The effect of systematic misperception of income on the subjective poverty line
Tummers, M.P.

Publication date:
1991

Document Version
Publisher's PDF, also known as Version of record

Citation for published version (APA):
THE EFFECT OF SYSTEMATIC MISPERCEPTION
OF INCOME ON THE SUBJECTIVE
POVERTY LINE

Drs. M.P. Tummers

FEW 509
The Effect of Systematic Misperception of Income on the Subjective Poverty Line

Martijn P. Tummers *
Tilburg University
P.O. Box 90153, 5000 LE Tilburg, The Netherlands
September, 1991

Abstract

Heads of households appear to misperceive their own household income. This misperception of income can be easily assessed, but also asks for some adjustment of the answers to subjective questions where household income serves as a frame of reference. The appropriate extent of adjustment can be estimated. However, it seems more natural to explain the unadjusted answers directly by both misperceived income and accurately measured income. The results show that adjustment of the answer to the so-called Minimum Income Question proportionate to the income misperception, as advocated by Kapteyn et al. (1988), causes an overestimation of the related Subjective Poverty Line for a one-person household and less pronounced household composition effects. The results, from estimated correction and in the case of direct use of misperceived income, are similar.

*The author thanks Peter Kooreman, Arie Kapteyn and Bertrand Melenberg for their invaluable comments. Ruud Muffels took care of the Statutory Poverty Line levels that appear in Table V. The Netherlands Central Bureau of Statistics kindly released the data for publication.
1 Introduction

Empirical evidence indicates that respondents misperceive their own household after tax income (See Kapteyn et al., 1988). Respondents appear to underestimate their household after tax income. As will be explained below, this underestimation turns out to have a downwards biasing effect on the subjective poverty line in empirical implementation. In Kapteyn et al. (1988), a method is presented to remedy this bias. One can adjust the responses to subjective questions if these questions are preceded by a question which measures the respondent's perception of his household after tax income. The misperception of income can be calculated from a comparison of the respondent's perception of the income with the measurement of income as the sum of a lengthy list of components. Next the responses to the subjective questions can be corrected. An alternative is of course to avoid the misperception, by prefacing the subjective questions with the detailed questions about household income components. Here, the focus is on the former case.

Kapteyn et al. (1988) assume that the answers to the subjective questions are biased in the same proportion as income is underestimated by the respondent. In this note, this assumption is tested within the context of the so-called Subjective Poverty Line (SPL). (See Goedhart et al., 1977). Section 2 concisely introduces the SPL concept. Section 3 presents the adjustment procedure as proposed in Kapteyn et al. (1988) and indicates how their assumption can be empirically relaxed\(^1\). An alternative assumption is also given through more direct use of the measurement of the respondent's perception of income in explaining subjective answers. Section 4 contains the estimation results. For comparison the same specification as in Kapteyn et al. (1988) is adopted. Section 5 concludes.

2 The Subjective Poverty Line

The SPL was introduced in Goedhart et al. (1977). It is called 'Subjective' because it springs from the respondents' answers to a survey question, the Minimum Income Question (MIQ). The MIQ runs as follows:

> Which after tax income for your household do you, in your circumstances, consider to be absolutely minimal? That is to say that with less you could not make both ends meet.

The MIQ answer, given by the head of household \(n\), is referred to as the respondent's minimum income \(y_{\text{min},n}\).

The SPL is operationalized by specifying a relation between \(y_{\text{min},n}\) on the one hand and household income and a vector of household characteristics on the other hand. To facilitate comparison, the SPL equation will initially be specified as in

\(^1\)This was suggested by a referee of Kapteyn et al. (1988).
Kapteyn et al. (1988):

\[
\ln y_{\text{min},n} = \alpha_0 + \alpha_1(1 - \alpha_2)fc_n + \psi(1 - \alpha_2)fc_n \ln y_n + \alpha_2 \ln y_n \\
+ (1 - \alpha_2)m_n - \alpha_1(1 - \alpha_2)hc_n - \psi(1 - \alpha_2)hc_nm_n + \epsilon_n
\]

(1)

where

- \(fc_n\) composition of household \(n\)
- \(y_n\) household after tax income
- \(m_n\) mean ln income in the reference group of household \(n\)
- \(hc_n\) mean household composition in the reference group of household \(n\)
- \(\epsilon_n\) error term

