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Robust Bayesian inference in LQ-spherical models

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Publication date:
1994

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

Citation for published version (APA):

Osiewalski, J., & Steel, M. F. J. (1994). *Robust Bayesian inference in LQ-spherical models*. (Reprint series / CentER for Economic Research; Vol. 157). Unknown Publisher.

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by

Jacek Osiewalski and
Mark F.J. Steel

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ISSN 0924-7874

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Robust Bayesian inference in l_q -spherical models

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SUMMARY

The class of multivariate l_q -spherical distributions is introduced and defined through their isodensity surfaces. We prove that, under a Jeffreys' type improper prior on the scale parameter, posterior inference on the location parameters is the same for all l_q -spherical sampling models with common q . This gives us perfect inference robustness with respect to any departures from the reference case of independent sampling from the exponential power distribution.

Some key words: Bayesian inference; Exponential power distributions; Inference robustness; l_q -norm; Symmetric multivariate distributions.

1. INTRODUCTION

A new class of multivariate distributions, which we name l_q -spherical, is defined through properties of the density function. In particular, the isodensity surfaces are spheres in l_q -norm for $q \geq 1$. Robustness results obtained by Osiewalski & Steel (1993) for the case $q = 2$, are here found to extend to general $q \in (0, \infty]$.

Fang, Kotz & Ng (1990) mention eight different ways of constructing symmetric multivariate distributions, one of which is symmetry of the density function. In their Chapter 5 they induce symmetry on the survival function with an l_1 -norm. They start from an exponential distribution (defined on the positive real line), resulting in a density function proportional to that of our l_1 -spherical distribution over the positive orthant of the sample space. In their Chapter 7 they use symmetry of the characteristic function to define α -symmetric distributions. For $\alpha = 2$ this corresponds to our l_2 -spherical distributions, usually referred to in the literature as spherical and discussed in detail by Kelker (1970), Cambanis, Huang & Simons (1981), Dickey & Chen (1985) and Fang et al. (1990, Ch. 2–4).

In the same way as independent sampling from a univariate Normal distribution constitutes a reference case for the l_2 -spherical family, independent sampling from exponential power distributions (Box & Tiao, 1973, Ch. 3) forms a useful reference class for the entire l_q -spherical family.

Within a Bayesian framework, we prove that under a commonly-used diffuse prior on the scale parameter posterior inference on the location vector is fully robust with respect to departures of any l_q -spherical sampling density from its reference case.

2. DEFINING l_q -SPHERICAL DISTRIBUTIONS

In this section we introduce the class of multivariate l_q -spherical distributions, where symmetry is imposed through the density function. This implies we only consider continuous distributions.

Let us first introduce the following notation, for $a = (a_1, \dots, a_n)'$:

$$v_q(a) = \begin{cases} \left(\sum_{i=1}^n |a_i|^q \right)^{1/q} & \text{if } 0 < q < \infty, \\ \max_{i=1, \dots, n} |a_i| & \text{if } q = \infty. \end{cases}$$

If we choose q in the range $[1, \infty]$ then $v_q(a) = \|a\|_q$, the l_q -norm of the vector a . In the case $q \in (0, 1)$, $v_q(\cdot)$ does not satisfy the triangle inequality. For our purposes, however, the latter is not required.

Definition. For any scalar $0 < q \leq \infty$, $x = (x_1, \dots, x_n)' \in \mathbb{R}^n$ has an l_q -spherical distribution with location $\mu = (\mu_1, \dots, \mu_n)' \in \mathbb{R}^n$ and scale $\tau^{-1} \in \mathbb{R}_+$, denoted as $x \sim I_q^n(\mu, \tau^{-1} I_n)$, if its density function is given by

$$p(x|\mu, \tau) = \tau^n g[v_q\{\tau(x - \mu)\}], \quad (1)$$

and $g(\cdot)$ is a nonnegative function such that $p(x|\mu, \tau)$ is a proper density.

The isodensity surfaces follow immediately from the Definition as

$$\{x \in \mathbb{R}^n | v_q\{\tau(x - \mu)\} = \alpha\}, \quad (2)$$

where $\alpha > 0$. For $q \geq 1$ they could be considered spheres with respect to l_q -norm centred at μ . This fact motivates calling these densities ' l_q -spherical'.

Let us now consider the conditions on $g(\cdot)$ imposed by our Definition. For finite q , we define

$$r = v_q\{\tau(x - \mu)\}, \quad z_i = \left(\tau \frac{|x_i - \mu_i|}{r} \right)^q \quad (i = 1, \dots, n).$$

Transforming x into $(z_1, \dots, z_{n-1}, r)$, we derive from $p(x|\mu, \tau)$ a product of an n -variate Dirichlet density on $z = (z_1, \dots, z_n)'$ with parameters q^{-1} and

$$p(r|z, \mu, \tau) = p(r) = \frac{\{2\Gamma(1+1/q)\}^n}{\Gamma(n/q)} q r^{n-1} g(r), \quad (3)$$

which is a proper density function over $\mathbb{R}_+$ if and only if

$$\int_0^\infty u^{n-1} g(u) du = \frac{\Gamma(n/q)}{q\{2\Gamma(1+1/q)\}^n} = c_q. \quad (4)$$

Extending the analysis of Dickey & Chen (1985), we can represent x in terms of three independent random quantities

$$\tau(x - \mu) = r(s \times z^{1/q}), \quad (5)$$

where $z^{1/q}$ denotes a coordinatewise power, $s \times z^{1/q}$ is a coordinatewise product of vectors and the n elements of s independently take the value 1 or -1 with probability $\frac{1}{2}$. This representation makes calculation of the moments straightforward. In particular, if $E(r^2) < \infty$,

$$E(x|\mu, \tau) = \mu, \quad (6)$$

$$\text{var}(x|\mu, \tau) = \frac{\Gamma(n/q)\Gamma(3/q)}{\Gamma(1/q)\Gamma\{(n+2)/q\}} \tau^{-2} E(r^2) I_n. \quad (7)$$

