

**"SEMI-COMPETITIVE COURNOT EQUILIBRIUM
IN MULTISTAGE OLIGOPOLIES"**

by
Sjur Didrik FLAM*
Georges ZACCOUR**

N° 88 / 26

* Sjur Didrik FLAM, Institute of Economics, University of Bergen, Norway

** Georges ZACCOUR, GERAD, Ecole des H.E.C., Montréal, Canada, and
Visiting Scholar at INSEAD, Fontainebleau, France

Director of Publication :

Charles WYPLOSZ, Associate Dean
for Research and Development

Printed at INSEAD,
Fontainebleau, France

SEMI-COMPETITIVE COURNOT EQUILIBRIUM IN MULTISTAGE OLIGOPOLIES¹⁾

Sjur Didrik Flåm*

Georges Zaccour**

* Institute of Economics, University of Bergen, N-5008
Bergen, Norway.

** GERAD, H.E.C., 5255 av. Decelles Montreal, Québec,
Canada H3T1V6 and INSEAD, 77305 Fontainebleau Cedex,
France.

Key words. Non-cooperative Games, Nash-Cournot Equilibria,
Multi-stage Oligopolies, Dynamic Programming.

1) The research has been supported in part by the Royal
Norwegian Council of Industrial and Scientific Research and
CRSNG-Canada.

ABSTRACT This paper deals with efficient computation of a certain type of Nash-Cournot equilibria in multi-stage oligopolies. The generic structure analyzed herein represents the case when at any one stage a single homogeneous output is produced that serves as the only input to the subsequent stage. Thus at each intermediate level in the production process several non-cooperative firms competitively buy appropriate quantities of one single input, transform these quantities, and then, à la Cournot, sell their homogeneous output further on. Eventually, at the final stage a finished product emerges to satisfy competitive demand. For such interrelated markets, suffering from imperfect competition, we propose to find non-cooperative equilibria by a dynamic programming approach. When cost are quadratic and final demand is linear it is shown that one backward recursion followed by a forward sweep, produces equilibrium solutions. This provides a facility to analyze issues on integration and mergers.

1. INTRODUCTION

The aim of this paper is to find equilibrium outcomes in industries composed of noncooperative firms where production proceeds through several stages. For simplicity we focus on the case involving single input-output and material balance throughout a sequential transformation process. To fix ideas one may think of the distribution of a single good via intermediate oligopolistic markets to satisfy final demand. We emphasize that firms need not be (vertically) integrated. However, effects of

integration and mergers (or incentives in such directions) can easily be analyzed within our framework, see Greenhut and Ohta [1976], [1979], Perry [1978], Haring and Kaserman [1978].

At any event, firms specializing in some production stage(s), will demand input from the preceding stage and convert this to a good needed one step further down-stream. Similar firms thus confront one another in the markets for input and output. To simplify we shall focus on the case where firms behave as if they were competitive (i.e. strategic dummies) in input markets and oligopolistic only with respect to output.

Our interest lies in finding production levels that will persist under individual attempts to reoptimize. More precisely, we seek stable outcomes in the sense that no single firm would regret its activities given the choice of all rivals. Such configurations, called Nash noncooperative equilibria, lies at the heart of a voluminous literature in economics, mathematical programming and operations research. If firms were totally integrated along the production stream, this paper would add little to celebrate the 150th anniversary of Cournot [1838]. However, contributions to multi-stage oligopoly theory are of recent date, see Salant et al. [1983], Waterson [1982], Sherali and Leleno [1987]. Also refer to Haurie and Breton [1985].

We also pursue this new direction, our concern being mainly with algorithms. The novelty here is to demonstrate that important problem instances may be easily solved by recursive computation

of equilibria in the constituent single-stage oligopolies.

The idea is simple. In general, any oligopoly located at one stage in the production line who faces a demand curve for its product will generate a (derived, competitive) demand curve for input from the preceding stage. This simple observation lends itself to a dynamic programming argument. Section 3 and 4 spell out the details. There we bring to fore the amenable case when the derived demand curve at some stage can be identified completely just by means of one equilibrium realization conditioned upon an arbitrary price for inputs. More generally, we show that derived demand for input is piece-wise linear provided product demand is of the same sort and costs are quadratic. Consequently, under such hypothesis, we need only estimate few points on the derived curve and associated slopes in order to advance our calculus one step up-stream. Ultimately we find the first stage demand curve and thereby the first stage equilibrium price. Proceeding from this price a single forward sweep furnishes equilibrium quantities and market clearing prices in all downstream oligopolies.

The paper is organized as follows. Section 2 provides a formal version of the model and lays the foundation for using dynamic programming. Section 3 characterizes equilibria and exhibits the optimality conditions that are used in Section 4 to compute derived demand functions. Section 5 terminates with some remarks.

2. THE MODEL AND PRELIMINARIES

This section formalizes the decision problem of each firm, and goes on to discuss existence, characterization and uniqueness of equilibria.

At each stage $t \in \{1, 2, \dots, T\}$, firm $i \in I_t$, $|I_t| < +\infty$, will avail itself with inputs $x_{it-1}^0 \geq 0$ at unit cost $p_{t-1} \geq 0$, in order to produce and sell a single homogenous output in quantities x_{it} at price $p_t \geq 0$. For notational simplicity we assume that $x_{it-1}^0 = x_{it}$, although a linear transformation

$$x_{it} = a_{it}x_{it-1}^0$$

with $a_{it} > 0$, can easily be accommodated.

