projects.

A. Under a research contract with the Belgian Government (Programme National d'Impulsion à la Recherche en Informatique) CORE has made further progress in developing an integrated programme library for Bayesian analysis. The two aspects of this programme have been developed further : the Bayesian Regression Programme (BRP) has been extended to cover the Normal Regression Model, Two-Block Heteroscedasticity, Pooling of Two Independent Samples, and Two Seemingly Unrelated Regressions; work to include also the general case of Seemingly Unrelated Regressions is nearly

completed. Work on the second aspect, the Poly-T Distribution programme (PTD) has been directed to enlarging its scope by including poly-t distributions of types 3-0, 3-1, and 1-2. In another direction, work is advanced to develop a programme to treat the single-equation model and permitting the introduction of non-linearities both on the level of the coefficients of the equation as well as on other parameters.

This work has been carried out by L. BAUWENS, J.-P. BULTEAU, Ph. GILLE, L. LONGREE, and H. TOMPA, under guidance from J. DREZE and J.-F. RICHARD.

B. Under the Energy Contract with the Belgian Government, numerous case studies using the electricity generation model have been performed for the Energy Administration. A first version of a global model has been constructed and it is currently being extended to include an adequate representation of the electricity and combined production. The first phase of the project is coming to an end in August 1978. The following models will be available (or almost completed) by that time with their corresponding software : electricity generation (deterministic and stochastic version); an electricity combined production national model; a district heating model and a static global model.

E. LOUTE (Belgian Energy Program) and B. CULOT (European Energy Program) are working on an MPSX 370 based decomposition code which is intended to solve large multinational and multiphase energy problems. This code is also intended to be a first stop towards a more specialized program designed for multiphase problems.

The Waste Water Treatment Plant optimisation project (FDS 146) is progressing normally. Two models have now been set up and their optimisation has been performed without encountering any special difficulty. This project will come to an end in December 1978.

C. The COMET modelling research was continued under contract with the Commission for the E.E.C. for the investigation of medium-term projections and policies.

G. d'ALCANTARA and E. SCHOKKAERT worked on the specification and maximum likelihood estimation of sectorwise production functions and corresponding joint input demand systems. As a byproduct of this work a maximum likelihood estimation software is available, offering many options to constrain the likelihood function and/or the coefficients.

D. The Nato Science Committee is sponsoring the research of a group of economists at Bonn, Cambridge (U.K.), Louvain and Paris on the Microeconomic Foundations of Economic Systems. The program is directed by J.H. DREZE, J.-M. GRANDMONT, F. HAHN and W. HILDENBRAND. It involves some twenty researchers altogether, some of which met at Churchill (U.K.) on January 13-15.

4. PUBLICATIONS

4.1. The following *Discussion Papers* were issued during the period covered by this report.

7737 Reduction of Bayesian experiments,
J.-P. Florens and M. Mouchart.

7738 The incidence and allocation effects of a tax on corporate distributions,
D.F. Bradford.

7739 On the free rider problem in the M.D.P. procedure,
C. Henry.

7740 Substitution versus addiction in the true index of real wages,
L. Phlips and P. Pieraerts.

7741 A note on the characteristic function of supergames,
J.-F. Mertens.

7742 Minmax and maxmin of repeated games with incomplete information,
J.-F. Mertens and S. Zamir.

7743 Optimal exploitation of monopoly on an exhaustive resource,
A. Zaman.

7744 On the validity of the intertemporal capital asset pricing model,
M.F. Hellwig.

7745 Intertemporal price discrimination and sticky prices,
L. Phlips.

7801 A comparative study of two methods for staircase linear programs,
J.K. Ho and E. Loute.

7802 Values and derivatives,
J.-F. Mertens.

7803 On the stability of dynamic processes in economic theory,
C. d'Aspremont and J.H. Drèze.

7804 Inflation : an infectious disease ?
H. Sneessens.

7805 Price taking or price making behavior in export pricing,
V. Ginsburgh and I. Zang.

7806 A solution method for multistage stochastic programs with recourse with application to an energy investment problem,
F.V. Louveaux.

7807 On Hotelling's "Stability in competition",
C. d'Aspremont, J. Jaskold Gabszewicz and J.-F. Thisse.

7808 Equilibrium under α-majority voting,
S. Slutsky.

7809 On self-selection strategies,
J.L. Guasch and A. Weiss.

7810 Sphero-convex sets,
J.-Ph. Vial.

7811 A modified reduced gradient method for a class of nondifferentiable problems,
W. Gochet and Y. Smeers.

7812 Some simple tests for non-linear time series models,
A. Pagan.

7813 Temporary equilibrium in a money economy,
H. Müller and U. Schweizer.

7814 A unified approach to estimation and inference for stochastically varying coefficient regression models,
A. Pagan.

7815 Pareto optimality and competitive equilibrium with public goods : a note on a recent paper of Groves and Ledyard,
M. Truchon.

