Tilburg University

A modified priority index for Günther's lot-sizing heuristic under capacitated single stage production

Selen, W.J.; Heuts, R.M.J.

Publication date:
1988

[Link to publication in Tilburg University Research Portal](#)

Citation for published version (APA):
Selen, W. J., & Heuts, R. M. J. (1988). *A modified priority index for Günther's lot-sizing heuristic under capacitated single stage production*. (Research memorandum / Tilburg University, Department of Economics; Vol. FEW 342). Unknown Publisher.

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

Take down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

CBM
R

7626
1988
342

UNIVERSITEIT
BRABANT

POSTBOX 90153
5000 LE TILBURG
THE NETHERLANDS

DEPARTMENT OF ECONOMICS
RESEARCH MEMORANDUM

7626
1988
342

A MODIFIED PRIORITY INDEX FOR
GÜNTHER'S LOT-SIZING HEURISTIC UNDER
CAPACITATED SINGLE STAGE PRODUCTION

W.J. Selen and R.M. Heuts

FEW 342

R 61

653.41

658.512

A modified priority index for Günther's lot-sizing heuristic
under capacitated single stage production

W.J. Selen and R.M. Heuts
Department of Econometrics,
Tilburg University,
P.O. Box 90153,
5000 LE Tilburg, The Netherlands

Abstract: This paper suggests a modification of Günther's lot-sizing heuristic for capacitated single stage production that may yield better results in terms of overall cost performance. The computational efficiency of the heuristic allows both versions to be incorporated in the decision making process, which is hereby improved. The performance of both versions of Günther's heuristic is compared in a number of test problems reflecting relatively stable and lumpy demand conditions, respectively.

A modified priority index for Günther's lot-sizing heuristic under capacitated single stage production.

1. Introduction

Günther [2] recently developed a heuristic for capacity constrained lot-sizing for multiple products to be produced on a single production facility. Demand was assumed deterministic and time-varying without backordering, where setup times did not consume limited production capacity. The objective then is to determine lot-sizes which minimize the sum of inventory holding and setup costs, based on Groff's [1] lot-sizing criterion. Feasibility of the schedule is guaranteed by means of a capacity balancing rule, where portions of current slack capacity are reserved in order to balance future capacity overloads. As such it is possible that a particular requirement may be split into several lots when capacity constraints are binding. Günther uses a priority index for this capacity balancing by computing the incremental cost per unit of additional capacity absorbed, where cost is defined as the sum of additional holding and setup costs. In computing this priority index, Günther states that "increasing the lot size of a particular product does not affect setup costs if the product is already scheduled in the current period". It is argued that this may not be the case when an entire future period requirement is added to the existing lot-size. The modified priority index that would result is discussed next.

2. Modified priority index

Relevant notation is briefly outlined below:

- k : current period of production
- $p(i)$: supply period for product i , defined as the next period with a positive requirement of product i
- q_{ip} : maximum quantity of product i which can be shifted from period $p(i)$ to period k for pre-production
- h_i : holding cost per unit and period for product i

S_i : setup cost for product i

x_{ik} : lot-size of product i in period k

$d(x_{ik})$: binary decision variable indicating whether product i is setup in period k or not, with $d(x_{ik}) = 1$ if $x_{ik} > 0$, zero otherwise

a_i : production time per unit for product i .

Günther computes the priority index for capacity balancing (denoted by v_i) as:

$$v_i = [(p(i) - k) q_{ip} h_i + S_i(1 - d(x_{ik}))]/(q_{ip} a_i) \quad (1)$$

The first part of this index indicates the additional holding cost of shifting q_{ip} requirements of product i from future period $p(i)$ to the current period of production k . The second part stands for the additional setup cost incurred when product i is not currently being produced. The denominator normalizes this cost in terms of the incremental capacity used.