The case of infinite q requires a separate treatment. Now we define

$$r = v_\infty\{\tau(x - \mu)\}, \quad z_i = \frac{w_i - w_{i-1}}{r} \quad (i = 1, \dots, n),$$

where $w_0 = 0$ and w_i ($i \geq 1$) is the i th ordered value of $\tau|x_j - \mu_j|$ ($j = 1, \dots, n$). The transformation from x to $(z_1, \dots, z_{n-1}, r)$ gives us a Dirichlet density for z with parameters 1 and

$$p(r|z, \mu, \tau) = p(r) = n 2^n r^{n-1} g(r), \quad (8)$$

from which the condition on $g(\cdot)$ implicit in the Definition becomes

$$\int_0^\infty u^{n-1} g(u) du = \frac{1}{n} 2^{-n} = c_\infty. \quad (9)$$

Using the exchangeability property of x , we derive for example

$$E(x|\mu, \tau) = \mu, \quad (10)$$

$$\text{var}(x|\mu, \tau) = \frac{n+2}{3n} \tau^{-2} E(r^2) I_n \quad (11)$$

for finite $E(r^2)$.

We remark that as $q \rightarrow \infty$ the right-hand side of (4) converges to that of (9), and the constant in (7) converges to the constant in (11). Clearly, such convergence also applies to the isodensity surfaces in (2).

3. EXPONENTIAL POWER DISTRIBUTIONS

An interesting special class of l_q -spherical distributions is generated by independent sampling from exponential power distributions (Box & Tiao, 1973, Ch. 3):

$$p(x_i|\mu, \tau) = d_q \tau \exp(-\frac{1}{2} \tau^q |x_i - \mu_i|^q), \quad (12)$$

with

$$d_q = \left\{ 2^{1+1/q} \Gamma\left(1 + \frac{1}{q}\right) \right\}^{-1} \quad (0 < q < \infty),$$

and from

$$p(x_i|\mu, \tau) = \frac{1}{2} \tau I(\mu_i - \tau^{-1} < x_i < \mu_i + \tau^{-1}) \quad (q = \infty), \quad (13)$$

where $I(\cdot)$ denotes the indicator function. Thus, sampling from (12) and (13) corresponds to particular choices of $g(\cdot)$ in the Definition. For $0 < q < \infty$ and $u \in \mathbb{R}_+$, we choose $g(u) = d_q^n \exp(-\frac{1}{2} u^q)$, from which, using (3), we obtain

$$p(r) = 2^{-n/q} \left\{ \Gamma\left(\frac{n}{q}\right) \right\}^{-1} q r^{n-1} \exp(-\frac{1}{2} r^q),$$

i.e. the q th power of the l_q -radius is Gamma distributed with parameters n/q and $\frac{1}{2}$. For infinite q , we implicitly choose $g(u) = 2^{-n} I(0 < u < 1)$, leading to a Beta distribution for r with parameters n and 1.

Due to the independence, the n -variate distribution considered in this section forms a convenient reference case within the class of l_q -spherical distributions. For $q=1$ we obtain the case of independent sampling from a double-exponential or Laplace distribution with variance $8\tau^{-2}$, for $q=2$ it corresponds to sampling from a Normal with variance τ^{-2} , and for $q=\infty$ we sample from a uniform distribution with variance $\tau^{-2}/3$. Box & Tiao (1973, Ch. 3) consider exponential power distributions for $q \geq 1$, and parameterize in terms of the sampling variance, rather than τ .

4. POSTERIOR INFERENCE

We now focus on conducting inference on the location vector μ when the sampling distribution is l_q -spherical. In many practical cases, μ will be parameterized in terms of a lower-dimensional parameter. However, such a regression context will not explicitly be considered here.

THEOREM. For any $q \in (0, \infty]$, if $x \sim l_q^n(\mu, \tau^{-1} I_n)$ and we assume the improper prior structure

$$p(\mu, \tau) = p(\mu)p(\tau) = k\tau^{-1}p(\mu), \quad (14)$$

$k > 0$, then

$$p(x, \mu) = kp(\mu)c_q\{v_q(x - \mu)\}^{-n}. \quad (15)$$

Proof. We need to integrate out τ from the joint density $p(x, \mu, \tau)$, which is the product of (1) and (14). Using the one-to-one transformation from (x, μ, τ) to (x, μ, r) , where $r = v_q\{\tau(x - \mu)\} = \tau v_q(x - \mu)$ and integrating out r through (4) for finite and (9) for infinite q , the result follows. $\square$

The prior structure in (14) is the product of an improper Jeffreys' type prior on τ , which is widely used to represent a lack of prior information about the scale, and any prior on μ , either proper or improper. Combining (14) with any $I_q^*(\mu, \tau^{-1}I_n)$ sampling density on the observables x results in the improper marginal density (15), which leads to a proper posterior density $p(\mu|x)$ provided $p(x) = \int p(x, \mu) d\mu < \infty$, where the integral is over the range $\mathbb{R}^n$. If part of x is not actually observed (e.g. missing data or forecasting), then the out-of-sample predictive density can easily be obtained from $p(x)$.