7816 Moral hasard and observability,
B. Holmström.

7817 Comments on "Some effects of taxation and collective goods in postwar U.S.A. : a tentative appraisal",
R.P. Parks.

7818 Degree sequences of random graphs,
G. Cornuéjols.

7819 Inflation in western economies,
H. Sneessens.

7820 The Lagrange multiplier test and its application to model specification in econometrics,
T.S. Breusch and A.R. Pagan.

7821 Estimation of the reciprocal of a normal mean,
A. Zaman.

7822 Statistical analysis of models with several regimes,
J.-F. Richard.

7823 Existence of electoral equilibrium,
G.H. Kramer.

7824 Worst-case and probabilistic analysis of algorithms for a location problem,
G. Cornuéjols, G.L. Nemhauser and L.A. Wolsey.

7825 Detecting autocorrelation after Bayesian regression,
A.R. Pagan.

7826 Commodity exchanges as gradient processes,
C. d'Aspremont and H. Tulkens.

7827 On the use of penumbras in blocking and antiblocking theory,
J. Tind and L.A. Wolsey.

7828 Groves scheme on restricted domains,
B. Holmström.

7829 Duality and optimality for some extremal problems described by convex multi-valued mappings,
S. Cruceanu.

7830 Deriving public sector preferences,
A.T. Denzau and R.P. Parks.

7831 Existence of voting-market equilibria,
A.T. Denzau and R.P. Parks.

7832 Maximizing submodular set functions : formulations, algorithms and applications,
G.L. Nemhauser and L.A. Wolsey.

7833 A note on some computationally difficult set covering problems,
D. Avis

CORE discussion papers undergo an internal refereeing process which is more informal than, but similar to, journal refereeing. The following people served as referees during the academic year 1977-1978 : A. BARTEN, V. BÖHM, S. CRUCEANU, Cl. d'ASPREMONT, G. de GHELLINCK, P. DEHEZ, J. DREZE, G. KRAMER, E. LOUTE, M. MARCHAND, J.-F. MERTENS, M. MOUCHART, A. PAGAN, R. PARKS, L. PHLIPS, J.-F. RICHARD, L. SIMAR, S. SLUTSKY, Y. SMEERS, J. TIND, H. TULKENS, J.-Ph. VIAL, L. WOLSEY.

4.2 CORE published *Reprints* of the following articles during this period :

289. Victor GINSBURGH and Jean WAELBROECK. Computational experience with a large general equilibrium model. *Computing Equilibria : How and Why*, ed. by Jerzy Łos and Maria W. Łos. North-Holland, 257-269, 1976.

290. Taku YAMAMOTO. A note on the use of two-step Aitken method in inappropriate situations. *The Economic Studies Quarterly*, 28 (1), 78-85, 1977.

291. Taku YAMAMOTO. Asymptotic mean square prediction error for an autoregressive model with estimated coefficients. *The Journal of the Royal Statistical Society, Series C (Applied Statistics)*, 25 (2), 123-127, 1976.

292. Gérard CORNUEJOLS, Marshall L. FISHER and George L. NEMHAUSER. Location of bank accounts to optimize float : An analytic study of exact and approximate algorithms. *Management Science*, 23 (8), 789-810, 1977.

293. Franz PALM. On univariate time series methods and simultaneous equation econometric models. *Journal of Econometrics*, 5, 379-388, 1977.

294. Richard C. GRINOLD. Finite horizon approximations of infinite horizon linear programs. *Mathematical Programming*, 12, 1-17, 1977.

295. Louis PHLIPS. Implications économétriques de l'enquête sur les budgets des ménages 1973-1974. *Revue Belge de Statistique, d'Informatique et de Recherche Opérationnelle*, 15-22, 1977.

296. John ROBERTS and Hugo SONNENSCHEIN. On the foundations of the theory of monopolistic competition. *Econometrica*, 45 (1), 101-113, 1977.

297. Paul CHAMPSAUR, Jacques DREZE and Claude HENRY. Stability theorems with economic applications. *Econometrica*, 45 (2), 273-294, 1977.

298. Andrzej WIECZOREK. On representations of social preferences - an algebraic approach. *Mathematical Economics and Game Theory. Essays in Honor of Oskar Morgenstern*, edited by R. Henn and O. Moeschlin. Springer-Verlag, 234-249, 1977.

299. Anton P. BARTEN and Gonzague d'ALCANTARA. The linkage of models of the EEC countries. *Quantitative Studies of International Economic Relations*, edited by H. Glejser. North-Holland, 25-71, 1976.

300. Jacques H. DREZE. Bayesian limited information analysis of the simultaneous equations model. *Econometrica*, 44 (5), 1045-1075, 1976.