Household composition is specified such that account is taken of both the number of persons in the household and their ages:

\[
f_{cn} = 1 + \ln f_{sn} + f(a_1) + \sum_{j=2}^{f_{sn}} f(a_j) \ln(j/j - 1)
\]

(2)

where

- \(f_{sn}\) number of persons in household \(n\)
- \(f(a_j) = 0\) \(a_j > 18\)
- \(f(a_j) = \gamma_2(18 - a_j)^2 + \gamma_3(18 - a_j)^2(36 + a_j)\) \(0 \leq a_j \leq 18\)

where \(a_j\) refers to the age of person \(j\) and \(\gamma_2\) and \(\gamma_3\) are parameters to be estimated.

From equation (1), \(y_{\text{min},n}\) can be written as a function of \(y_n\), for given values of the other variables on the RHS, as set out in Figure 1. The MIQ answers are aggregated into the SPL by the following reasoning. Suppose one obtains an income to the right of \(y_{\text{min},n}\) in Figure 1. Take the corresponding minimum income level and return it as income. Through an iterated habituation process that person will end up in the fixed point of the function set out in Figure 1. The SPL is defined by this fixed point of that function, \(y_{\text{min},n}\), which equals

\[
\exp \frac{\alpha_0 + \alpha_1(1 - \alpha_2)fc_n + (1 - \alpha_2)m_n - \alpha_1(1 - \alpha_2)hc_n - \psi(1 - \alpha_2)hc_nm_n}{(1 - \alpha_2)(1 - \psi fc_n)}
\]

(3)

The income level \(y_{\text{min},n}\) is the point where a household can just make both ends meet. Eventually, a household is not able to manage with less income and with more income it is. Having estimated the parameters in equation (1), the SPL can be evaluated for various household compositions.
3 Adjusting for Downward Bias

In the definition of the SPL, the respondent’s income appears to be a crucial variable. So it is important to know which estimate of his own household income the respondent has in mind when answering the MIQ. If the respondent underestimates this income, it is likely that he will also underestimate $y_{min,n}$. As mentioned before, the factor of downward bias can be calculated from comparison between the respondent's estimate of income and a more accurate measurement of income. Just before the MIQ in the survey, the respondent’s perception of his household after tax income is measured by the following question where the respondent can choose out of seven income brackets:

Can you indicate roughly what the total after tax income of your household has been during the past 12 months? Less than Dfl. 17,500; 17,500–20,000; 20,000–24,000; 24,000–28,000; 28,000–34,000; 34,000–43,000; 43,000 or more.

Table I reflects the underestimation of household income.

In order to analyze the systematic difference in Table I between the results from the two income measures, Kapteyn et al. postulate the following relation between income $y_n^*$, the answer to the income question in brackets, and the income components $y_{ni}$ ($i = 1, \ldots, I$) recorded at the end of the questionnaire

$$y_n^* = \left( \sum_{i=1}^{I} \beta_i y_{ni} \right) e^n$$  \hspace{1cm} (4)
where the $\beta_i$'s are parameters to be estimated and $\eta$ is a normally distributed error term with mean zero and variance $\sigma^2_t$. The values of $\beta_i$ are expected to lie in the unit interval $[0,1]$. The smaller a parameter $\beta_i$, the more the respondents 'forget' the $i$th income component in response to the income question in brackets. The parameters $\beta_i$ and $\sigma^2_t$ can be estimated by means of maximum likelihood.

Denote the factor of underestimation by $g_n$. The parameters $\beta_i$ being estimated, this factor can be evaluated as $g_n = \sum_{i=1}^I y_{ni}/\sum_{i=1}^I \beta_i y_{ni}$. Kapteyn et al. now assume that the respondent underestimates his minimum income $y_{min,n}$ by the same proportion as his current income $y_n$. It is however not entirely obvious why the adjustment of $y_{min}$ should be proportionate to the underestimation of $y$, for in equation (1) $y_{min}$ and $y$ are not linearly related. Moreover it appears that the extent to which $y_{min}$ should be corrected, can be estimated. After substituting the adjusted value $y_{min,n}g_n$ for $y_{min,n}$, equation (1) becomes

$$\ln y_{min,n} = -\delta \ln g_n + \alpha_0 + \alpha_1 (1-\alpha_2) f c_n + \psi (1-\alpha_2) f c_n \ln y_n + \alpha_2 \ln y_n$$

$$+ (1-\alpha_2) m_n - \alpha_1 (1-\alpha_2) h c_n - \psi (1-\alpha_2) h c_n m_n + \epsilon_n$$

where $\delta$ indicates the extent of adjustment. Note that $\delta$ is identified so that it is possible to test whether proportional adjustment is appropriate, i.e. $\delta = 1$ vs. $\delta \neq 1$.