The main implication of the Theorem can be deduced from the functional form of (15), where $g(\cdot)$ no longer appears. In other words, for a given q any choice of $g(\cdot)$ which leads to a proper sampling density in (1) will produce the same inference on μ and the unobserved part of x . Therefore, the prior in (14) is sufficient for complete robustness of posterior (on μ) and predictive inference within the entire class of I_q -spherical sampling distributions with q fixed. As stressed in § 3, the case obtained by independent sampling from an exponential power distribution is a particularly convenient member of the I_q -spherical class. Our Theorem thus tells us that, assuming (14), the posterior results of Box & Tiao (1973, Ch. 3), obtained under independent sampling from (12) or (13), remain unaffected by any departure within the class of multivariate I_q -spherical sampling densities with the same q .

Such robustness does not hold for the scale parameter τ ; in fact, the entire influence of the choice of labelling function $g(\cdot)$ is summarized in the conditional posterior of τ

$$p(\tau|x, \mu) = c_q^{-1} \{v_q(x - \mu)\}^n \tau^{n-1} g[v_q(\tau(x - \mu))],$$

which is proper by (4) and (9). Clearly, τ given μ is updated by the sample information and its posterior does not preserve the functional form in (14). Thus, the Theorem does not hold for more than one independent vector observation from $I_q^*(\mu, \tau^{-1}I_n)$, and achieving robustness seems a hopeless task in this case.

5. EXTENSIONS

We can easily generalize the Theorem in the previous section to cases where we sample from $y = Ax$ with $x \sim I_q^*(\mu, \tau^{-1}I_n)$ and A is a nonsingular matrix function of parameters η . Under the prior structure $p(\mu, \eta, \tau) = k\tau^{-1}p(\mu, \eta)$ ($k > 0$) we obtain

$$p(y, \mu, \eta) = kp(\mu, \eta)c_q|\det(A)|^{-1}\{v_q(A^{-1}y - \mu)\}^{-n},$$

which extends the robustness results to the posterior of η . For $q = 2$ the sampling distribution on y is called elliptical or ellipsoidal, a case which was treated by Osiewalski & Steel (1993) within a regression context.

Finally, our Theorem formally suggests a possible extension to a wider class of sampling densities $p(x|\mu, \tau) = \tau^n g[v(\tau(x - \mu))]$, where we require $v(\cdot) \geq 0$, $v(\alpha a) = \alpha v(a)$ for any positive scalar α , and we choose $g(\cdot)$ in the class G of nonnegative functions such that $\int u^{n-1}g(u) du = c < \infty$, with the integral over the range $(0, \infty)$, and $p(x|\mu, \tau)$ is proper (in the case of I_q -sphericity, the last two conditions coincide). Then, the prior in (14) will result in (15) with c and $v(\cdot)$ instead of c_q and $v_q(\cdot)$. Therefore we achieve robustness for inference on the location μ (and on unobserved elements of x) within the entire class G .

ACKNOWLEDGEMENTS

We benefited from useful discussions with Carmen Fernández, Jean-Pierre Florens and Michel Mouchart. Of course, the usual disclaimer applies. The second author gratefully acknowledges the hospitality of the Academy of Economics, Kraków.

REFERENCES

- BOX, G. E. P. & TIAO, G. C. (1973). *Bayesian Inference in Statistical Analysis*. Reading, Mass.: Addison-Wesley.
- CAMBANIS, S., HUANG, S. & SIMONS, G. (1981). On the theory of elliptically contoured distributions. *J. Mult. Anal.* **11**, 368-85.
- DICKEY, J. M. & CHEN, C. H. (1985). Direct subjective-probability modelling using ellipsoidal distributions. In *Bayesian Statistics 2*, Ed. J. M. Bernardo, M. H. DeGroot, D. V. Lindley and A. F. M. Smith, pp. 157-82. Amsterdam: North-Holland.
- FANG, K.-T., KOTZ, S. & NG, K. W. (1990). *Symmetric Multivariate and Related Distributions*. London: Chapman and Hall.
- KELKER, D. (1970). Distribution theory of spherical distributions and a location-scale generalization. *Sankhyā A* **32**, 419-30.
- OSIEWALSKI, J. & STEEL, M. F. J. (1993). Robust Bayesian inference in elliptical regression models. *J. Econometrics* **57**. To appear.

[Received July 1992. Revised November 1992]