301. Jack EDMONDS and Rick GILES. A min-max relation for submodular functions on graphs. *Annals of Discrete Mathematics*, 1, 185-204, 1977.

302. Laurence A. WOLSEY. Valid inequalities, covering problems and discrete dynamic programs. *Annals of Discrete Mathematics*, 1, 527-538, 1977.

303. Léopold SIMAR. A note on Stieltjes moment sequences. *SIAM Journal on Mathematical Analysis*, 8 (3), 533-534, 1977.

304. Laurence A. WOLSEY. Cubical Sperner lemmas as applications of generalized complementary pivoting. *Journal of Combinatorial Theory, Series A*, 23 (1), 78-87, 1977.

305. Anton P. BARTEN and Gonzague d'ALCANTARA. Models of bilateral trade flows. *Quantitative Wirtschaftsforschung. Wilhelm Krelle zum 60. Geburtstag*, edited by H. Albach, E. Helmstädter und R. Henn. J.C.B. Mohr, 43-57, 1977.

306. Robert G. BLAND. A combinatorial abstraction of linear programming. *Journal of Combinatorial Theory, Series B*, 23 (1), 33-57, 1977.

307. Géry DAENINCK and Yves SMEERS. Using shortest paths in some transshipment problems with concave costs. *Mathematical Programming*, 12, 18-25, 1977.

308. I. ZANG, E.U. CHOO and M. AVRIEL. On functions whose stationary points are global minima. *Journal of Optimization Theory and Applications*, 22 (2), 195-208, 1977.

309. Jean-François MERTENS and Shmuel ZAMIR. The maximal variation of a bounded martingale. *Israel Journal of Mathematics*, 27 (3-4), 252-276, 1977.

310. Jacques H. DREZE, Jean JASKOLD GABSZEWICZ and Andrew POSTLEWAITE. Disadvantageous monopolies and disadvantageous endowments. *Journal of Economic Theory*, 16 (1), 116-121, 1977.

311. Jean-François MERTENS and Shmuel ZAMIR. On a repeated game without a recursive structure. *International Journal of Game Theory*, 5 (4), 173-182, 1976.

312. Jean-François MERTENS and Shmuel ZAMIR. The normal distribution and repeated games. *International Journal of Game Theory*, 5 (4), 187-197, 1976.

313. Pierre DEHEZ and Jean JASKOLD GABSZEWICZ. Saving behaviour and disequilibrium analysis. *Systèmes dynamiques et modèles économiques. Colloques Internationaux du CNRS*, 259, 197-212, 1977.

314. Yves SMEERS. An algorithm for some special nondifferentiable optimization problems. *Operations Research*, 25 (5), 808-817, 1977.

315. Robert G. BLAND. New finite pivoting rules for the simplex method. *Mathematics of Operations Research*, 2 (2), 103-107, 1977.

316. Jacques H. DREZE. Bayesian regression analysis using poly-t densities. *Journal of Econometrics*, 6, 329-354, 1977.

317. Jean-François RICHARD. Bayesian analysis of the regression model when the disturbances are generated by an autoregressive process. *New Developments in the Applications of Bayesian Methods*, edited by A. Aykaç and C. Brumat. North-Holland, 185-209, 1977.

318. Volker BÖHM and Heinz MÜLLER. Two examples of equilibria under price rigidities and quantity rationing. *Zeitschrift für Nationalökonomie*, 37 (1-2), 165-173, 1977.

319. Claus WEDDEPOHL. Equilibrium in a market with incomplete preferences where the number of consumers may be finite. *Equilibrium and Disequilibrium in Economic Theory*, edited by G. Schwödiauer. D. Reidel, 15-26, 1977.

320. Volker BÖHM. Non-stable cores of exchange economies. *Equilibrium and Disequilibrium in Economic Theory*, edited by G. Schwödiauer. D. Reidel, 53-66, 1977.

321. Jean-François MERTENS and Shmuel ZAMIR. A duality theorem on a pair of simultaneous functional equations. *Journal of Mathematical Analysis and Applications*, 60, 550-558, 1977.

322. Roland BLOMME. Etude des propriétés dynamiques d'un modèle non-stationnaire. *Cahiers du Centre d'Etudes de Recherche Opérationnelle*, 19, 339-347, 1977 (*Colloque Séries Chronologiques : Approches Fréquentielle et Temporelle*, 5-6 mai 1977).

323. Françoise SCHOUMAKER. Révélation des préférences et planification : une approche stratégique. *Recherches Economiques de Louvain*, 43, 245-259, 1977.

324. Yves SMEERS. Generalized reduced gradient method as an extension of feasible direction methods. *Journal of Optimization Theory and Applications*, 22, 209-226, 1977.