From equation (1) readily an alternative specification suggests itself. In the response to the MIQ, income serves as a frame of reference. This is represented by $\ln y_n$ in equation (1). However, $\ln y_n^*$ seems a more natural candidate to capture this frame of reference, or perhaps a combination of $\ln y_n$ and $\ln y_n^*$ is best. So the alternative specification reads

**Table I: Comparison of Two Income Measures**

<table>
<thead>
<tr>
<th>Income Bracket</th>
<th>Average Income $10^3$</th>
<th>$N_n$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$&lt; 17,500$</td>
<td>17.201</td>
<td>564</td>
</tr>
<tr>
<td>17,500 - 20,000</td>
<td>25.085</td>
<td>355</td>
</tr>
<tr>
<td>20,000 - 24,000</td>
<td>28.690</td>
<td>521</td>
</tr>
<tr>
<td>24,000 - 28,000</td>
<td>32.128</td>
<td>632</td>
</tr>
<tr>
<td>28,000 - 34,000</td>
<td>38.305</td>
<td>635</td>
</tr>
<tr>
<td>34,000 - 43,000</td>
<td>45.412</td>
<td>686</td>
</tr>
<tr>
<td>$&gt; 43,000$</td>
<td>65.006</td>
<td>698</td>
</tr>
</tbody>
</table>

Dfl. per year. The second column gives the average income of all households in the corresponding income bracket according to the detailed measurement of income. $N_n$ heads the number of respondents in the income bracket. SEP Oct86.
\[ \ln y_{\text{min},n} = \alpha_0 + \alpha_1(1 - \alpha_2)fc_n + (\psi(1 - \alpha_2)fc_n + \alpha_2)((1 - \lambda) \ln y_n + \lambda \ln y_n') + (1 - \alpha_2)m_n - \alpha_1(1 - \alpha_2)hc_n - \psi(1 - \alpha_2)hc_nm_n + \epsilon_n \] (6)

The equations (5) and (6) are identical if \( \ln g_n = \ln y_n - \ln y_n' \) and \( \delta = \lambda(\psi(1 - \alpha_2)fc_n + \alpha_2) \). For equation (5), \( \ln y_{\text{min},n} + \delta \ln g_n \) is substituted for \( \ln y_{\text{min},n} \) in equation (1) and for equation (6), \( \ln y_n \) in equation (1) is replaced by \( (1 - \lambda) \ln y_n + \lambda \ln y_n' \). In estimation, equation (6) results in special cases of equation (5). The concurrences are tabulated in terms of \( \delta \) and \( \lambda \) in Table III.

<table>
<thead>
<tr>
<th>( \delta )</th>
<th>( \lambda )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>( \lambda(\psi(1 - \alpha_2)fc_n + \alpha_2) )</td>
<td>( \lambda )</td>
</tr>
<tr>
<td>( \psi(1 - \alpha_2)fc_n + \alpha_2 )</td>
<td>1</td>
</tr>
<tr>
<td>( \delta )</td>
<td>-</td>
</tr>
<tr>
<td>1</td>
<td>-</td>
</tr>
</tbody>
</table>

In the next section, the estimation results are given for both equation (5) and (6). Assuming that \( \epsilon_n \) and \( \eta_n \) are independent and follow a normal distribution the parameters are estimated by maximizing the loglikelihood

\[ L = \sum_{n=1}^{N} \left( \ln P_n - \frac{1}{2} \ln(\sigma^2 + \delta^2 \sigma^2_n) - \frac{1}{2} \frac{e_n^2}{\sigma^2 + \delta^2 \sigma^2_n} \right) \] (7)