The initial price p_0 is given. With no loss of generality we set it equal to zero. Prices p_1, \dots, p_T are endogenous and must have the property that all markets are cleared. Precisely how prices are determined in practice will not occupy our attention.

Indeed, as Cournot himself we shall leave the actual process of price formation in some obscurity.

The analysis relies on the following construction. Final demand is governed by a specified inverse law $P_T(\cdot)$. Conceive now of the input price p_{T-1} as a given parameter. Then non-cooperative optimization, that is to say, the (alleged unique) Nash-Cournot equilibrium of the (parametrized) last stage oligopoly, yields a derived demand $X_{T-1}(p_{T-1})$ for inputs. We invert this relation to have the (inverse) schedule $P_{T-1}(\cdot)$.

This essentially reduces the hierarchical game from T to $T-1$ stages, because $P_{T-1}(\cdot)$ is the only down-stream information firms at stage $T-1$ need. With $P_{T-1}(\cdot)$ perfectly known we then treat P_{T-2} as a parameter to let $(T-1)$ -stage equilibria generate the derived schedule $P_{T-2}(\cdot)$, and so on.

This backward recursion continues until finally $P_1(\cdot)$ is listed as an extensive catalogue. Then time has come to solve the first stage oligopoly to find equilibrium quantities x_{i1}^* , $i \in I_1$, the associated aggregate supply

$$X^* = \sum_{i \in I_1} x_{i1}^*$$

and the equilibrium prices

$$p_t^* = P_t(X^*), \quad t = 1, \dots, T.$$

Since the X^* is known to prevail at all stages, it is relatively easy now to find x_{it}^* , $i \in I_t$, $t > 1$, as being zero or a root of the optimality equation

$$p_t^* - p_{t-1}^* + P_t'(X^*)x_{it} - c_{it}'(x_{it}) = 0,$$

where $c_{it}(x_{it})$ is the production cost of firm $i \in I_t$.

To reiterate, we say that

$x_{it}^* \geq 0$, $i \in I_t$, $t \in \{1, \dots, T\}$ with aggregate supply X^* at all stages, is a multi-stage, semi-competitive Cournot equilibrium if

for each stage $t \in \{1, \dots, T\}$, the production levels x_{it}^* , $i \in I_t$, constitute a non-cooperative solution for the oligopoly located there provided this oligopoly faces derived demand $P_t(\cdot)$ and must pay a unit price $P_{t-1}(X^*)$ for inputs.

This definition begs several questions. Above all, when is existence of an equilibrium ensured, and if so, how can it be found? In order to address these questions the rest of this paper is devoted first, to technical issues that we glossed over so far, and second, to make the above scheme computationally tractable.

3 EXISTENCE AND CHARACTERIZATION OF EQUILIBRIA

The decision problem of a firm $i \in I_t$, $t \in \{1, \dots, T\}$, is to

$$(3.1) \quad \text{maximize } x_{it}[P_t(X_t) - p_{t-1}] - c_{it}(x_{it})$$

subject to $x_{it} \geq 0$. Here

$$X_t = \sum_{i \in I_t} x_{it}$$

is the aggregate output at stage t . In order to focus on essentials, let us consider the generic problem of a single oligopolist:

$$(3.2) \quad \text{maximize } xP(X+x) - c(x) \quad \text{over } x \geq 0,$$

where X_- , the aggregate supply of rivals, and total supply X are related by

$$X = X_- + x.$$

Clearly, (3.1) is a particular instance of (3.2) with

$$P = P_t, \quad x = x_{it}, \quad c(x) = c_{it}(x) + p_{t-1}x, \quad \text{and } X = X_t.$$

3.1. Existence of multi-stage equilibria.

Let us first turn to existence of single-stage equilibria. As in more general non-cooperative games it suffices that each firm's profit be quasi-concave and upper semi-continuous in its own output (provided, of course, some compactness or coercivity condition comes into play).

Usually concavity properties of the objectives are ensured by imposing conditions on demand and cost functions separately. In this respect the following example is interesting. Suppose $XP'(X)$ is decreasing and P is twice continuously differentiable, strictly decreasing on $[0, \infty)$. Then Murphy et.al. [1982] show that for each $X_- \geq 0$,

$$xP(X_- + x)$$

is strictly concave in x on $[0, \infty)$. Thus, under these hypothesis, it would complete the scenario, using concave criteria, to require that cost be convex functions. However, Novshek [1985]

has recently demonstrated that it is really not necessary to go that far. As long as $XP'(X)$ decreases it suffices for existence that demand and cost functions are differentiable and monotone.

Coming now to the multi-stage problem, the crucial point is what features a derived demand curve will inherit from down-stream cost and demand functions. It is generally known that optimization tends to destroy smoothness properties. Thus in general it seems not wise to expect much more than Lipschitz continuity of derived demand. This will also be confirmed and brought out by the subsequent development. For now we shall circumvent all of these difficulties by considering only a special, but important case.