325. Louis PHLIPS. A taste-dependent true wage index. *Theory and Applications of Economic Theory*, edited by W. Eichhorn. Physica-Verlag, 401-415, 1978.

326. Robert G. BLAND and Michel LAS VERGNAS. Orientability of matroids. *Journal of Combinatorial Theory, Series B*, 94-123, 1978.

327. Gérard CORNUEJOLS and George L. NEMHAUSER. Tight bounds for Christofides' traveling salesman heuristic. *Mathematical Programming*, 14, 116-121, 1978.

328. Laurence A. WOLSEY. Valid inequalities and superadditivity for 0-1 integer programs. *Mathematics of Operations Research*, 2 (1), 66-77, 1977.

329. Jean-Philippe VIAL and Israel ZANG. Unconstrained optimization by approximation of the gradient path. *Mathematics of Operations Research*, 2 (3), 253-265, 1977.

330. Joseph GREENBERG and Benyamin SHITOVITZ. Advantageous monopolies. *Journal of Economic Theory* 16 (2), 394-402, 1977.

331. Serge BOUTE and Victor GINSBURGH. Performances économiques et résultats des élections législatives en Belgique : une approche quantitative. *Recherches Economiques de Louvain*, 43 (4), 345-369, 1977.

332. Jacques H. DREZE and Kare P. HAGEN. Choice of product quality : equilibrium and efficiency. *Econometrica*, 46 (3), 493-513, 1978.

4.3 The following *books* by members or (former) visiting members of the CORE staff were published during the period covered by this report :

- B. BEREANU, *Proceedings of the 5th Conference on probability theory*. Editura Akademiei Republicii Socialiste, Bucuresti, 1977.

- S. CRUCEANU, *Introduction to the Mathematical Theory of the Von Neumann Type Growth Models* (Rumanian). Ed. Academiei RSR, Bucuresti, 1978.

- S. CRUCEANU and C. VANSAN, *Optimal Control and Applications in Economics* (Rumanian). Ed. Tehnica, Bucuresti, 1978.

- L.A. GERARD-VARET, a.o., *Analyse mathématique pour l'économie*. Dalloz, 1977.

- M. MOUCHART et L. SIMAR, *Méthodes non-paramétriques*. UCL, Comité de Statistique, 1978.

4.4 *Editorial Activities*

- J. JASKOLD GABSZEWICZ, associate editor, *Journal of Economic Theory*.

- G.H. KRAMER, associate editor, *Econometrica*,
  editorial board member, *American Political Science Review*,
  editorial board member, *Public Choice*,
  editorial board member, *Journal of Conflict Resolution*.

- L. PHLIPS, Europe managing editor, *Journal of Industrial Economics*,
  associate editor, *European Economic Review*,
  associate editor, *Economics Letters*.

- J.-F. RICHARD, editorial board member, *Review of Economic Studies*,
  associate editor, *Econometrica*.

- H. TULKENS, associate editor, *Public Finance/Finances Publiques*.

4.5 Two research associates at CORE successfully defended their *doctoral dissertation* this year.

- On December 23, 1977, F. SCHOUMAKER, "Révélation des préférences et planification. Une approche stratégique". (Docteur en Sciences Economiques, UCL).

- On March 17, 1978, R. BLOMME, "Etude des propriétés dynamiques d'un modèle stochastique : Application au cas du modèle Anelise". (Docteur en Sciences Economiques, UCL).

5. SEMINARS AND WORKSHOPS

The three regular weekly seminars in econometrics, mathematical economics and operations research were held from October through June. CORE also continued its participation in the sponsorship of the Joint Economics Faculty Workshop. Also, in addition to special series of informal seminars in mathematical economics and econometrics, two workshops were organized. A complete listing of seminars and workshops is given below.

5.1 The *Mathematical Programming Seminar* met as follows.

1. October 11, 1977, G. de GHELLINCK, CORE,
   Max flow and assignment problems revisited.
2. October 18, 1977, I. ZANG, Tel Aviv University,
   A new arc algorithm for unconstrained optimization.
3. October 25, 1977, P. HUARD, Electricité de France,
   Point to set maps (correspondences) : Applications to optimization algorithms.
4. November 8, 1977, J. HO, Brookhaven National Laboratory, New York, and E. LOUTE, CORE,
   A comparative study of two methods for staircase linear programs.
5. November 15, 1977, P. TOLLA, Université de Paris 6,
   Validating certain implementations of the simplex method.
6. November 22, 1977, L. TROTTER, Bonn and Cornell,
   Near-optimal integral solutions to certain classes of linear programming problems.