We note that in formula (1), when q_{ip} equals x_{ip} or an entire period requirement is shifted forward under the condition that product i is currently produced, the priority index yields:

$$v_i = [(p(i) - k) q_{ip} h_i]/(q_{ip} a_i) \quad (2)$$

However, for the above situation an additional setup is saved, in particular the one for period $p(i)$. As the entire period requirement is added to a current lotsize, that period's setup is saved and is reflected in the following modified priority index:

$$v_i = [(p(i) - k) q_{ip} h_i + S_i(1 - d(x_{ik})) - S_i(1 - d(x_{ip}, q_{ip}))]/(q_{ip} a_i) \quad (3)$$

where $d(x_{ip}, q_{ip})$ is a binary decision variable indicating whether or not an entire period requirement of product i is shifted forward, with

$$d(x_{ip}, q_{ip}) = 1 \text{ if } x_{ip} > q_{ip}$$

$$= 0 \text{ if } x_{ip} = q_{ip}$$

Equation (3) is rewritten as:

$$v_i = [(p(i) - k)q_{ip}h_i + S_i(d(x_{ip}, q_{ip}) - d(x_{ik}))]/(q_{ip}a_i) \quad (4)$$

Using this priority index, the possible contingency situations in terms of potential savings in setup costs, are summarized in Figure 1.

		Current period requirement x_{ik}	
		$x_{ik} = 0$	$x_{ik} > 0$
Future period require- ment x_{ip}	$x_{ip} > q_{ip}$	$v_i = [(p(i) - k)q_{ip}h_i + S_i]/(q_{ip}a_i)$ or one additional setup incurred	$v_i = [(p(i) - k)q_{ip}h_i]/(q_{ip}a_i)$ or no incremental setup cost savings
	$x_{ip} = q_{ip}$	$v_i = [(p(i) - k)q_{ip}h_i]/(q_{ip}a_i)$ or no incremental setup cost savings	$v_i = [(p(i) - k)q_{ip}h_i - S_i]/(q_{ip}a_i)$ or one setup saved

Figure 1. Possible contingency situations

3. Example problems

A turbo-PASCAL computer program of Günther's heuristic was developed, yielding two versions depending on which rule was used. These versions are denoted by "Günther" and "modified Günther", respectively.

A set of 10 randomly selected example problems were generated to illustrate the performance of both versions, based upon the following production setting as is illustrated in Table 1.

Table 1. Production Setting

Product	Production time (hours)	Holding cost/unit/period (\$)	Setup cost (\$)
1	0.12	5.2	268
2	0.15	4.5	321
3	0.20	5.4	380

A planning horizon of seven periods was chosen, with respective production capacities as are shown in Table 2.

Table 2. Production Capacities (hours)

Period	1	2	3	4	5	6	7
Capacity	25	25	10	10	10	10	10

The sample set of 10 problems consisted of 5 randomly chosen problems with relative stable demand, and five examples in which demand was lumpy, whereby total demand over the seven period planning horizon was held constant for all cases. The demand patterns for all cases are shown in Table 3, in which cases 6 through 10 reflect the lumpy demand pattern.

The resulting production schedules and relevant costs for both approaches are depicted in Tables 4 and 5 according to the demand structure.

Table 3. Demand - Example cases.

Case	Product	Period							Σ
		1	2	3	4	5	6	7	
1	1	46	40	55	48	46	40	60	335
	2	28	20	25	35	37	30	24	199
	3	10	8	12	7	9	7	8	61
2	1	42	44	50	53	42	48	56	335
	2	25	30	22	25	30	35	32	199
	3	10	9	11	8	7	8	8	61
3	1	40	44	50	55	47	49	50	335
	2	29	32	27	38	25	27	20	199
	3	10	10	9	7	10	8	7	61
4	1	60	55	48	40	46	46	40	335
	2	37	30	28	20	30	25	29	199
	3	7	7	12	10	8	9	8	61
5	1	47	50	52	54	48	46	38	335
	2	24	20	25	35	32	30	33	199
	3	12	10	7	10	8	9	5	61
6	1	80	70	80	20	30	20	35	335
	2	80	100	10	0	0	7	2	199
	3	9	0	0	5	0	27	20	61
7	1	30	20	29	31	110	80	35	335
	2	8	12	10	11	18	85	55	199
	3	1	8	5	4	4	23	16	61
8	1	90	10	83	20	30	32	70	335
	2	50	12	10	9	80	15	23	199
	3	6	16	5	20	4	5	5	61
9	1	60	60	60	28	35	30	62	335
	2	12	80	18	10	60	10	9	199
	3	20	8	10	5	4	0	14	61
10	1	5	100	0	130	80	20	0	335
	2	80	0	0	90	20	5	4	199
	3	2	0	7	2	0	30	20	61

Table 4. Production results - Günther (G) and Modified Günther (MG)
Stable Demand