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- No. 1 G. Marini and F. van der Ploeg, Monetary and fiscal policy in an optimising model with capital accumulation and finite lives, *The Economic Journal*, vol. 98, no. 392, 1988, pp. 772 - 786.
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- No. 13 R.J.M. Alessie and A. Kapteyn, Consumption, savings and demography, in A. Wenig, K.F. Zimmermann (eds.), *Demographic Change and Economic Development*, Berlin/Heidelberg: Springer-Verlag, 1989, pp. 272 - 305.
- No. 14 A. Hoque, J.R. Magnus and B. Pesaran, The exact multi-period mean-square forecast error for the first-order autoregressive model, *Journal of Econometrics*, vol. 39, no. 3, 1988, pp. 327 - 346.
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- No. 18 T. Wansbeek and A. Kapteyn, Estimation of the error-components model with incomplete panels, *Journal of Econometrics*, vol. 41, no. 3, 1989, pp. 341 - 361.
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- No. 21 J.R. Magnus and B. Pesaran, The exact multi-period mean-square forecast error for the first-order autoregressive model with an intercept, *Journal of Econometrics*, vol. 42, no. 2, 1989, pp. 157 - 179.
- No. 22 F. van der Ploeg, Two essays on political economy: (i) The political economy of overvaluation, *The Economic Journal*, vol. 99, no. 397, 1989, pp. 850 - 855; (ii) Election outcomes and the stockmarket, *European Journal of Political Economy*, vol. 5, no. 1, 1989, pp. 21 - 30.
- No. 23 J.R. Magnus and A.D. Woodland, On the maximum likelihood estimation of multivariate regression models containing serially correlated error components, *International Economic Review*, vol. 29, no. 4, 1988, pp. 707 - 725.
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- No. 29 F. van der Ploeg and A.J. de Zeeuw, Perfect equilibrium in a model of competitive arms accumulation, *International Economic Review*, vol. 31, no. 1, 1990, pp. 131 - 146.
- No. 30 J.R. Magnus and A.D. Woodland, Separability and aggregation, *Economica*, vol. 57, no. 226, 1990, pp. 239 - 247.
- No. 31 F. van der Ploeg, International interdependence and policy coordination in economies with real and nominal wage rigidity, *Greek Economic Review*, vol. 10, no. 1, June 1988, pp. 1 - 48.
- No. 32 E. van Damme, Signaling and forward induction in a market entry context, *Operations Research Proceedings 1989*, Berlin-Heidelberg: Springer-Verlag, 1990, pp. 45 - 59.
- No. 33 A.P. Barten, Toward a levels version of the Rotterdam and related demand systems, *Contributions to Operations Research and Economics*, Cambridge: MIT Press, 1989, pp. 441 - 465.
- No. 34 F. van der Ploeg, International coordination of monetary policies under alternative exchange-rate regimes, in F. van der Ploeg (ed.), *Advanced Lectures in Quantitative Economics*, London-Orlando: Academic Press Ltd., 1990, pp. 91 - 121.
- No. 35 Th. van de Klundert, On socioeconomic causes of 'wait unemployment', *European Economic Review*, vol. 34, no. 5, 1990, pp. 1011 - 1022.
- No. 36 R.J.M. Alessie, A. Kapteyn, J.B. van Lochem and T.J. Wansbeek, Individual effects in utility consistent models of demand, in J. Hartog, G. Ridder and J. Theeuwes (eds.), *Panel Data and Labor Market Studies*, Amsterdam: Elsevier Science Publishers B.V. (North-Holland), 1990, pp. 253 - 278.
- No. 37 F. van der Ploeg, Capital accumulation, inflation and long-run conflict in international objectives, *Oxford Economic Papers*, vol. 42, no. 3, 1990, pp. 501 - 525.
- No. 38 Th. Nijman and F. Palm, Parameter identification in ARMA Processes in the presence of regular but incomplete sampling, *Journal of Time Series Analysis*, vol. 11, no. 3, 1990, pp. 239 - 248.
- No. 39 Th. van de Klundert, Wage differentials and employment in a two-sector model with a dual labour market, *Metroeconomica*, vol. 40, no. 3, 1989, pp. 235 - 256.

- No. 40 Th. Nijman and M.F.J. Steel, Exclusion restrictions in instrumental variables equations, *Econometric Reviews*, vol. 9, no. 1, 1990, pp. 37 - 55.
- No. 41 A. van Soest, I. Woittiez and A. Kapteyn, Labor supply, income taxes, and hours restrictions in the Netherlands, *Journal of Human Resources*, vol. 25, no. 3, 1990, pp. 517 - 558.
- No. 42 Th.C.M.J. van de Klundert and A.B.T.M. van Schaik, Unemployment persistence and loss of productive capacity: a Keynesian approach, *Journal of Macro- economics*, vol. 12, no. 3, 1990, pp. 363 - 380.
- No. 43 Th. Nijman and M. Verbeek, Estimation of time-dependent parameters in linear models using cross-sections, panels, or both, *Journal of Econometrics*, vol. 46, no. 3, 1990, pp. 333 - 346.
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- No. 45 C. Dang, The D_j -triangulation of $\mathbb{R}^n$ for simplicial algorithms for computing solutions of nonlinear equations, *Mathematics of Operations Research*, vol. 16, no. 1, 1991, pp. 148 - 161.
- No. 46 Th. Nijman and F. Palm, Predictive accuracy gain from disaggregate sampling in ARIMA models, *Journal of Business & Economic Statistics*, vol. 8, no. 4, 1990, pp. 405 - 415.
- No. 47 J.R. Magnus, On certain moments relating to ratios of quadratic forms in normal variables: further results, *Sankhya: The Indian Journal of Statistics*, vol. 52, series B, part. 1, 1990, pp. 1 - 13.
- No. 48 M.F.J. Steel, A Bayesian analysis of simultaneous equation models by combining recursive analytical and numerical approaches, *Journal of Econometrics*, vol. 48, no. 1/2, 1991, pp. 83 - 117.
- No. 49 F. van der Ploeg and C. Withagen, Pollution control and the ramsey problem, *Environmental and Resource Economics*, vol. 1, no. 2, 1991, pp. 215 - 236.
- No. 50 F. van der Ploeg, Money and capital in interdependent economies with overlapping generations, *Economica*, vol. 58, no. 230, 1991, pp. 233 - 256.
- No. 51 A. Kapteyn and A. de Zeeuw, Changing incentives for economic research in the Netherlands, *European Economic Review*, vol. 35, no. 2/3, 1991, pp. 603 - 611.
- No. 52 C.G. de Vries, On the relation between GARCH and stable processes, *Journal of Econometrics*, vol. 48, no. 3, 1991, pp. 313 - 324.
- No. 53 R. Alessie and A. Kapteyn, Habit formation, interdependent preferences and demographic effects in the almost ideal demand system, *The Economic Journal*, vol. 101, no. 406, 1991, pp. 404 - 419.
- No. 54 W. van Groenendaal and A. de Zeeuw, Control, coordination and conflict on international commodity markets, *Economic Modelling*, vol. 8, no. 1, 1991, pp. 90 - 101.