where

\[ P_n = \Phi \left( \frac{\ln ub_n - \ln \sum_{i=1}^{l} \beta_i y_{ni} - \frac{\delta \sigma^2}{\sigma^2 + \delta^2 \sigma^2_n} \epsilon_n}{\sigma \sigma_n / \sqrt{\sigma^2 + \delta^2 \sigma^2_n}} \right) - \Phi \left( \frac{\ln lb_n - \ln \sum_{i=1}^{l} \beta_i y_{ni} - \frac{\delta \sigma^2}{\sigma^2 + \delta^2 \sigma^2_n} \epsilon_n}{\sigma \sigma_n / \sqrt{\sigma^2 + \delta^2 \sigma^2_n}} \right) \]

where \( e_n = \epsilon_n + \delta \eta_n \), \( \Phi \) is the cumulative standard normal distribution function and \( ub_n \) and \( lb_n \) are respectively the upper and lower bound of the income bracket \( y_n' \) is part of.
4 Estimation results

The data are from the October 1986 wave of the Social Economic Panel survey conducted by the Netherlands Central Bureau of Statistics. Table III lists the income components distinguished, $y_{ni}$.

<table>
<thead>
<tr>
<th>TABLE III: INCOME COMPONENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head of household's wages, salaries, benefits</td>
</tr>
<tr>
<td>Head of household's fringe benefits</td>
</tr>
<tr>
<td>Rent subsidies</td>
</tr>
<tr>
<td>Household allowances</td>
</tr>
<tr>
<td>Profits, employer's contribution to health insurance premiums, scholarships</td>
</tr>
<tr>
<td>Head of household's other income</td>
</tr>
<tr>
<td>Spouse's income</td>
</tr>
<tr>
<td>Eldest child's income</td>
</tr>
<tr>
<td>Other household members' income</td>
</tr>
</tbody>
</table>

Table IV presents the estimation results for equations (4) and (5). The estimated parameters $\beta_i$ indicate that the head of household’s wages etc. appear to be recalled almost completely. Components like incomes of children and other household members, rent subsidies and head of household’s other income are often forgotten.

Clearly, the hypothesis $\delta = 1$ has to be rejected. A striking result is that $\delta = 0$ performs even better than $\delta = 1$. The three columns in the middle do not manifest much within difference. The estimation result $\lambda > 1$ is difficult to interpret. At a high significance level ($\chi^2_{1,0.01} = 6.63$) however, the restriction $\lambda = 1$ holds, which signifies that only income as perceived by the head of the household, $y^*_n$, is the frame of reference when completing the survey.

To compare the results between the columns in Table IV, Figure 2 presents the five corresponding age functions $f(age)$ and Table IV exhibits the implied poverty lines for various household compositions. The poverty lines have been computed with $m_n$ and $h s_n$ set equal to their sample means.

Except for $\delta = 0$, the age functions look rather similar. Although the age functions show a dip, the poverty lines in Table V rise when household size in number of persons increases. Household size in number of persons compensates the age dips below zero. For $\delta = 1$, i.e. overadjustment of $\ln y_{\text{min},n}$ according to Table IV, the poverty line for a one-person household appears to be overestimated with respect to $\delta$ unrestricted. Similarly the economies of scale are overestimated in this case.

Just for comparison the last column of Table V contains the levels of the statutory poverty line for the selected household compositions. The levels are based on the Social Assistance Act and include holiday and family allowances. The steeper household composition compensation does offset the lower starting level of a one-person
**Table IV: Estimation Results Equations (4) and (5)**

<table>
<thead>
<tr>
<th></th>
<th>( \delta )</th>
<th>( \lambda(\psi(1-\alpha_2)c_n + \alpha_2) )</th>
<th>( 0.40(0.02) )</th>
<th>1</th>
<th>0.11(0.05)</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \delta_0 )</td>
<td>-0.43(0.03)</td>
<td>-0.38(0.01)</td>
<td>-0.39(0.01)</td>
<td>-0.38(0.01)</td>
<td>-0.30(0.01)</td>
<td></td>
</tr>
<tr>
<td>( \delta_1 )</td>
<td>3.88(0.78)</td>
<td>-0.12(0.25)</td>
<td>-0.13(0.25)</td>
<td>0.48(0.32)</td>
<td>-2.00(0.21)</td>
<td></td>
</tr>
<tr>
<td>( \delta_2 )</td>
<td>0.54(0.04)</td>
<td>0.34(0.03)</td>
<td>0.35(0.03)</td>
<td>0.39(0.03)</td>
<td>0.29(0.04)</td>
<td></td>
</tr>
<tr>
<td>( \delta_3 )</td>
<td>0.05(0.01)</td>
<td>0.03(0.01)</td>
<td>0.03(0.01)</td>
<td>0.03(0.01)</td>
<td>0.03(0.01)</td>
<td></td>
</tr>
<tr>
<td>( \delta_4 )</td>
<td>-1*10^{-3}</td>
<td>-1*10^{-3}</td>
<td>-1*10^{-3}</td>
<td>-1*10^{-3}</td>
<td>-1*10^{-3}</td>
<td></td>
</tr>
</tbody>
</table>