Case	Product	Method	Production per period							Setup Cost	Holding Cost	Total Cost
			1	2	3	4	5	6	7			
1	1	G	86	103	0	0	46	40	60	3764 4085	2106.20 1592.03	5870.20 5677.03
		MG	86	0	83.33	65.67	0	40	60			
	2	G	48	0	60	66.67	0	24.33	0			
		MG	48	60	0	0	37	34.67	19.33			
	3	G	37	0	0	0	16	0	8			
		MG	37	0	0	9	15	0	0			
2	1	G	42	94	83.33	0	45	14.67	56	3652 4032	2008.70 1725.33	5660.70 5757.33
		MG	42	94	0	53	83.33	6.67	56			
	2	G	77	0	0	55	0	54.93	12.07			
		MG	77	0	55	0	0	50.67	16.33			
	3	G	38	0	0	0	23	0	0			
		MG	38	0	0	15	0	8	0			
3	1	G	40	94	0	83.33	18.67	49	50	4353 4733	1056.83 1024.17	5409.83 5757.17
		MG	40	94	0	66.67	35.33	49	50			
	2	G	61	0	65	0	27.73	27.47	16.8			
		MG	61	0	65	0	27.73	27.47	16.8			
	3	G	36	0	0	0	18	0	7			
		MG	36	0	0	10	8	0	7			
4	1	G	60	103	0	83.33	2.67	46	40	3973 4353	1164.33 966.30	5137.33 5319.30
		MG	60	103	0	40	46	46	40			
	2	G	67	0	48	0	30	25	29			
		MG	67	0	48	0	30	29.87	24.13			
	3	G	36	0	0	0	25	0	0			
		MG	36	0	0	17	0	0	8			
5	1	G	47	102	0	83.33	18.67	46	38	4353 4353	1103.63 1035.70	5456.63 5388.70
		MG	47	102	0	54	48	46	38			
	2	G	44	0	66.67	0	29.07	29.87	29.4			
		MG	44	0	66.67	0	28.27	29.87	30.2			
	3	G	39	0	0	0	17	0	5			
		MG	39	0	0	17	0	0	5			

Table 5. Production results - Günther (G) and Modified Günther (MG).
Lumpy Demand

Case	Product	Method	Production per period							Setup Cost	Holding Cost	Total Cost
			1	2	3	4	5	6	7			
6	1	G	80	70	80	50	0	20	35	3711 SAME	291 SAME	4002 SAME
		MG				SAME						
	2	G	80	110	0	0	0	9	0			
		MG				SAME						
	3	G	14	0	0	0	0	27	20			
		MG				SAME						
7	1	G	50	170	80	0	0	0	35	3116 3764	4945.20 4263.70	8061.20 8027.70
		MG	50	60	0	83.33	83.33	58.33	0			
	2	G	41	0	0	0	66.67	66.67	24.67			
		MG	41	103	0	0	0	20	35			
	3	G	22	0	0	39	0	0	0			
		MG	22	0	23	0	0	0	16			
8	1	G	100	0	83	50	0	32	70	3764 SAME	950.80 SAME	4714.80 SAME
		MG				SAME						
	2	G	72	0	0	26.67	62.33	38	0			
		MG				SAME						
	3	G	6	50	0	0	0	0	5			
		MG				SAME						
9	1	G	60	60	60	63	0	59.58	32.42	3652 3652	865.93 787.70	4517.93 4439.70
		MG	60	60	60	63	0	30	62			
	2	G	12	108	0	0	60	19	0			
		MG				SAME						
	3	G	47	0	0	0	0	0	14			
		MG	47	0	0	0	0	14	0			
10	1	G	5	100	83.33	46.67	80	20	0	4032 4032	1456.33 1399.67	5488.33 5431.67
		MG	5	100	47.92	82.08	80	20	0			
	2	G	80	86.67	0	28.33	0	0	4			
		MG	80	86.67	28.33	0	0	0	4			
	3	G	11	0	0	0	0	30	20			
		MG				SAME						

Interestingly, the better performance of the amended heuristic lies in the improvement in inventory holding costs over the potential worsening of setup costs. This is easily explained by the fact that the amended version employs a different decision rule (priority index) for shifting future requirements forward in time, yielding different production schedules as is shown in Tables 4 and 5. For the examples generated, in 7 out of 10 cases, the modified version outperformed or performed equally well as Günther's approach. However, it is important to note that, due to the different priority indices of either approach, the modified version is not always guaranteed to produce better results as compared to Günther's solutions. There exists an indication the amended version may perform better for lumpy demand conditions, allowing the decision maker to run both versions and select the better solution, moreover as Günther's heuristic proved to be computationally very efficient.