7. November 29, 1977, J. TIND, CORE,
   Polarity of sets and polyhedra.

8. November 29, 1977, R. MIFFLIN, IIASA,
   Some applications and methods of nonsmooth optimization.

9. December 13, 1977, L.A. WOLSEY, CORE,
   A natural algorithm for maximizing a submodular set function, with application to location problems and Benders decomposition.

10. December 20, 1977, Y. SMEERS, CORE,
    A modified reduced gradient method for a class of nondifferentiable problems with linear constraints.

11. February 7, 1978, S. CRUCEANU, Rumanian Academy of Sciences and CORE
    Concave problems and optimality conditions for some allocation problems.

12. February 14, 1978, J. ANTHONISSE, Mathematisch Centrum Amsterdam,
    Matrix generators for linear programming.

13. April 10, 1978, J. KRARUP, University of Copenhagen,
    Uniloc, a new algorithm for location problems.

14. April 18, 1978, C.E. LEMKE, R.P.I. and E.T.H. Zürich,
    Some pivot schemes for the linear complementarity problem.

15. May 23, 1978, D. AVIS, Mc Gill University and CORE,
    Lower bounds from extremal properties of polyhedra.

5.2 The *Mathematical Economics Seminar* met as follows.

1. October 10, 1977, L. PHLIPS, CORE,
   Intertemporal price discrimination and sticky prices.

2. October 24, 1977, G. LAROQUE, Unité de Recherche, INSEE,
   The fixed price equilibria : some results in local comparative statics.

3. October 24, 1977, J. DREZE, CORE,
   Public goods with exclusion.

4. November 4, 1977, M. MASCHLER, The Hebrew University of Jerusalem,
   The ordinal and the cardinal bargaining sets for games without side-payments.

5. November 14, 1977, S. SLUTSKY, Cornell University and CORE,
   Voting over public goods and general equilibrium.

6. November 23, 1977, E. MALINVAUD, INSEE,
   Research agenda for a theory of the middle-term course of short-run equilibria.
   (Joint with the Econometrics Seminar and the Joint Economics Faculty Workshop.)

7. December 5, 1977, B. HOLMSTRÖM, CORE,
   Moral hazard and observability.

8. December 12, 1977, S. HONKAPOHJA, Yrjö Jahnsson Foundation,
   On the dynamics of disequilibria in a macro model with flexible wages and prices.

9. December 12, 1977, P.J. HAMMOND, University of Essex,
   General asset markets and the existence of temporary Walrasian equilibrium.

10. January 16, 1978, R. AUMANN, The Hebrew University of Jerusalem and CORE,
    Shapley values of public goods economies.

11. January 30, 1978, H. MOULIN, ENSAE and Université de Paris-Dauphine,
    Decision schemes with lotteries : A new approach to Gibbard problem.

12. January 30, 1978, J.-F. MERTENS, CORE,
    The characteristic function of supergames.

13. February 13, 1978, K. SHELL, University of Pennsylvania,
    Applications of the overlapping-generations model to monetary theory.

14. February 13, 1978, D.P. BARON, Northwestern University and KUL,
    Automatic adjustment clauses, efficiency and regulatory policy.

15. February 27, 1978, R. AUMANN, The Hebrew University of Jerusalem and CORE,
    On the rate of convergence of the core.

16. February 27, 1978, P. LEVINE and J.-P. PONSSARD,
    Université de Paris VI and Ecole Polytechnique,
    Power and bargaining.

17. March 6, 1978, Y. TAUMAN, Tel-Aviv University,
    The partition value.

18. March 13, 1978, J. LESOURNE, OECD,
    Theoretical analysis of the firm's policy through a business cycle.

19. March 13, 1978, M. KURZ, Stanford University,
Altruistic equilibrium.

20. April 10, 1978, N. REIF, Universität Hamburg,
The computation of Dreze equilibria.

21. April 10, 1978, I. FRADERA, Universidad Autonoma de Barcelona,
On the convergence of monopolistic to perfect competition.

22. April 24, 1978, J.-P. CROUZEIX, Université de Clermont,
Convexifiability of quasiconvex functions.

23. April 24, 1978, M. QUINZII, Université d'Aix-Marseille,
Dynamic processes for tax reform theory.

24. May 8, 1978, R.P. PARKS, Washington University and CORE,
Voting-market equilibria.

25. May 8, 1978, Y. BALASKO, Université de Paris XII and CEPREMAP
Budget constrained Pareto efficient allocations.

26. June 9, 1978, J. GREENBERG, Virginia Polytechnic Institute,
Consistent majority rules over compact sets of alternatives.