PROPOSITION 1. Suppose final demand $P_T(\cdot)$ is linear decreasing and all cost functions c_{it} , $i \in I_t$, $t \geq 2$ are quadratic convex. Also suppose that all firms are active and that there exists a quantity $X^- > 0$ such that

$$(3.3) \quad c'_{it}(X^-) \geq P_T(X^-) \quad \text{for all } i \in I_t, \quad t \geq 1.$$

Then a multi-stage equilibrium will exist provided c_{i1} , $i \in I_1$ are all monotone differentiable, or all convex.

PROOF. It is shown in Section 4 that all derived demand functions P_t , $t \in \{1, \dots, T\}$ are linear decreasing. Thus existence of a first stage equilibrium is granted by features of P_1 and by Novshek's result [1985], or alternatively by the concavity of individual profit functions at stage 1. Condition (3.3) serves

to bound solutions to the interval $[0, |I_T|X^-]$ since no final stage firm will find it profitable to produce more than X^- .

■

3.2. Characterization of equilibria.

First we point out that the non-negativity constraint $x \geq 0$ in (3.2) can reasonably be dropped. Towards this suppose that any price function $P(\cdot)$ considered in this paper is non-negative and non-increasing. We may extend both functions $P(\cdot)$ and $c(\cdot)$ in (3.2) to be defined for negative arguments without violating the natural condition that $P(\cdot)$ still be non-negative, non-increasing and $c(\cdot)$ be strictly decreasing over $(-\infty, 0]$. (Also, with no loss, let these extensions be say, twice differentiable over $(-\infty, 0]$). After this modification of the givens in problem (3.2), the profit mentioned there will increase over $(-\infty, 0]$. This is so because increasing $x^- < 0$ to $x \leq 0$, implies, with $p := P(X_+ + x)$ and $p^- := P(X_+ + x^-)$, that profit changes by the amount

$$\begin{aligned} & [xp - c(x)] - [x^-p^- - c(x^-)] \\ = & c(x^-) - c(x) + (x - x^-)p + x^-(p - p^-) > 0. \end{aligned}$$

The upshot of this is that (3.2) may equivalently be replaced by its unconstrained version

$$(3.4) \quad \text{maximize } \pi(X_+, x) := xP(X_+ + x) - c(x).$$

This replacement entails obvious analytical advantages.

Specifically, provided some weak form of smoothness, the necessary optimality condition of (3.2) now becomes

$$(3.5) \quad 0 \in \partial_x \pi(X_{-i}^*, x^*)$$

where ∂_x denotes the generalized partial gradient (set) in the sense of Clarke [1983]. In fact, since P , as previously remarked, is in general not differentiable, nonsmooth analysis seems to offer the appropriate set of tools.

(3.5) can be reformulated in a variational sense, namely that

$$(3.6) \quad \pi'(X_{-i}^*, x^*; x - x^*) \leq 0 \quad \text{for all } x \geq 0,$$

where the left hand side of (3.6) denotes a generalized directional derivative (with respect to x) at x^* in the direction $x - x^*$. This reformulation leads us to recognize (3.6) as a sufficient condition whenever π is pseudo-concave in x , see Bazarra and Shetty [1979]. (3.6) also bears on existence and uniqueness of equilibria. To see this, denote by I the set of firms forming the single-stage oligopoly in question, and let

$$(3.7) \quad m(x) := (\partial_{x_i} \pi_i(X_{-i}, x_i))_{i \in I}$$

be the (possibly non-unique) vector of marginal revenues $\partial \pi_i$ evaluated at $x = (x_i)_{i \in I}$ with X_{-i} being the aggregate supply of firm i 's rivals.

If $m(\cdot)$, as defined in (3.7), is (strictly) monotone in the sense that for all $x, \bar{x} \geq 0, x \neq \bar{x}$ we have

$$(3.8) \quad \langle m(x) - m(\bar{x}), x - \bar{x} \rangle \leq 0 \quad (\langle 0, \text{ respectively}),$$

then existence is granted (again under compactness assumptions), and moreover, uniqueness will follow from strict monotonicity, see Auslender [1976]. We refer to Harker [1986] for conditions on demand and cost functions that yield monotonicity, and to Harker, Pang [1987] for a review of the variational inequality approach.

We now conclude this section by stating some of the above results in a form needed for our purposes.

PROPOSITION 2. Suppose all derived demand curves and all cost functions are such that individual (derived) profits are partially differentiable in the sense of nonsmooth analysis. Also suppose that individual profits are strictly pseudo-concave or alternatively, that marginal profits are strictly monotone as in (3.7). Then for each input price $p_{t-1} \geq 0$ at stage $t \in \{1, \dots, T\}$ there exists a unique Cournot equilibrium at that stage satisfying the system

$$(3.9) \quad 0 \in P_t(X_t) - p_{t-1} + P'_t(X_t)x_{it} - c'_{it}(x_{it})$$

where $X_t = \sum_{i \in I_t} x_{it}$ is the aggregate supply.

Thus (x_{it}^*) is an equilibrium with aggregate supply $X^* = \sum_{i \in I_1} x_{i1}^*$ if and only if

$$(3.10) \quad 0 \in P_t(X^*) - P_{t-1}(X^*) + P_t'(X^*)x_{it}^* - c_{it}'(x_{it}^*)$$

for all $i \in I_t$, $t \geq 1$, with $P_0 \equiv 0$. ■

Remark. (3.9) says grosso modo that marginal revenue equals the cost of input. We observe that under the hypothesis of Prop. 2, derived demand $X_t(p_{t-1})$ is well defined.