- No. 55 F. van der Ploeg and A.J. Markink, Dynamic policy in linear models with rational expectations of future events: A computer package, *Computer Science in Economics and Management*, vol. 4, no. 3, 1991, pp. 175 - 199.
- No. 56 H.A. Keuzenkamp and F. van der Ploeg, Savings, investment, government finance, and the current account: The Dutch experience, in G. Alogoskoufis, L. Papademos and R. Portes (eds.), *External Constraints on Macroeconomic Policy: The European Experience*, Cambridge: Cambridge University Press, 1991, pp. 219 - 263.
- No. 57 Th. Nijman, M. Verbeek and A. van Soest, The efficiency of rotating-panel designs in an analysis-of-variance model, *Journal of Econometrics*, vol. 49, no. 3, 1991, pp. 373 - 399.
- No. 58 M.F.J. Steel and J.-F. Richard, Bayesian multivariate exogeneity analysis - an application to a UK money demand equation, *Journal of Econometrics*, vol. 49, no. 1/2, 1991, pp. 239 - 274.
- No. 59 Th. Nijman and F. Palm, Generalized least squares estimation of linear models containing rational future expectations, *International Economic Review*, vol. 32, no. 2, 1991, pp. 383 - 389.
- No. 60 E. van Damme, Equilibrium selection in 2×2 games, *Revista Espanola de Economia*, vol. 8, no. 1, 1991, pp. 37 - 52.
- No. 61 E. Bennett and E. van Damme, Demand commitment bargaining: the case of apex games, in R. Selten (ed.), *Game Equilibrium Models III - Strategic Bargaining*, Berlin: Springer-Verlag, 1991, pp. 118 - 140.
- No. 62 W. Güth and E. van Damme, Gorbey games - a game theoretic analysis of disarmament campaigns and the defense efficiency - hypothesis -, in R. Avenhaus, H. Karkar and M. Rudnianski (eds.), *Defense Decision Making - Analytical Support and Crisis Management*, Berlin: Springer-Verlag, 1991, pp. 215 - 240.
- No. 63 A. Roell, Dual-capacity trading and the quality of the market, *Journal of Financial Intermediation*, vol. 1, no. 2, 1990, pp. 105 - 124.
- No. 64 Y. Dai, G. van der Laan, A.J.J. Talman and Y. Yamamoto, A simplicial algorithm for the nonlinear stationary point problem on an unbounded polyhedron, *Siam Journal of Optimization*, vol. 1, no. 2, 1991, pp. 151 - 165.
- No. 65 M. McAleer and C.R. McKenzie, Keynesian and new classical models of unemployment revisited, *The Economic Journal*, vol. 101, no. 406, 1991, pp. 359 - 381.
- No. 66 A.J.J. Talman, General equilibrium programming, *Nieuw Archief voor Wiskunde*, vol. 8, no. 3, 1990, pp. 387 - 397.
- No. 67 J.R. Magnus and B. Pesaran, The bias of forecasts from a first-order autoregression, *Econometric Theory*, vol. 7, no. 2, 1991, pp. 222 - 235.

- No. 68 F. van der Ploeg, Macroeconomic policy coordination issues during the various phases of economic and monetary integration in Europe, *European Economy - The Economics of EMU*, Commission of the European Communities, special edition no. 1, 1991, pp. 136 - 164.
- No. 69 H. Keuzenkamp, A precursor to Muth: Tinbergen's 1932 model of rational expectations, *The Economic Journal*, vol. 101, no. 408, 1991, pp. 1245 - 1253.
- No. 70 L. Zou, The target-incentive system vs. the price-incentive system under adverse selection and the ratchet effect, *Journal of Public Economics*, vol. 46, no. 1, 1991, pp. 51 - 89.
- No. 71 E. Bomhoff, Between price reform and privatization: Eastern Europe in transition, *Finanzmarkt und Portfolio Management*, vol. 5, no. 3, 1991, pp. 241 - 251.
- No. 72 E. Bomhoff, Stability of velocity in the major industrial countries: a Kalman filter approach, *International Monetary Fund Staff Papers*, vol. 38, no. 3, 1991, pp. 626 - 642.
- No. 73 E. Bomhoff, Currency convertibility: when and how? A contribution to the Bulgarian debate, *Kredit und Kapital*, vol. 24, no. 3, 1991, pp. 412 - 431.
- No. 74 H. Keuzenkamp and F. van der Ploeg, Perceived constraints for Dutch unemployment policy, in C. de Neubourg (ed.), *The Art of Full Employment - Unemployment Policy in Open Economies*, Contributions to Economic Analysis 203, Amsterdam: Elsevier Science Publishers B.V. (North-Holland), 1991, pp. 7 - 37.
- No. 75 H. Peters and E. van Damme, Characterizing the Nash and Raiffa bargaining solutions by disagreement point axioms, *Mathematics of Operations Research*, vol. 16, no. 3, 1991, pp. 447 - 461.
- No. 76 P.J. Deschamps, On the estimated variances of regression coefficients in misspecified error components models, *Econometric Theory*, vol. 7, no. 3, 1991, pp. 369 - 384.
- No. 77 A. de Zeeuw, Note on 'Nash and Stackelberg solutions in a differential game model of capitalism', *Journal of Economic Dynamics and Control*, vol. 16, no. 1, 1992, pp. 139 - 145.
- No. 78 J.R. Magnus, On the fundamental bordered matrix of linear estimation, in F. van der Ploeg (ed.), *Advanced Lectures in Quantitative Economics*, London-Orlando: Academic Press Ltd., 1990, pp. 583 - 604.
- No. 79 F. van der Ploeg and A. de Zeeuw, A differential game of international pollution control, *Systems and Control Letters*, vol. 17, no. 6, 1991, pp. 409 - 414.
- No. 80 Th. Nijman and M. Verbeek, The optimal choice of controls and pre-experimental observations, *Journal of Econometrics*, vol. 51, no. 1/2, 1992, pp. 183 - 189.
- No. 81 M. Verbeek and Th. Nijman, Can cohort data be treated as genuine panel data?, *Empirical Economics*, vol. 17, no. 1, 1992, pp. 9 - 23.