\[ (3*10^{-4}) \quad (2*10^{-4}) \quad (3*10^{-4}) \quad (2*10^{-4}) \]

|   | \( \psi \) | \( \beta_1 \) | \( \beta_2 \) | \( \beta_3 \) | \( \beta_4 \) | \( \beta_5 \) | \( \beta_6 \) | \( \beta_7 \) | \( \beta_8 \) | \( \beta_9 \) | \( \delta_1 \) | \( \delta_2 \) | \( \delta_3 \) | \( \delta_4 \) | \( \delta_5 \) | \( \delta_6 \) | \( \delta_7 \) | \( \delta_8 \) | \( \delta_9 \) | \( L \) |
| \( \psi \) | -0.35(0.07) | 0.03(0.02) | 0.03(0.02) | -0.03(0.03) | 0.21(0.02) |  |
| \( \beta_1 \) | 0.91(0.01) | 0.91(0.01) | 0.90(0.01) | 0.90(0.01) | 0.90(0.01) |  |
| \( \beta_2 \) | 0.95(0.07) | 0.77(0.06) | 0.78(0.06) | 0.79(0.06) | 0.84(0.04) |  |
| \( \beta_3 \) | 0.39(0.08) | 0.42(0.08) | 0.41(0.08) | 0.42(0.08) | 0.63(0.08) |  |
| \( \beta_4 \) | 0.44(0.07) | 0.79(0.07) | 0.79(0.07) | 0.78(0.07) | 0.75(0.06) |  |
| \( \beta_5 \) | 0.73(0.02) | 0.68(0.02) | 0.68(0.02) | 0.68(0.02) | 0.69(0.02) |  |
| \( \beta_6 \) | 0.45(0.03) | 0.45(0.03) | 0.45(0.03) | 0.45(0.03) | 0.48(0.03) |  |
| \( \beta_7 \) | 0.47(0.02) | 0.90(0.02) | 0.90(0.02) | 0.90(0.02) | 0.90(0.02) |  |
| \( \beta_8 \) | 0.43(0.03) | 0.42(0.03) | 0.42(0.03) | 0.42(0.03) | 0.41(0.03) |  |
| \( \beta_9 \) | 0.48(0.04) | 0.48(0.05) | 0.48(0.05) | 0.48(0.05) | 0.48(0.04) |  |
| \( \delta_1 \) | 0.31(0.003) | 0.29(0.003) | 0.29(0.003) | 0.29(0.003) | 0.31(0.004) |  |
| \( \delta_2 \) | 0.29(0.004) | 0.30(0.004) | 0.30(0.004) | 0.29(0.003) | 0.29(0.004) |  |
| \( L \) | -3543.6 | -3312.2 | -3315.3 | -3312.5 | -3803.0 |  |

\( N = 4091 \), standard errors in parentheses.
Figure 2: Age Functions, \(- \delta = 0, \ldots, \lambda = \hat{\lambda}, \ldots, \lambda = 1, \ldots, \delta = \hat{\delta}, \ldots, \delta = 1\).