27. June 9, 1978, G.H. KRAMER, Yale University and CORE,
Some solved and unsolved problems in the theory of elections.

28. June 19, 1978, V. BÖHM, Mannheim University and CORE,
Simple macro-economic disequilibrium models.

5.3 The *Econometric Seminar* met as follows.

1. October 12, 1977, I. ZANG, Tel-Aviv University,
   The numerical solutions of switching regression problems.

2. October 19, 1977,
   Presentation of the "Bayesian Regression Programme" Part I
   J.H. DREZE, CORE,
   A users-oriented review of Bayesian methods in econometrics.
   J.-F. RICHARD, CORE,
   A users-oriented review of the models currently covered by BRP.
   L. BAUWENS and J.-F. RICHARD, CORE,
   Introduction to Part II.

3. October 26, 1977,
   Presentation of the "Bayesian Regression Programme" Part II : Application to estimation of a Cobb-Douglas production function for the United States.
   J.-F. RICHARD, CORE,
   Presentation of the model.
   L. BAUWENS, CORE,
   Presentation of the input and results.

4. November 9, 1977, A. CHESHER, University of Birmingham,
   Power transformation to a family of symmetric distributions.

5. November 16, 1977, A. PAGAN, Australian National University and CORE,
   The Lagrange multiplier test and its applications.

6. November 23, 1977, E. MALINVAUD, INSEE, Paris,
   Research agenda for a theory of the middle-term course of short-run equilibria.
   (Joint with the Mathematical Economics Seminar and the Joint Economics Faculty Workshop.)

7. November 30, 1977, A. ZAMAN, CORE,
   Estimating the reciprocal of a normal mean.

8. December 7, 1977, A. DEATON, University of Bristol,
   Testing linear versus logarithmic regression models.

9. December 14, 1977, St. NICKEL, London School of Economics,
   Estimating the probability of leaving unemployment.

10. February 8, 1978, R. BLOMME, IRES and CORE,
    Testing the dynamic properties of an econometric model : An application to the model Anelise.

11. February 15, 1978, A. PAGAN, Australian National University and CORE,
    An approach to estimation and inference for varying coefficients regression models.

12. February 22, 1978, P. MAZODIER, INSEE, Paris,
    Modelisation and estimation for time series of cross sections.

13. March 1, 1978, K. VELUPILLAI, University of Lund and CORE,
    On detecting time varying structures.

14. March 15, 1978, M.R. WICKENS, University of Essex,
    An econometric model of labour turnover in U.K. manufacturing industries 1956-73.

15. March 22, 1978, F. THIJS-CLEMENT, DULBEA (ULB), The reduced form of Breughel II. (A middle-term policy model for Belgium.)

16. April 19, 1978, D. HENDRY, London School of Economics, The demand for narrow money.

17. April 26, 1978, A.F.M. SMITH, University of Nottingham, Bayesian approaches to robustness. (Under joint sponsorship with the Institute of Mathematics, Louvain.)

18. May 3, 1978, J.-J. LAFFONT, Ecole Polytechnique, Paris, Disequilibrium econometrics in simultaneous equations systems.

19. May 10, 1978, D.R. COX, Imperial College, London, Foundations of statistical inference : A review. (Under joint sponsorship with the Institute of Mathematics, Louvain.)

5.4. CORE joined with the Institut des Sciences Economiques of UCL, and the Centrum voor Economische Studies of KUL, to organise a *Joint Economics Faculty Workshop*. The following meetings were held, with the three sponsors taking turns as host.

1. October 27, 1977, A. INGHAM, University of Southampton and Institut des Sciences Economiques (UCL), Communal production in English agriculture and the enclosure movement : A quantitative analysis.

2. December 8, 1977, F. THIJS-CLEMENT and A. BERCKMANS, DULBEA (ULB), Breughel II : Modèle belge à moyen terme de politique économique.

3. February 16, 1978, Ch. KINDLEBERGER, Massachusetts Institute of Technology,
   Ownership or contract in international business.

4. March 23, 1978, J. KAY, Oxford University and ISE,
   The practical case for an expenditure tax.

5. May 3, 1978, W.H. CORDEN, Australian National University,
   Exchange rate protection.

6. May 11, 1978, M. GERARD, Facultés universitaires Notre-Dame de la Paix (Namur),
   Fiscal policy, investment and capacity utilization.

7. May 11, 1978, I. GIDDY, Graduate School of Business, Columbia University, New York,
   A study of exchange rate determination in forward markets.

8. May 22, 1978, F. LAWRENCE, Staff member of the Carnegie Endowment for International Peace, Washington D.C.,
   Current European-American finance policies : An appraisal.

5.5 A series of *lectures* on Shapley value was held in February, March and April and was directed by R.J. AUMANN.

5.6 CORE participated actively in a *seminar* on Dynamic Systems directed by J. ROELS and held at CORE.

5.7 During the second semester , A.R. PAGAN delivered a set of four *lectures* on Estimation of ARMAX Systems.

5.8 The Summer *Workshop* of the Econometric Society was

held and organised at CORE, June 7 - 9, 1978, under the sponsorship of CORE and IBM, Belgium. The topic was Inference Methods in Econometrics. The program and the list of participants are available upon request.