- No. 82 E. van Damme and W. Güth, Equilibrium selection in the Spence signaling game, in R. Selten (ed.), *Game Equilibrium Models II - Methods, Morals, and Markets*, Berlin: Springer-Verlag, 1991, pp. 263 - 288.
- No. 83 R.P. Gilles and P.H.M. Ruys, Characterization of economic agents in arbitrary communication structures, *Nieuw Archief voor Wiskunde*, vol. 8, no. 3, 1990, pp. 325 - 345.
- No. 84 A. de Zeeuw and F. van der Ploeg, Difference games and policy evaluation: a conceptual framework, *Oxford Economic Papers*, vol. 43, no. 4, 1991, pp. 612 - 636.
- No. 85 E. van Damme, Fair division under asymmetric information, in R. Selten (ed.), *Rational Interaction - Essays in Honor of John C. Harsanyi*, Berlin/Heidelberg: Springer-Verlag, 1992, pp. 121 - 144.
- No. 86 F. de Jong, A. Kemna and T. Kloek, A contribution to event study methodology with an application to the Dutch stock market, *Journal of Banking and Finance*, vol. 16, no. 1, 1992, pp. 11 - 36.
- No. 87 A.P. Barten, The estimation of mixed demand systems, in R. Bewley and T. Van Hoa (eds.), *Contributions to Consumer Demand and Econometrics, Essays in Honour of Henri Theil*, Basingstoke: The Macmillan Press Ltd., 1992, pp. 31 - 57.
- No. 88 T. Wansbeek and A. Kapteyn, Simple estimators for dynamic panel data models with errors in variables, in R. Bewley and T. Van Hoa (eds.), *Contributions to Consumer Demand and Econometrics, Essays in Honour of Henri Theil*, Basingstoke: The Macmillan Press Ltd., 1992, pp. 238 - 251.
- No. 89 S. Chib, J. Osiewalski and M. Steel, Posterior inference on the degrees of freedom parameter in multivariate-*t* regression models, *Economics Letters*, vol. 37, no. 4, 1991, pp. 391 - 397.
- No. 90 H. Peters and P. Wakker, Independence of irrelevant alternatives and revealed group preferences, *Econometrica*, vol. 59, no. 6, 1991, pp. 1787 - 1801.
- No. 91 G. Alogoskoufis and F. van der Ploeg, On budgetary policies, growth, and external deficits in an interdependent world, *Journal of the Japanese and International Economies*, vol. 5, no. 4, 1991, pp. 305 - 324.
- No. 92 R.P. Gilles, G. Owen and R. van den Brink, Games with permission structures: The conjunctive approach, *International Journal of Game Theory*, vol. 20, no. 3, 1992, pp. 277 - 293.
- No. 93 J.A.M. Potters, I.J. Curiel and S.H. Tijs, Traveling salesman games, *Mathematical Programming*, vol. 53, no. 2, 1992, pp. 199 - 211.
- No. 94 A.P. Jurg, M.J.M. Jansen, J.A.M. Potters and S.H. Tijs, A symmetrization for finite two-person games, *Zeitschrift für Operations Research - Methods and Models of Operations Research*, vol. 36, no. 2, 1992, pp. 111 - 123.

- No. 95 A. van den Nouweland, P. Borm and S. Tijs, Allocation rules for hypergraph communication situations, *International Journal of Game Theory*, vol. 20, no. 3, 1992, pp. 255 - 268.
- No. 96 E.J. Bomhoff, Monetary reform in Eastern Europe, *European Economic Review*, vol. 36, no. 2/3, 1992, pp. 454 - 458.
- No. 97 F. van der Ploeg and A. de Zeeuw, International aspects of pollution control, *Environmental and Resource Economics*, vol. 2, no. 2, 1992, pp. 117 - 139.
- No. 98 P.E.M. Borm and S.H. Tijs, Strategic claim games corresponding to an NTU-game, *Games and Economic Behavior*, vol. 4, no. 1, 1992, pp. 58 - 71.
- No. 99 A. van Soest and P. Kooreman, Coherency of the indirect translog demand system with binding nonnegativity constraints, *Journal of Econometrics*, vol. 44, no. 3, 1990, pp. 391 - 400.
- No. 100 Th. ten Raa and E.N. Wolff, Secondary products and the measurement of productivity growth, *Regional Science and Urban Economics*, vol. 21, no. 4, 1991, pp. 581 - 615.
- No. 101 P. Kooreman and A. Kapteyn, On the empirical implementation of some game theoretic models of household labor supply, *The Journal of Human Resources*, vol. 25, no. 4, 1990, pp. 584 - 598.
- No. 102 H. Bester, Bertrand equilibrium in a differentiated duopoly, *International Economic Review*, vol. 33, no. 2, 1992, pp. 433 - 448.
- No. 103 J.A.M. Potters and S.H. Tijs, The nucleolus of a matrix game and other nucléoli, *Mathematics of Operations Research*, vol. 17, no. 1, 1992, pp. 164 - 174.
- No. 104 A. Kapteyn, P. Kooreman and A. van Soest, Quantity rationing and concavity in a flexible household labor supply model, *Review of Economics and Statistics*, vol. 72, no. 1, 1990, pp. 55 - 62.
- No. 105 A. Kapteyn and P. Kooreman, Household labor supply: What kind of data can tell us how many decision makers there are?, *European Economic Review*, vol. 36, no. 2/3, 1992, pp. 365 - 371.
- No. 106 Th. van de Klundert and S. Smulders, Reconstructing growth theory: A survey, *De Economist*, vol. 140, no. 2, 1992, pp. 177 - 203.
- No. 107 N. Rankin, Imperfect competition, expectations and the multiple effects of monetary growth, *The Economic Journal*, vol. 102, no. 413, 1992, pp. 743 - 753.
- No. 108 J. Greenberg, On the sensitivity of von Neumann and Morgenstern abstract stable sets: The stable and the individual stable bargaining set, *International Journal of Game Theory*, vol. 21, no. 1, 1992, pp. 41 - 55.
- No. 109 S. van Wijnbergen, Trade reform, policy uncertainty, and the current account: A non-expected-utility approach, *American Economic Review*, vol. 82, no. 3, 1992, pp. 626 - 633.