4. Conclusions

The priority rule for pre-production in Günther's lot-sizing heuristic was modified to correctly reflect the situation where an entire future period requirement is shifted to the current period of production. This modification subsequently yields a different production plan that may outperform Günther's heuristic solution, as was illustrated. The computational efficiency of the heuristic allows both versions to be incorporated in the decision making process, which is hereby improved.

References

- [1] Groff, G.K., "A lot sizing rule for time phased component demand", *Production and Inventory Management* 20 (1979) 47-53.
- [2] Günther, H.O., "Planning lot sizes and capacity requirements in a single stage production system", *European Journal of Operational Research* 31 (1987) 223-231.

IN 1987 REEDS VERSCHENEN

- 242 Gerard van den Berg
Nonstationarity in job search theory
- 243 Annie Cuyt, Brigitte Verdonk
Block-tridiagonal linear systems and branched continued fractions
- 244 J.C. de Vos, W. Vervaat
Local Times of Bernoulli Walk
- 245 Arie Kapteyn, Peter Kooreman, Rob Willemse
Some methodological issues in the implementation
of subjective poverty definitions
- 246 J.P.C. Kleijnen, J. Kriens, M.C.H.M. Lafleur, J.H.F. Pardoel
Sampling for Quality Inspection and Correction: AOQL Performance
Criteria
- 247 D.B.J. Schouten
Algemene theorie van de internationale conjuncturele en structurele
afhankelijkheden
- 248 F.C. Bussemaker, W.H. Haemers, J.J. Seidel, E. Spence
On (v,k,λ) graphs and designs with trivial automorphism group
- 249 Peter M. Kort
The Influence of a Stochastic Environment on the Firm's Optimal Dyna-
mic Investment Policy
- 250 R.H.J.M. Gradus
Preliminary version
The reaction of the firm on governmental policy: a game-theoretical
approach
- 251 J.G. de Gooijer, R.M.J. Heuts
Higher order moments of bilinear time series processes with symmetri-
cally distributed errors
- 252 P.H. Stevers, P.A.M. Versteijne
Evaluatie van marketing-activiteiten
- 253 H.P.A. Mulders, A.J. van Reeken
DATAAL - een hulpmiddel voor onderhoud van gegevensverzamelingen
- 254 P. Kooreman, A. Kapteyn
On the identifiability of household production functions with joint
products: A comment
- 255 B. van Riel
Was er een profit-squeeze in de Nederlandse industrie?
- 256 R.P. Gilles
Economies with coalitional structures and core-like equilibrium con-
cepts

- 257 P.H.M. Ruys, G. van der Laan
Computation of an industrial equilibrium
- 258 W.H. Haemers, A.E. Brouwer
Association schemes
- 259 G.J.M. van den Boom
Some modifications and applications of Rubinstein's perfect equilibrium model of bargaining
- 260 A.W.A. Boot, A.V. Thakor, G.F. Udell
Competition, Risk Neutrality and Loan Commitments
- 261 A.W.A. Boot, A.V. Thakor, G.F. Udell
Collateral and Borrower Risk
- 262 A. Kapteyn, I. Woittiez
Preference Interdependence and Habit Formation in Family Labor Supply
- 263 B. Bettonvil
A formal description of discrete event dynamic systems including perturbation analysis
- 264 Sylvester C.W. Eijffinger
A monthly model for the monetary policy in the Netherlands
- 265 F. van der Ploeg, A.J. de Zeeuw
Conflict over arms accumulation in market and command economies
- 266 F. van der Ploeg, A.J. de Zeeuw
Perfect equilibrium in a model of competitive arms accumulation
- 267 Aart de Zeeuw
Inflation and reputation: comment
- 268 A.J. de Zeeuw, F. van der Ploeg
Difference games and policy evaluation: a conceptual framework
- 269 Frederick van der Ploeg
Rationing in open economy and dynamic macroeconomics: a survey
- 270 G. van der Laan and A.J.J. Talman
Computing economic equilibria by variable dimension algorithms: state of the art
- 271 C.A.J.M. Dirven and A.J.J. Talman
A simplicial algorithm for finding equilibria in economies with linear production technologies
- 272 Th.E. Nijman and F.C. Palm
Consistent estimation of regression models with incompletely observed exogenous variables
- 273 Th.E. Nijman and F.C. Palm
Predictive accuracy gain from disaggregate sampling in arima - models