COROLLARY. We posit the assumption of Prop. 1 with c_{i1} , $i \in I_1$ being convex. Then $(x_{i,t}^*)$ is an equilibrium if and only if equation system (3.10) is satisfied. Moreover, this solution is unique.

PROOF. Again, as shown in Section 4, all derived demand functions P_t , $t \in \{1, \dots, T\}$ are linear decreasing. Then all individual profit functions are easily seen to be strictly concave, hence strictly pseudo-concave. ■

4. DERIVED DEMAND CURVES.

In this section we make explicit how derived demand can efficiently be identified.

Right at the outset we remark that, in principle, it is possible to tabulate $P_{t-1}(\cdot)$ by solving for the stage t Cournot equilibrium $(x_{it}(p_{t-1}))_{i \in I_t}$ (supposed here to be unique) as a function of input price p_{t-1} , then summing to get a (supposedly decreasing) aggregate demand

$$X_t(p_{t-1}) = \sum_{i \in I_t} x_{it}(p_{t-1})$$

However, this laborious task should be reduced by exploiting the fact that for specified p_{t-1} , both $X_t(p_{t-1})$ and its derivative can often be assessed simultaneously with no extra effort.

Indeed, referring back to (3.9) let us suppose that this inclusion is satisfied as an equation with P_t piecewise linear and c_{it} quadratic. For given input price p_{t-1} , denote by $I_t(p_{t-1})$ the set of firms $i \in I_t$ that face zero right-hand marginal profit. Then (3.9) takes on the form

$$(4.0) \quad P_t(X) - p_{t-1} + P_t^+(X)x_{it} - c'_{it}(x_{it}) = 0$$

where $P_t^+(X)$ denotes the right hand derivative of P_t at X . Firms in $I_t(p_{t-1})$ will not increase their production unless inputs become cheaper. Thus, upon differentiating (4.0) with respect to p_{t-1} from the left, we obtain

$$(4.1) \quad P_t^+ X_t^- - 1 + (P_t^+ - c_{it}^'') x_{it}^- = 0$$

where X_t^- , x_{it}^- denote left hand derivatives. Assume that $P_t^+ - c_{it}^'' < 0$, which is quite reasonable since $P_t^+ \leq 0$, $c_{it}^'' \geq 0$, and let

$$(4.2) \quad \varphi_t^- = \sum_{i \in I_t(p_{t-1})} 1 / (P_t^+ - c_{it}^'')$$

Now divide (4.1) by $P_t^+ - c_{it}^''$ and sum over $i \in I_t(p_{t-1})$ to yield

$$\varphi_t^- P_t^+ X_t^- - \varphi_t^- + X_t^- = 0,$$

i.e.

$$(4.3) \quad X_t^- = \frac{\varphi_t^-}{\varphi_t^- P_t^+ + 1}$$

The argument leading to (4.3) focused on firms that enjoy profitable production or are just about to do so. That is to say, their right hand marginal profit is actually zero. By contrast, when seeking the right hand derivative of X_t , no currently inactive firm should contribute to the sum in (4.2). Specifically,

$$(4.4) \quad X_t^+ = \varphi_t^+ / (\varphi_t^+ P_t^-(x_t) + 1)$$

where φ_t^+ is defined as in (4.2) but with the sum extending only over currently active firms.

The right hand sides of (4.3) and (4.4) are piecewise constant. This is a consequence of the following facts: One-sided derivatives of the demand function are themselves piecewise constant, all c_i'' are constant, and finally, the sums in question (e.g. (4.2)) range over piecewise invariant subsets of I_t . The upshot of all this is that at some threshold prices p_{t-1} the curve $X_t(p_{t-1})$ will change its slope. Such thresholds coincide with points where $P_t(\cdot)$ is kinked, or they stem from the exit or entry of some firm $i \in I_t$. Thus X_t is not globally linear, but rather only piecewise so.

We notice that any slope given by (4.3) or (4.4) is negative. Thus the derived inverse demand is strictly downward sloping.

Here it is appropriate to inquire about further curvature properties of derived demand. For this suppose that $P_t(\cdot)$ is convex. Being also piecewise linear the convexity amounts to the statement that

$$P_t^+ \geq P_t^-$$

which implies

$$\varphi^+ \geq \varphi^-$$

and, most important,

$$X_t^+ \geq X_t^-,$$

saying that X_t is also convex.

We summarize these findings in the following

PROPOSITION 3 Suppose final demand of any oligopoly is piecewise linear strictly decreasing and individual costs are quadratic. Then competitive derived demand for inputs to that oligopoly is

also piecewise linear strictly decreasing. If final demand in addition is convex, then derived demand is also so.

Kinks of the latter curve are explained by entry and exit of individual firms or by nonsmoothness of final demand.

Derived demand is linear in the particular case when final demand is also linear and all firms are active.

5. CONCLUDING REMARKS.

Viewed with an eye towards applications the model presented here has the weakness that no firm realizes and utilizes its market power when buying inputs. If indeed it did, equation (3.9) would no longer be valid. Also, the dynamic programming approach would have to be modified.

For computational reasons we have focused on the case with linear final demand and quadratic cost functions. If such conditions are not met, one might start out by linearizing final demand and by approximating cost functions to second order around some consistent reference trajectories. In the next iteration these functional approximations would be updated around the equilibrium solution just computed. To analyze convergence of such procedures refer to Harker, Pang [1987] and the references therein.