- No. 110 M. Verbeek and Th. Nijman, Testing for selectivity bias in panel data models, *International Economic Review*, vol. 33, no. 3, 1992, pp. 681 - 703.
- No. 111 Th. Nijman and M. Verbeek, Nonresponse in panel data: The impact on estimates of a life cycle consumption function, *Journal of Applied Econometrics*, vol. 7, no. 3, 1992, pp. 243 - 257.
- No. 112 I. Bomze and E. van Damme, A dynamical characterization of evolutionarily stable states, *Annals of Operations Research*, vol. 37, 1992, pp. 229 - 244.
- No. 113 P.J. Deschamps, Expectations and intertemporal separability in an empirical model of consumption and investment under uncertainty, *Empirical Economics*, vol. 17, no. 3, 1992, pp. 419 - 450.
- No. 114 K. Kamiya and D. Talman, Simplicial algorithm for computing a core element in a balanced game, *Journal of the Operations Research*, vol. 34, no. 2, 1991, pp. 222 - 228.
- No. 115 G.W. Imbens, An efficient method of moments estimator for discrete choice models with choice-based sampling, *Econometrica*, vol. 60, no. 5, 1992, pp. 1187 -1214.
- No. 116 P. Borm, On perfectness concepts for bimatrix games, *OR Spektrum*, vol. 14, no. 1, 1992, pp. 33 - 42.
- No. 117 A.P. Jurg, I. Garcia Jurado and P.E.M. Borm, On modifications of the concepts of perfect and proper equilibria, *OR Spektrum*, vol. 14, no. 2, 1992, pp. 85 - 90.
- No. 118 P. Borm, H. Keiding, R.P. McLean, S. Oortwijn and S. Tijs, The compromise value for NTU-games, *International Journal of Game Theory*, vol. 21, no. 2, 1992, pp. 175 - 189.
- No. 119 M. Maschler, J.A.M. Potters and S.H. Tijs, The general nucleolus and the reduced game property, *International Journal of Game Theory*, vol. 21, no. 1, 1992, pp. 85 - 106.
- No. 120 K. Wärneryd, Communication, correlation and symmetry in bargaining, *Economics Letters*, vol. 39, no. 3, 1992, pp. 295 - 300.
- No. 121 M.R. Baye, D. Kovenock and C.G. de Vries, It takes two to tango: equilibria in a model of sales, *Games and Economic Behavior*, vol. 4, no. 4, 1992, pp. 493 - 510.
- No. 122 M. Verbeek, Pseudo panel data, in L. Mátyás and P. Sevestre (eds.), *The Econometrics of Panel Data*, Dordrecht: Kluwer Academic Publishers, 1992, pp. 303 - 315.
- No. 123 S. van Wijnbergen, Intertemporal speculation, shortages and the political economy of price reform, *The Economic Journal*, vol. 102, no. 415, 1992, pp. 1395 - 1406.
- No. 124 M. Verbeek and Th. Nijman, Incomplete panels and selection bias, in L. Mátyás and P. Sevestre (eds.), *The Econometrics of Panel Data*, Dordrecht: Kluwer Academic Publishers, 1992, pp. 262 - 302.