- 274 Raymond H.J.M. Gradus
The net present value of governmental policy: a possible way to find the Stackelberg solutions
- 275 Jack P.C. Kleijnen
A DSS for production planning: a case study including simulation and optimization
- 276 A.M.H. Gerards
A short proof of Tutte's characterization of totally unimodular matrices
- 277 Th. van de Klundert and F. van der Ploeg
Wage rigidity and capital mobility in an optimizing model of a small open economy
- 278 Peter M. Kort
The net present value in dynamic models of the firm
- 279 Th. van de Klundert
A Macroeconomic Two-Country Model with Price-Discriminating Monopolists
- 280 Arnoud Boot and Anjan V. Thakor
Dynamic equilibrium in a competitive credit market: intertemporal contracting as insurance against rationing
- 281 Arnoud Boot and Anjan V. Thakor
Appendix: "Dynamic equilibrium in a competitive credit market: intertemporal contracting as insurance against rationing"
- 282 Arnoud Boot, Anjan V. Thakor and Gregory F. Udell
Credible commitments, contract enforcement problems and banks: intermediation as credibility assurance
- 283 Eduard Ponds
Wage bargaining and business cycles a Goodwin-Nash model
- 284 Prof.Dr. hab. Stefan Mynarski
The mechanism of restoring equilibrium and stability in polish market
- 285 P. Meulendijks
An exercise in welfare economics (II)
- 286 S. Jørgensen, P.M. Kort, G.J.C.Th. van Schijndel
Optimal investment, financing and dividends: a Stackelberg differential game
- 287 E. Nijssen, W. Reijnders
Privatisering en commercialisering; een oriëntatie ten aanzien van verzelfstandiging
- 288 C.B. Mulder
Inefficiency of automatically linking unemployment benefits to private sector wage rates

- 289 M.H.C. Paardekooper
A Quadratically convergent parallel Jacobi process for almost diagonal matrices with distinct eigenvalues
- 290 Pieter H.M. Ruys
Industries with private and public enterprises
- 291 J.J.A. Moors & J.C. van Houwelingen
Estimation of linear models with inequality restrictions
- 292 Arthur van Soest, Peter Kooreman
Vakantiebestemming en -bestedingen
- 293 Rob Alessie, Raymond Gradus, Bertrand Melenberg
The problem of not observing small expenditures in a consumer expenditure survey
- 294 F. Boekema, L. Oerlemans, A.J. Hendriks
Kansrijkheid en economische potentie: Top-down en bottom-up analyses
- 295 Rob Alessie, Bertrand Melenberg, Guglielmo Weber
Consumption, Leisure and Earnings-Related Liquidity Constraints: A Note
- 296 Arthur van Soest, Peter Kooreman
Estimation of the indirect translog demand system with binding non-negativity constraints

IN 1988 REEDS VERSCHENEN

- 297 Bert Bettonvil
Factor screening by sequential bifurcation
- 298 Robert P. Gilles
On perfect competition in an economy with a coalitional structure
- 299 Willem Selen, Ruud M. Heuts
Capacitated Lot-Size Production Planning in Process Industry
- 300 J. Kriens, J.Th. van Lieshout
Notes on the Markowitz portfolio selection method
- 301 Bert Bettonvil, Jack P.C. Kleijnen
Measurement scales and resolution IV designs: a note
- 302 Theo Nijman, Marno Verbeek
Estimation of time dependent parameters in linear models
using cross sections, panels or both
- 303 Raymond H.J.M. Gradus
A differential game between government and firms: a non-cooperative
approach
- 304 Leo W.G. Strijbosch, Ronald J.M.M. Does
Comparison of bias-reducing methods for estimating the parameter in
dilution series
- 305 Drs. W.J. Reijnders, Drs. W.F. Verstappen
Strategische bespiegelingen betreffende het Nederlandse kwaliteits-
concept
- 306 J.P.C. Kleijnen, J. Kriens, H. Timmermans and H. Van den Wildenberg
Regression sampling in statistical auditing
- 307 Isolde Woittiez, Arie Kapteyn
A Model of Job Choice, Labour Supply and Wages
- 308 Jack P.C. Kleijnen
Simulation and optimization in production planning: A case study
- 309 Robert P. Gilles and Pieter H.M. Ruys
Relational constraints in coalition formation
- 310 Drs. H. Leo Theuns
Determinanten van de vraag naar vakantiereizen: een verkenning van
materiële en immateriële factoren
- 311 Peter M. Kort
Dynamic Firm Behaviour within an Uncertain Environment
- 312 J.P.C. Blanc
A numerical approach to cyclic-service queueing models