REFERENCES

- AUSLENDER, A. 1976. .Optimisation, Methodes Numeriques Masson, Paris.
- BAZARAA, M. S. AND C. M. SHETTY. 1979. Nonlinear Programming. J. Wiley, New York.
- CLARKE, F. H. 1983. Nonsmooth Analysis and Optimization, J. Wiley, New York
- COURNOT, A. A. 1838. Recherches sur les Principes Mathématiques de la Théorie des Richesses. In Librairie de Sciences Politiques et Sociale. M. Riviers & Cie, Paris.
- GREENHUT, M. L. AND H. OHTA. 1976. Related Market Conditions and Interindustrial Mergers. American Economic Review 66, 267-277.
- GREENHUT, M. L. AND H. OHTA. 1979. Vertical Integration of Successive Oligopolies. American Economic Review 69, 137-141.
- HARING, J. R. AND D. L. KASERMAN. 1978. Related Market Conditions and Inter-industrial Mergers: Comment. American Economic Review 68, 225-227.
- HARKER, P. T. 1986. Alternative Models of Spatial Competition. Operations Research, 34, 3, 410-425.
- HARKER, P. T. AND J-S. PANG. 1987. Finite-dimensional Variational Inequality and Non-linear Complementarity Problems: A Survey of Algorithms and Applications, Working Paper, Wharton School, Department of Decision Sciences.
- HAURIE, H. AND M. BRÉTON. 1985. Market Equilibrium in a Multistage Commodity Network. Automatica, 21, 5, 585-596.
- MURPHY, F. H., H. D. SHERALI AND A. L. SOYSTER. 1982. A Mathematical Programming Approach for Determining Oligopolistic Market Equilibrium. Mathematical Programming 24, 92-106.
- NOVSHEK, W. 1984. Finding all n-Firm Cournot Equilibria. International Economic Review 25, 61-70.
- NOVSHEK, W. 1985. On the Existence of Cournot Equilibrium. Review of Economic Studies, 52, 85-98.
- PERRY, M. K. 1978. Related Market Conditions and Interindustrial Mergers: Comment. The American Economic Review 68, 221-224.
- SALANT, S. W., S. SWITZER AND R. J. REYNOLDS. 1983. Losses From Horizontal Merger: The Effects of an Exogenous Change in Industry Structure on Cournot-Nash Equilibrium. The

Quarterly Journal of Economics 98, 185-199.

SHERALI, H. D. AND J. M. LELENO. A Mathematical Programming Approach to a Nash-Cournot Equilibrium Analysis for a Two-Stage Network of Oligopolies. To appear in Operations Research.

WATERSON, M. 1982. Vertical Integration, Variable Proportions and Oligopoly. The Economic Journal 92, 129-144.

INSEAD WORKING PAPERS SERIES

1985

- 85/01 Jean DERMINE "The measurement of interest rate risk by financial intermediaries", December 1983, Revised December 1984.
- 85/02 Philippe A. NAERT and Els GIJSBRECHTS "Diffusion model for new product introduction in existing markets" .
- 85/03 Philippe A. NAERT and Els GIJSBRECHTS "Towards a decision support system for hierarchically allocating marketing resources across and within product groups" .
- 85/04 Philippe A. NAERT and Marcel WEVERBERGH "Market share specification, estimation and validation: towards reconciling seemingly divergent views" .
- 85/05 Ahmet AYKAC, Marcel CORSTJENS, David GAUTSCHI and Ira HOROWITZ "Estimation uncertainty and optimal advertising decisions", Second draft, April 1985.
- 85/06 Kasra FERDOWS "The shifting paradigms of manufacturing: inventory, quality and now versatility", March 1985.
- 85/07 Kasra FERDOWS, Jeffrey G. MILLER, Jinchiro NAKANE and Thomas E. VOLLMANN. "Evolving manufacturing strategies in Europe, Japan and North-America"
- 85/08 Spyros MAKRIDAKIS and Robert CARBONE "Forecasting when pattern changes occur beyond the historical data" , April 1985.
- 85/09 Spyros MAKRIDAKIS and Robert CARBONE "Sampling distribution of post-sample forecasting errors" , February 1985.
- 85/10 Jean DERMINE "Portfolio optimization by financial intermediaries in an asset pricing model".
- 85/11 Antonio M. BORGES and Alfredo M. PEREIRA "Energy demand in Portuguese manufacturing: a two-stage model".
- 85/12 Arnoud DE MEYER "Defining a manufacturing strategy - a survey of European manufacturers".
- 85/13 Arnoud DE MEYER "Large European manufacturers and the management of R & D".
- 85/14 Ahmet AYKAC, Marcel CORSTJENS, David GAUTSCHI and Douglas L. MacLACHLAN "The advertising-sales relationship in the U.S. cigarette industry: a comparison of correlational and causality testing approaches".
- 85/15 Arnoud DE MEYER and Roland VAN DIERDONCK "Organizing a technology jump or overcoming the technological hurdle".
- 85/16 Hervig M. LANGOHR and Antony M. SANTOMERO "Commercial bank refinancing and economic stability: an analysis of European features".