- No. 125 J.J. Sijben, Monetary policy in a game-theoretic framework, *Jahrbücher für Nationalökonomie und Statistik*, vol. 210, no. 3/4, 1992, pp. 233 - 253.
- No. 126 H.A.A. Verbon and M.J.M. Verhoeven, Decision making on pension schemes under rational expectations, *Journal of Economics*, vol. 56, no. 1, 1992, pp. 71 - 97.
- No. 127 L. Zou, Ownership structure and efficiency: An incentive mechanism approach, *Journal of Comparative Economics*, vol. 16, no. 3, 1993, pp. 399 - 431.
- No. 128 C. Fershtman and A. de Zeeuw, Capital accumulation and entry deterrence: A clarifying note, in G. Feichtinger (ed.), *Dynamic Economic Models and Optimal Control*, Amsterdam: Elsevier Science Publishers B.V. (North-Holland), 1992, pp. 281 - 296.
- No. 129 L. Bovenberg and C. Petersen, Public debt and pension policy, *Fiscal Studies*, vol. 13, no. 3, 1992, pp. 1 - 14.
- No. 130 R. Gradus and A. de Zeeuw, An employment game between government and firms, *Optimal Control Applications & Methods*, vol. 13, no. 1, 1992, pp. 55 - 71.
- No. 131 Th. Nijman and R. Beetsma, Empirical tests of a simple pricing model for sugar futures, *Annales d'Économie et de Statistique*, no. 24, 1991, pp. 121 - 131.
- No. 132 F. Groot, C. Withagen and A. de Zeeuw, Note on the open-loop Von Stackelberg equilibrium in the Cartel versus Fringe model, *The Economic Journal*, vol. 102, no. 415, 1992, pp. 1478 - 1484.
- No. 133 S. Eijffinger and N. Grujters, On the effectiveness of daily intervention by the Deutsche Bundesbank and the Federal Reserve System in the US dollar - deutsche mark exchange market, in Baltensperger/Sinn (eds), *Exchange-Rate Regimes and Currency Unions*, Basingstoke: The Macmillan Press Ltd., 1992, pp. 131 - 156.
- No. 135 A. K. Bera and S. Lee, Information matrix test, parameter heterogeneity and ARCH: a synthesis, *Review of Economic Studies*, 60, 1993, pp. 229 - 240.
- No. 136 H. G. Bloemen and A. Kapteyn, The joint estimation of a non-linear labour supply function and a wage equation using simulated response probabilities, *Annales d'Économie et de Statistique*, No. 29, 1993, pp. 175 - 205.
- No. 137 H. Bester, Bargaining versus price competition in markets with quality uncertainty, *The American Economic Review*, Vol. 83, No. 1, March 1993, pp. 278 - 288.
- No. 138 K. Wärneryd, Anarchy, uncertainty, and the emergence of property rights, *Economics and Politics*, Vol. 5, No. 1, March 1993, pp. 1 - 14.
- No. 139 A. L. Bovenberg and L.H. Goulder, Promoting investment under international capital mobility: an intertemporal general equilibrium analysis, *The Scandinavian Journal of Economics*, Vol. 95, No. 2, 1993, pp. 133 - 156.
- No. 140 S. Eijffinger and E. Schaling, Central bank independence in twelve industrial countries, *Banca Nazionale del Lavoro Quarterly Review*, No. 184, March 1993, pp. 49 - 89.

- No. 141 S. Eijffinger and A. van Rixtel, The Japanese financial system and monetary policy: a descriptive review, *Japan and the World Economy*, Vol. 4, No. 4, 1992, pp 291-309.
- No. 142 A. L. Bovenberg, Investment-promoting policies in open economies: the importance of intergenerational and international distributional effects, *Journal of Public Economics*, Vol. 51, 1993, North Holland, pp. 3-54 .
- No. 143 A. Özcam, G. Judge, A. Bera and T. Yancey, The risk properties of a pre-test estimator for Zellner's seemingly unrelated regression model, *Journal of Quantitative Economics*, Vol. 9, No. 1, January 1993, pp. 41-52.
- No. 144 F. C. Drost and T. E. Nijman, Temporal aggregation of garch processes, *Econometrica*, Vol. 61, No. 4, July 1993, pp. 909-927.
- No. 145 J. J. G. Lemmen and S.C.W. Eijffinger, The degree of financial integration in the European Community, *De Economist*, Vol. 141, No. 2, 1993, pp. 189-213.
- No. 146 R. Sarin and P. Wakker, A simple axiomatization of nonadditive expected utility, *Econometrica*, Vol. 60, No. 6, November 1992, pp. 1255-1272.
- No. 147 S. Muto, On licensing policies in bertrand competition, *Games and Economic Behaviour*, 5, 1993, pp. 257-267.
- No. 148 M. Verbeek and T. Nijman, Minimum MSE estimation of a regression model with fixed effects from a series of cross-sections, *Journal of Econometrics*, 59, 1993, pp. 125-136.
- No. 149 R. de Groof and M. van Tuijl, Financial integration and fiscal policy in interdependent two-sector economies with real and nominal wage rigidity, *European Journal of Political Economy*, Vol. 9, 1993, North Holland, pp. 209-232.
- No. 150 A. van Soest, A. Kapteyn and P. Kooreman, Coherency and regularity of demand systems with equality and inequality constraints, *Journal of Econometrics*, Vol. 57, 1993, North- Holland, pp. 161-188.
- No. 151 W. Härdle and A.B. Tsybakov, How sensitive are average derivatives?, *Journal of Econometrics*, Vol. 58, 1993, North-Holland, pp. 31-48.
- No. 152 H. Bester, The role of collateral in a model of debt renegotiation, *Journal of Money, Credit and Banking*, Vol. 26, No. 1, February 1994, pp. 72-86.
- No. 153 J. J. Sijben, Credit markets, financial fragility, and the real economy, *Kredit und Kapital*, Vol. 26, No. 4, 1993, pp. 481-515.
- No. 154 Y. Dai and D. Talman, Linear stationary point problems on unbounded polyhedra, *Mathematics of Operations Research*, Vol. 18, No. 3, August 1993, pp. 635-644.
- No. 155 P. J. Deschamps, Joint tests for regularity and autocorrelation in allocation systems, *Journal of Applied Econometrics*, Vol. 8, 1993, pp. 195-211.

- No. 156 G. J. Almekinders and S. C. W. Eijffinger, Daily Bundesbank and Federal Reserve interventions: Are they a reaction to changes in the level and volatility of the DM/\$-Rate?, *Empirical Economics*, Vol. 19, 1994, pp. 111-130.
- No. 157 J. Osiewalski and M. F. J. Steel, Robust Bayesian inference in l_q -spherical models, *Biometrika*, Vol. 80, No. 2, 1993, pp. 456-460.

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