- 313 Drs. N.J. de Beer, Drs. A.M. van Nunen, Drs. M.O. Nijkamp
Does Morkmon Matter?
- 314 Th. van de Klundert
Wage differentials and employment in a two-sector model with a dual labour market
- 315 Aart de Zeeuw, Fons Groot, Cees Withagen
On Credible Optimal Tax Rate Policies
- 316 Christian B. Mulder
Wage moderating effects of corporatism
Decentralized versus centralized wage setting in a union, firm, government context
- 317 Jörg Glombowski, Michael Krüger
A short-period Goodwin growth cycle
- 318 Theo Nijman, Marno Verbeek, Arthur van Soest
The optimal design of rotating panels in a simple analysis of variance model
- 319 Drs. S.V. Hannema, Drs. P.A.M. Versteijne
De toepassing en toekomst van public private partnership's bij de grote en middelgrote Nederlandse gemeenten
- 320 Th. van de Klundert
Wage Rigidity, Capital Accumulation and Unemployment in a Small Open Economy
- 321 M.H.C. Paardekoooper
An upper and a lower bound for the distance of a manifold to a nearby point
- 322 Th. ten Raa, F. van der Ploeg
A statistical approach to the problem of negatives in input-output analysis
- 323 P. Kooreman
Household Labor Force Participation as a Cooperative Game; an Empirical Model
- 324 A.B.T.M. van Schaik
Persistent Unemployment and Long Run Growth
- 325 Dr. F.W.M. Boekema, Drs. L.A.G. Oerlemans
De lokale produktiestructuur doorgelicht.
Bedrijfstakverkenningen ten behoeve van regionaal-economisch onderzoek
- 326 J.P.C. Kleijnen, J. Kriens, M.C.H.M. Lafleur, J.H.F. Pardoel
Sampling for quality inspection and correction: AOQL performance criteria

- 327 Theo E. Nijman, Mark F.J. Steel
Exclusion restrictions in instrumental variables equations
- 328 B.B. van der Genugten
Estimation in linear regression under the presence of heteroskedasticity of a completely unknown form
- 329 Raymond H.J.M. Gradus
The employment policy of government: to create jobs or to let them create?
- 330 Hans Kremers, Dolf Talman
Solving the nonlinear complementarity problem with lower and upper bounds
- 331 Antoon van den Elzen
Interpretation and generalization of the Lemke-Howson algorithm
- 332 Jack P.C. Kleijnen
Analyzing simulation experiments with common random numbers, part II: Rao's approach
- 333 Jacek Osiewalski
Posterior and Predictive Densities for Nonlinear Regression. A Partly Linear Model Case
- 334 A.H. van den Elzen, A.J.J. Talman
A procedure for finding Nash equilibria in bi-matrix games
- 335 Arthur van Soest
Minimum wage rates and unemployment in The Netherlands
- 336 Arthur van Soest, Peter Kooreman, Arie Kapteyn
Coherent specification of demand systems with corner solutions and endogenous regimes
- 337 Dr. F.W.M. Boekema, Drs. L.A.G. Oerlemans
De lokale produktiestructuur doorgelicht II. Bedrijfstakverkenningen ten behoeve van regionaal-economisch onderzoek. De zeescheepsnieuw-bouwindustrie
- 338 Gerard J. van den Berg
Search behaviour, transitions to nonparticipation and the duration of unemployment
- 339 W.J.H. Groenendaal and J.W.A. Vingerhoets
The new cocoa-agreement analysed
- 340 Drs. F.G. van den Heuvel, Drs. M.P.H. de Vor
Kwantificering van ombuigen en bezuinigen op collectieve uitgaven 1977-1990
- 341 Pieter J.F.G. Meulendijks
An exercise in welfare economics (III)

Bibliotheek K. U. Brabant

17 000 01065975 4