- 85/17 Manfred F.R. KETS DE VRIES and Danny MILLER "Personality, culture and organization".
- 85/18 Manfred F.R. KETS DE VRIES "The darker side of entrepreneurship".
- 85/19 Manfred F.R. KETS DE VRIES and Dany MILLER "Narcissism and leadership: an object relations perspective".
- 85/20 Manfred F.R. KETS DE VRIES and Dany MILLER "Interpreting organizational texts".
- 85/21 Hervig M. LANGOHR and Claude J. VIALLET "Nationalization, compensation and wealth transfers: France 1981-1982" 1, Final version July 1985.
- 85/22 Hervig M. LANGOHR and B. Espen ECKBO "Takeover premiums, disclosure regulations, and the market for corporate control. A comparative analysis of public tender offers, controlling-block trades and minority buyout in France", July 1985.
- 85/23 Manfred F.R. KETS DE VRIES and Dany MILLER "Barriers to adaptation: personal, cultural and organizational perspectives".
- 85/24 Spyros MAKRIDAKIS "The art and science of forecasting: an assessment and future directions".
- 85/25 Gabriel HAWAVINI "Financial innovation and recent developments in the French capital markets", October 1985.
- 85/26 Karel O. COOL and Dan E. SCHENDEL "Patterns of competition, strategic group formation and the performance case of the US pharmaceutical industry, 1963-1982", October 1985.
- 85/27 Arnoud DE MEYER "European manufacturing: a comparative study (1985)".
- 1986
- 86/01 Arnoud DE MEYER "The R & D/Production interface".
- 86/02 Philippe A. NAERT Marcel WEVERBERGH and Guido VERSWIJVEL "Subjective estimation in integrating communication budget and allocation decisions: a case study", January 1986.
- 86/03 Michael BRIMM "Sponsorship and the diffusion of organizational innovation: a preliminary view".
- 86/04 Spyros MAKRIDAKIS and Michèle HIBON "Confidence intervals: an empirical investigation for the series in the M-Competition" .
- 86/05 Charles A. WYPLOSZ "A note on the reduction of the workweek", July 1985.

86/06	Francesco GIAVAZZI, Jeff R. SHEEN and Charles A. WYPLOSZ	"The real exchange rate and the fiscal aspects of a natural resource discovery", Revised version: February 1986.	86/22	Albert CORHAY, Gabriel A. HAWAVINI and Pierre A. MICHEL	"Seasonality in the risk-return relationships some international evidence", July 1986.
86/07	Douglas L. MacLACHLAN and Spyros MAKRIDAKIS	"Judgmental biases in sales forecasting", February 1986.	86/23	Arnoud DE MEYER	"An exploratory study on the integration of information systems in manufacturing", July 1986.
86/08	José de la TORRE and David H. NECKAR	"Forecasting political risks for international operations", Second Draft: March 3, 1986.	86/24	David GAUTSCHI and Vithala R. RAO	"A methodology for specification and aggregation in product concept testing", July 1986.
86/09	Philippe C. HASPELAGH	"Conceptualizing the strategic process in diversified firms: the role and nature of the corporate influence process", February 1986.	86/25	H. Peter GRAY and Ingo WALTER	"Protection", August 1986.
86/10	R. MOENART, Arnoud DE MEYER, J. BARBE and D. DESCHOOLMEESTER.	"Analysing the issues concerning technological de-maturity".	86/26	Barry EICHENGREEN and Charles WYPLOSZ	"The economic consequences of the Franc Poincare", September 1986.
86/11	Philippe A. NAERT and Alain BULTEZ	"From "Lydiametry" to "Pinkhamization": misspecifying advertising dynamics rarely affects profitability".	86/27	Karel COOL and Ingemar DIERICKX	"Negative risk-return relationships in business strategy: paradox or truism?", October 1986.
86/12	Roger BETANCOURT and David GAUTSCHI	"The economics of retail firms", Revised April 1986.	86/28	Manfred KETS DE VRIES and Danny MILLER	"Interpreting organizational texts.
86/13	S.P. ANDERSON and Damien J. NEVEN	"Spatial competition à la Cournot".	86/29	Manfred KETS DE VRIES	"Why follow the leader?".
86/14	Charles WALDMAN	"Comparaison internationale des marges brutes du commerce", June 1985.	86/30	Manfred KETS DE VRIES	"The succession game: the real story.
86/15	Mihkel TOMBAK and Arnoud DE MEYER	"How the managerial attitudes of firms with FMS differ from other manufacturing firms: survey results", June 1986.	86/31	Arnoud DE MEYER	"Flexibility: the next competitive battle", October 1986.
86/16	B. Espen ECKBO and Hervig M. LANGOHR	"Les primes des offres publiques, la note d'information et le marché des transferts de contrôle des sociétés".	86/31	Arnoud DE MEYER, Jinichiro NAKANE, Jeffrey G. MILLER and Kasra FERDOVS	"Flexibility: the next competitive battle", Revised Version: March 1987
86/17	David B. JEMISON	"Strategic capability transfer in acquisition integration", May 1986.	86/32	Karel COOL and Dan SCHENDEL	Performance differences among strategic group members", October 1986.
86/18	James TEBOUL and V. MALLERET	"Towards an operational definition of services", 1986.	86/33	Ernst BALTENSPERGER and Jean DERMINE	"The role of public policy in insuring financial stability: a cross-country, comparative perspective", August 1986, Revised November 1986.
86/19	Rob R. WEITZ	"Nostradamus: a knowledge-based forecasting advisor".	86/34	Philippe HASPELAGH and David JEMISON	"Acquisitions: myths and reality", July 1986.
86/20	Albert CORHAY, Gabriel HAWAVINI and Pierre A. MICHEL	"The pricing of equity on the London stock exchange: seasonality and size premium", June 1986.	86/35	Jean DERMINE	"Measuring the market value of a bank, a primer", November 1986.
86/21	Albert CORHAY, Gabriel A. HAWAVINI and Pierre A. MICHEL	"Risk-premia seasonality in U.S. and European equity markets", February 1986.	86/36	Albert CORHAY and Gabriel HAWAVINI	"Seasonality in the risk-return relationship: some international evidence", July 1986.
			86/37	David GAUTSCHI and Roger BETANCOURT	"The evolution of retailing: a suggested economic interpretation".
			86/38	Gabriel HAWAVINI	"Financial innovation and recent developments in the French capital markets", Updated: September 1986.