Table V: Poverty Lines

<table>
<thead>
<tr>
<th>Household Composition</th>
<th>(\delta = 0)</th>
<th>(\lambda = \hat{\lambda})</th>
<th>(\lambda = 1)</th>
<th>(\delta = \hat{\delta})</th>
<th>(\delta = 1)</th>
<th>Statutory Poverty Line</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Adult</td>
<td>14,239</td>
<td>15,310</td>
<td>15,181</td>
<td>15,091</td>
<td>15,489</td>
<td>13,218</td>
</tr>
<tr>
<td>2 Adults</td>
<td>18,095</td>
<td>17,415</td>
<td>17,091</td>
<td>17,537</td>
<td>16,387</td>
<td>18,882</td>
</tr>
<tr>
<td>2 Adults + 6</td>
<td>18,298</td>
<td>18,359</td>
<td>18,017</td>
<td>18,564</td>
<td>16,832</td>
<td>19,963</td>
</tr>
<tr>
<td>2 Adults + 12</td>
<td>19,100</td>
<td>18,481</td>
<td>18,070</td>
<td>18,702</td>
<td>16,942</td>
<td>20,233</td>
</tr>
<tr>
<td>2 Adults + 12,6</td>
<td>19,240</td>
<td>19,199</td>
<td>18,772</td>
<td>19,462</td>
<td>17,337</td>
<td>22,071</td>
</tr>
<tr>
<td>2 Adults + 12,6,1</td>
<td>20,575</td>
<td>20,430</td>
<td>19,969</td>
<td>20,788</td>
<td>18,158</td>
<td>23,360</td>
</tr>
<tr>
<td>2 Adults + 12,6,2,1</td>
<td>21,222</td>
<td>21,290</td>
<td>20,811</td>
<td>21,681</td>
<td>18,834</td>
<td>24,933</td>
</tr>
<tr>
<td>2 Adults + 18,12,6,1</td>
<td>21,996</td>
<td>21,335</td>
<td>20,742</td>
<td>21,723</td>
<td>19,000</td>
<td>28,281</td>
</tr>
</tbody>
</table>

Dfl. per year.
household. The statutory poverty line levels end up to be higher than the subjective poverty line levels for all selected household compositions, except for the first one, no matter the specification.

5 Conclusions

If in a questionnaire, the Minimum Income Question is not preceded by detailed questions on household income to avoid misperception of this income by the head of the household when answering the MIQ, the answer should be corrected. Prefacing the MIQ with a measure of the perception of household income enables adjustment in explaining the answer to the MIQ. If one prefers to adjust the answers, it is possible to estimate the appropriate size of adjustment. Also the measurement of perceived income may be used more directly in explaining the MIQ answers. Either approach shows that adjustment proportionate to income misperception leads to both an overestimation of the Subjective Poverty Line for a one-person household and an overestimation of the economies of scale with an increasing number of household members.

References


IN 1990 REEDS VERSCHENEN

419 Bertrand Melenberg, Rob Alessie
   A method to construct moments in the multi-good life cycle consumption model

420 J. Kriens
   On the differentiability of the set of efficient \((\mu, \sigma^2)\) combinations
   in the Markowitz portfolio selection method

421 Steffen Jørgensen, Peter M. Kort
   Optimal dynamic investment policies under concave-convex adjustment costs

422 J.P.C. Blanc
   Cyclic polling systems: limited service versus Bernoulli schedules

423 M.H.C. Paardekooper
   Parallel normreducing transformations for the algebraic eigenvalue problem

424 Hans Gremmen
   On the political (ir)relevance of classical customs union theory

425 Ed Nijssen
   Marketingstrategie in Machtsperspectief

426 Jack P.C. Kleijnen
   Regression Meta-models for Simulation with Common Random Numbers:
   Comparison of Techniques

427 Harry H. Tigelaar
   The correlation structure of stationary bilinear processes

428 Drs. C.H. Veld en Drs. A.H.F. Verboven
   De waardering van aandelenwarrants en langlopende call-opties

429 Theo van de Klundert en Anton B. van Schaik
   Liquidity Constraints and the Keynesian Corridor

430 Gert Nieuwenhuis
   Central limit theorems for sequences with \(m(n)\)-dependent main part

431 Hans J. Gremmen
   Macro-Economic Implications of Profit Optimizing Investment Behaviour

432 J.M. Schumacher
   System-Theoretic Trends in Econometrics

433 Peter M. Kort, Paul M.J.J. van Loon, Mikulás Luptacik
   Optimal Dynamic Environmental Policies of a Profit Maximizing Firm

434 Raymond Gradus
   Optimal Dynamic Profit Taxation: The Derivation of Feedback Stackelberg Equilibria
435 Jack P.C. Kleijnen
Statistics and Deterministic Simulation Models: Why Not?