6. GUESTS

In addition to the longer stays of the visiting faculty and research fellows, CORE benefitted from the visits of a number of scholars whose stays ranged from a few days to several months. Among these were :

- A. ANDO, University of Pennsylvania.
- R. AUMANN, The Hebrew University of Jerusalem.
- R. BINOSI, Milano University.
- T. FEARN, University of London.
- L.A. GERARD-VARET, Université Paris-Dauphine.
- J. GREENBERG, Virginia Polytechnic Institute and State University, Blacksburg.
- W. HILDENBRAND, Bonn University
- J. HO, Brookhaven National Laboratory.
- S. HONKAPOHJA, Yrjö Jahnsson Foundation.
- M. KURZ, Stanford University
- M. MASCHLER, The Hebrew University of Jerusalem.
- E. MALINVAUD, INSEE, Paris.
- G. NEMHAUSER, Cornell University.
- U. SCHWEIZER, Bonn University.
- C. SIMS, Minnesota University.
- K. STAHL, Dortmund University.
- Y. TAUMAN, Tel-Aviv University.
- L. TROTTER, Bonn and Cornell University
- S. ZAMIR, The Hebrew University of Jerusalem
- I. ZANG, Tel-Aviv University.

7. ACADEMIC VISITS

Academic visits by CORE members to other institutions.

July 1977
- V. GINSBURGH, University of Stockholm
- E. LOUTE, Brookhaven National Laboratory.

August 1977
- G. de GHELLINCK, University of Vancouver, Canada.
- E. LOUTE, Brookhaven National Laboratory.

September 1977
- Y. SMEERS, Brookhaven National Laboratory.

November 1977
- L. PHLIPS, Université Libre de Bruxelles.
- H. TULKENS, Université Paris XII.
- K. VELUPILLAI, Cambridge University.

December 1977
- P. DEHEZ, University of Bonn.
- L. PHLIPS, University of Bristol.

January 1978
- G.H. KRAMER, University of Bonn
  University College of London.
- J.-Ph. VIAL, University of Dortmund.
- L. WOLSEY, Lunteren, Holland.

February 1978
- V. BÖHM, University of Essex.
- J. DREZE, Norwegian School of Economics, Bergen.
- M. TRUCHON, Université de Genève.

- K. VELUPILLAI, London School of Economics
  Cambridge University.

March 1978
- L. PHLIPS, Facultés Universitaires Notre-Dame de la Paix, Namur.

April 1978
- A. BARTEN, Katholieke Hogeschool Tilburg, Holland.
- J. DREZE, International Institute for Applied Systems Analysis, Vienna.
- B. HOLMSTRÖM, Ecole Polytechnique, Paris.
- J. JASKOLD GABSZEWICZ, University of Bonn.
- J. TIND, University of Bonn.
- H. TULKENS, University of Copenhagen.

May 1978
- J. DREZE, University of Essex, Colchester.
- J. JASKOLD GABSZEWICZ, University of Bonn
  Université d'Aix-Marseille II.
- G.H. KRAMER, University of Zürich.
- M. MOUCHART, Université d'Aix-Marseille II
- A. PAGAN, University of Lund, Sweden
  INSEE, Paris.
- J. TIND, University of Köln.
- M. TRUCHON, Ecole Polytechnique, Paris.

June, 1978
- D. AVIS, Université de Paris
  Electricité de France
- J. JASKOLD GABSZEWICZ, University of Bonn.
- M. TRUCHON, Université de Genève.
- K. VELUPILLAI, Perugia University
  International Mathematical Summer Centre, Cortona.

8. CONFERENCES AND MEETINGS

8.1 Organisation of *Meetings*

CORE members participated in the organisation of the following conferences.

August 1977

- Advanced Research Institute on Discrete Optimization and Systems Applications, University of British Columbia, Chairman session on Networks, Assignments, Travelling Salesman Problems : G. de GHELLINCK.

September 1977

- European Meeting of the Econometric Society, Vienna, Co-chairman in econometrics : J.-F. RICHARD.
  Members of the program committee : M. DESAI, M. MOUCHART, L. PHLIPS, H. TULKENS.

November 1977

- Statistics Day of the Société Belge de Statistique, Bruxelles,
  L. PHLIPS.

January 1978

- Fourth Cycle Seminar in Statistical Analysis, Louvain-la-Neuve,
  M. MOUCHART, J.-F. RICHARD, L. SIMAR.

April 1978

- Fourth Cycle Seminar in Nondifferentiable Optimization, Namur,
  E. LOUTE, H. NGUYEN, J.-Ph. VIAL.