- 86/39 Gabriel HAWAVINI, Pierre MICHEL and Albert CORHAY "The pricing of common stocks on the Brussels stock exchange: a re-examination of the evidence", November 1986.
- 86/40 Charles WYPLOSZ "Capital flows liberalization and the EMS, a French perspective", December 1986.
- 86/41 Kasra FERDOWS and Wickham SKINNER "Manufacturing in a new perspective", July 1986.
- 86/42 Kasra FERDOWS and Per LINDBERG "FMS as indicator of manufacturing strategy", December 1986.
- 86/43 Damien NEVEN "On the existence of equilibrium in hotelling's model", November 1986.
- 86/44 Ingemar DIERICKX, Carmen MATUTES and Damien NEVEN "Value added tax and competition", December 1986.
- 1987
- 87/01 Manfred KETS DE VRIES "Prisoners of leadership".
- 87/02 Claude VIALLET "An empirical investigation of international asset pricing", November 1986.
- 87/03 David GAUTSCHI and Vithala RAO "A methodology for specification and aggregation in product concept testing", Revised Version: January 1987.
- 87/04 Sumantra GHOSHAL and Christopher BARTLETT "Organizing for innovations: case of the multinational corporation", February 1987.
- 87/05 Arnoud DE MEYER and Kasra FERDOWS "Managerial focal points in manufacturing strategy", February 1987.
- 87/06 Arun K. JAIN, Christian PINSON and Naresh K. MALHOTRA "Customer loyalty as a construct in the marketing of banking services", July 1986.
- 87/07 Rolf BANZ and Gabriel HAWAVINI "Equity pricing and stock market anomalies", February 1987.
- 87/08 Manfred KETS DE VRIES "Leaders who can't manage", February 1987.
- 87/09 Lister VICKERY, Mark PILKINGTON and Paul READ "Entrepreneurial activities of European MBAs", March 1987.
- 87/10 André LAURENT "A cultural view of organizational change", March 1987.
- 87/11 Robert PILDES and Spyros MAKRIDAKIS "Forecasting and loss functions", March 1987.
- 87/12 Fernando BARTOLOME and André LAURENT "The Janus Head: learning from the superior and subordinate faces of the manager's job", April 1987.
- 87/13 Sumantra GHOSHAL and Nitin NOHRIA "Multinational corporations as differentiated networks", April 1987.
- 87/14 Landis GABEL "Product Standards and Competitive Strategy: An Analysis of the Principles", May 1987.
- 87/15 Spyros MAKRIDAKIS "METAPROCASTING: Ways of improving Forecasting. Accuracy and Usefulness", May 1987.
- 87/16 Susan SCHNEIDER and Roger DUNBAR "Takeover attempts: what does the language tell us?", June 1987.
- 87/17 André LAURENT and Fernando BARTOLOME "Managers' cognitive maps for upward and downward relationships", June 1987.
- 87/18 Reinhard ANGELMAR and Christoph LIEBSCHER "Patents and the European biotechnology lag: a study of large European pharmaceutical firms", June 1987.
- 87/19 David BEGG and Charles WYPLOSZ "Why the EMS? Dynamic games and the equilibrium policy regime", May 1987.
- 87/20 Spyros MAKRIDAKIS "A new approach to statistical forecasting", June 1987.
- 87/21 Susan SCHNEIDER "Strategy formulation: the impact of national culture", Revised: July 1987.
- 87/22 Susan SCHNEIDER "Conflicting ideologies: structural and motivational consequences", August 1987.
- 87/23 Roger BETANCOURT and David GAUTSCHI "The demand for retail products and the household production model: new views on complementarity and substitutability".
- 87/24 C.B. DERR and André LAURENT "The internal and external careers: a theoretical and cross-cultural perspective", Spring 1987.
- 87/25 A. K. JAIN, N. K. MALHOTRA and Christian PINSON "The robustness of MDS configurations in the face of incomplete data", March 1987, Revised: July 1987.
- 87/26 Roger BETANCOURT and David GAUTSCHI "Demand complementarities, household production and retail assortments", July 1987.
- 87/27 Michael BURDA "Is there a capital shortage in Europe?", August 1987.
- 87/28 Gabriel HAWAVINI "Controlling the interest-rate risk of bonds: an introduction to duration analysis and immunization strategies", September 1987.
- 87/29 Susan SCHNEIDER and Paul SHRIVASTAVA "Interpreting strategic behavior: basic assumptions themes in organizations", September 1987.
- 87/30 Jonathan HAMILTON, W. Bentley MACLEOD and Jacques-François THISSE "Spatial competition and the Core", August 1987.

87/31	Martine QUINZII and Jacques-François THISSE	"On the optimality of central places", September 1987.	88/01	Michael LAWRENCE and Spyros MAKRIDAKIS	"Factors affecting judgemental forecasts and confidence intervals", January 1988.
87/32	Arnoud DE MEYER	"German, French and British manufacturing strategies less different than one thinks", September 1987.	88/02	Spyros MAKRIDAKIS	"Predicting recessions and other turning points", January 1988.
87/33	Yves DOZ and Amy SHUEN	"A process framework for analyzing cooperation between firms", September 1987.	88/03	James TEBOUL	"De-industrialize service for quality", January 1988.
87/34	Kasra FERDOUS and Arnoud DE MEYER	"European manufacturers: the dangers of complacency. Insights from the 1987 European manufacturing futures survey, October 1987.	88/04	Susan SCHNEIDER	"National vs. corporate culture: implications for human resource management", January 1988.
87/35	P. J. LEDERER and J. F. THISSE	"Competitive location on networks under discriminatory pricing", September 1987.	88/05	Charles WYPLOSZ	"The swinging dollar: is Europe out of step?", January 1988.
87/36	Manfred KETS DE VRIES	"Prisoners of leadership", Revised version October 1987.	88/06	Reinhard ANGELMAR	"Les conflits dans les canaux de distribution", January 1988.
87/37	Landis GABEL	"Privatization: its motives and likely consequences", October 1987.	88/07	Ingemar DIERICKX and Karel COOL	"Competitive advantage: a resource based perspective", January 1988.
87/38	Susan SCHNEIDER	"Strategy formulation: the impact of national culture", October 1987.	88/08	Reinhard ANGELMAR and Susan SCHNEIDER	"Issues in the study of organizational cognition", February 1988.
87/39	Manfred KETS DE VRIES	"The dark side of CEO succession", November 1987	88/09	Bernard SINCLAIR-DESGAGNÉ	"Price formation and product design through bidding", February 1988.
87/40	Carmen MATUTES and Pierre REGIBEAU	"Product compatibility and the scope of entry", November 1987	88/10	Bernard SINCLAIR-DESGAGNÉ	"The robustness of some standard auction game forms", February 1988.
87/41	Gavriel HAWAVINI and Claude VIALLET	"Seasonality, size premium and the relationship between the risk and the return of French common stocks", November 1987	88/11	Bernard SINCLAIR-DESGAGNÉ	"When stationary strategies are equilibrium bidding strategy: The single-crossing property", February 1988.
87/42	Damien NEVEN and Jacques-P. THISSE	"Combining horizontal and vertical differentiation: the principle of max-min differentiation", December 1987	88/12	Spyros MAKRIDAKIS	"Business firms and managers in the 21st century", February 1988
87/43	Jean GABSZEWICZ and Jacques-F. THISSE	"Location", December 1987	88/13	Manfred KETS DE VRIES	"Alexithymia in organizational life: the organization man revisited", February 1988.
87/44	Jonathan HAMILTON, Jacques-F. THISSE and Anita WESKAMP	"Spatial discrimination: Bertrand vs. Cournot in a model of location choice", December 1987	88/14	Alain NOEL	"The interpretation of strategies: a study of the impact of CEOs on the corporation", March 1988.
87/45	Karel COOL, David JEMISON and Ingemar DIERICKX	"Business strategy, market structure and risk-return relationships: a causal interpretation", December 1987.	88/15	Anil DEOLALIKAR and Lars-Hendrik ROLLER	"The production of and returns from industrial innovation: an econometric analysis for a developing country", December 1987.
87/46	Ingemar DIERICKX and Karel COOL	"Asset stock accumulation and sustainability of competitive advantage", December 1987.	88/16	Gabriel HAWAVINI	"Market efficiency and equity pricing: international evidence and implications for global investing", March 1988.
			88/17	Michael BURDA	"Monopolistic competition, costs of adjustment and the behavior of European employment",

- 88/18 Michael BURDA "Reflections on "Wait Unemployment" in Europe", November 1987, revised February 1988.
- 88/19 M.J. LAWRENCE and Spyros MAKRIDAKIS "Individual bias in judgements of confidence", March 1988.
- 88/20 Jean DERMINE, Damien NEVEN and J.F. THISSE "Portfolio selection by mutual funds, an equilibrium model", March 1988.
- 88/21 James TBOUL "De-industrialize service for quality", March 1988 (88/03 Revised).
- 88/22 Lars-Hendrik RÖLLER "Proper Quadratic Functions with an Application to AT&T", May 1987 (Revised March 1988).
- 88/23 Sjur Didrik FLAM and Georges ZACCOUR "Equilibres de Nash-Cournot dans le marché européen du gaz: un cas où les solutions en boucle ouverte et en feedback coïncident", Mars 1988
- 88/24 B. Espen ECKBO and Herwig LANGOHR "Information disclosure, means of payment, and takeover premia. Public and Private tender offers in France", July 1985, Sixth revision, April 1988.
- 88/25 Everette S. GARDNER and Spyros MAKRIDAKIS "The future of forecasting", April 1988.