June 1978

- Summer Workshop of the Econometrics Society, Louvain-la-Neuve,
  Chairman : J.-F. RICHARD,
  Member of the program committee : A. PAGAN.

8.2 *Attendance*

CORE members attended the following *conferences* and most presented papers.

July 1977

- Summer Research Workshop, University of Warwick,
  L. PHLIPS.
- XIII TIMS Meeting, Athens,
  Y. SMEERS.

August 1977

- Meeting of the European Statistician, Leuven,
  M. MOUCHART.
- Advanced Research Institute on Discrete Optimization and Systems Applications, Banff, Canada,
  G. de GHELLINCK, L. WOLSEY.

September 1977

- European Meeting of the Econometric Society, Vienna,
  Cl. d'ASPREMONT, P. DEHEZ, J. JASKOLD GABSZEWICZ,
  M. MOUCHART, L. PHLIPS, J.-F. RICHARD, H. TULKENS.
- Symposium on Extremal Methods, Austin, Texas,
  Y. SMEERS.
- Combinatorial Programming Conference, University of
  Liverpool,
  L. WOLSEY.

January 1978

- School for Economic Planning for Government and Industry,
  SOGESTA, Urbino (Italy),
  A. BARTEN, G. CARRIN.
- Winter Symposium of the Econometric Society, Sindelfingen,
  P. DEHEZ.
- NATO Conference on Disequilibrium,
  V. BÖHM, P. DEHEZ, J. DREZE.
- Séminaire sur l'Emploi des Modèles pour l'Evaluation des
  Possibilités d'Economie d'Energie, Commission Economique
  pour l'Europe, Genève,
  Y. SMEERS.

February 1978

- Symposium on Convex Analysis and Mathematical Economics,
  Tilburg, Holland,
  S. CRUCEANU, P. DEHEZ, J. TIND, M. TRUCHON.
- Inter-University Seminar in Statistics, ULB,
  A. PAGAN.

- London School of Economics, Econometrics Seminar,
  K. VELUPILLAI.

March 1978

- Southampton Department of Economics Staff Seminars,
  Southampton,
  A. PAGAN.
- Study Group in Econometrics, London School of Economics,
  A. PAGAN.
- Public Choice Society Meeting, New Orleans,
  S. SLUTSKY.
- Seminar on Energy Modelling, Ecole Polytechnique Fédérale
  de Lausanne,
  Y. SMEERS.

April 1978

- Public Economics Symposium organised for the 50th Anniversary of the University of Aarhus, Denmark,
  H. TULKENS.

May 1978

- Symposium on Optimization of Dynamic Problems, European Institute for Advanced Studies in Management, Bruxelles,
  Cl. d'ASPREMONT, P. DEHEZ, H. TULKENS.
- NBER Control Conference, Austin, Texas,
  K. VELUPILLAI.
- Colloque sur les Structures Economiques et Econométrie,
  Université de Lyon,
  Cl. d'ASPREMONT.

- Journées Rhodaniennes de l'Econométrie et de Mathématique Economique, Lyon,
  J. JASKOLD GABSZEWICZ.
- Journées de l'Optimisation, Montréal,
  F. LOUVEAUX.
- Journées d'Etudes du Programme National R-D Energie, Wepion, Belgique,
  Y. SMEERS.

June 1978

- Léon Walras Seminar, CEPREMAP, Paris,
  J. DREZE, G.H. KRAMER.
- Summer Workshop of the Econometric Society, Louvain-la-Neuve,
  M. MOUCHART, A. PAGAN, J.-F. RICHARD.
- Modelling and Control in River Quality, Florence,
  Y. SMEERS.

9. INSTITUTIONAL ASPECTS

9.1 *Management*

New officers elected for the period September 1977 - August 1980 are :

President : J. DREZE
Research Director : J. JASKOLD GABSZEWICZ
Executive Committee : J.-F. RICHARD and L. WOLSEY

9.2 *Internal Rules*

Further modifications were made to increase the opportunity for more general participation in CORE's management.

9.3 *External Support*

Part of CORE's research activities continue to be supported by external sources :

A. CORE's Ford Grant was extended through 1979 without any further appropriation. The unexpended balance will enable CORE to support a Research Fellow from Eastern Europe during the next year.

B. The Belgian Government supports two projects :

(i) development of computer programs and software for statistical decision making, supervised by G. de GHELLINCK;

(ii) modelling of production of energy, supervised by
Y. SMEERS.

C. The Commission of the European Economic Community supports 3 projects :

(i) building a medium-term econometric model of the EEC, supervised by
A. BARTEN;

(ii) implementation of large scale linear programming techniques in global energy models
Part I
Part II
supervised by
Y. SMEERS.

D. The "Fonds de la Recherche Fondamentale Collective" supports one project

(i) inflation in an international context, supervised by
A. BARTEN.