436 M.J.G. van Eijs, R.J.M. Heuts, J.P.C. Kleijnen
Analysis and comparison of two strategies for multi-item inventory systems with joint replenishment costs

437 Jan A. Weststrate
Waiting times in a two-queue model with exhaustive and Bernoulli service

438 Alfons Daems
Typologie van non-profit organisaties

439 Drs. C.H. Veld en Drs. J. Grazell
Motieven voor de uitgifte van converteerbare obligatieleningen en warrantobligatieleningen

440 Jack P.C. Kleijnen
Sensitivity analysis of simulation experiments: regression analysis and statistical design

441 C.H. Veld en A.H.F. Verboven
De waardering van conversierechten van Nederlandse converteerbare obligaties

442 Drs. C.H. Veld en Drs. P.J.W. Duffhues
Verslaggevingsaspecten van aandelenwarrants

443 Jack P.C. Kleijnen and Ben Annink
Vector computers, Monte Carlo simulation, and regression analysis: an introduction

444 Alfons Daems
"Non-market failures": Imperfections in de budgetsector

445 J.P.C. Blanc
The power-series algorithm applied to cyclic polling systems

446 L.W.G. Strijbosch and R.M.J. Heuts
Modelling (s,Q) inventory systems: parametric versus non-parametric approximations for the lead time demand distribution

447 Jack P.C. Kleijnen
Supercomputers for Monte Carlo simulation: cross-validation versus Rao's test in multivariate regression

448 Jack P.C. Kleijnen, Greet van Ham and Jan Rotmans
Techniques for sensitivity analysis of simulation models: a case study of the CO₂ greenhouse effect

449 Harrie A.A. Verbon and Marijn J.M. Verhoeven
Decision-making on pension schemes: expectation-formation under demographic change
450 Drs. W. Reijnders en Drs. P. Verstappen
Logistiek management marketinginstrument van de jaren negentig

451 Alfons J. Daems
Budgeting the non-profit organization
An agency theoretic approach

452 W.H. Haemers, D.G. Higman, S.A. Hobart
Strongly regular graphs induced by polarities of symmetric designs

453 M.J.G. van Eijs
Two notes on the joint replenishment problem under constant demand

454 B.B. van der Genugten
Iterated WLS using residuals for improved efficiency in the linear
model with completely unknown heteroskedasticity

455 F.A. van der Duyn Schouten and S.G. Vanneste
Two Simple Control Policies for a Multicomponent Maintenance System

456 Geert J. Almekinders and Sylvester C.W. Eijffinger
Objectives and effectiveness of foreign exchange market intervention
A survey of the empirical literature

457 Saskia Oortwijn, Peter Borm, Hans Keiding and Stef Tijs
Extensions of the t-value to NTU-games

458 Willem H. Haemers, Christopher Parker, Vera Pless and
Vladimir D. Tonchev
A design and a code invariant under the simple group Co3

459 J.P.C. Blanc
Performance evaluation of polling systems by means of the power-
series algorithm

460 Leo W.G. Strijbosch, Arno G.M. van Doorne, Willem J. Selen
A simplified MOLP algorithm: The MOLP-S procedure

461 Arie Kapteyn and Aart de Zeeuw
Changing incentives for economic research in The Netherlands

462 W. Spanjers
Equilibrium with co-ordination and exchange institutions: A comment

463 Sylvester Eijffinger and Adrian van Rixtel
The Japanese financial system and monetary policy: A descriptive
review

464 Hans Kremers and Dolf Talman
A new algorithm for the linear complementarity problem allowing for
an arbitrary starting point

465 René van den Brink, Robert P. Gilles
A social power index for hierarchically structured populations of
economic agents
IN 1991 REEDS VERSCHENEN

466 Prof. Dr. Th. C. M. J. van de Klundert - Prof. Dr. A. B. T. M. van Schaik
Economische groei in Nederland in een internationaal perspectief

467 Dr. Sylvester C. W. Eijffinger
The convergence of monetary policy - Germany and France as an example

468 E. Nijsen
Strategisch gedrag, planning en prestatie. Een inductieve studie
binnen de computerbranche

469 Anne van den Nouweland, Peter Borm, Guillermo Owen and Stef Tijs
Cost allocation and communication

470 Drs. J. Grazell en Drs. C. H. Veld
Motieven voor de uitgifte van converteerbare obligatieleningen en
warrant-obligatieleningen: een agency-theoretische benadering

471 P. C. van Batenburg, J. Kriens, W. M. Lammerts van Bueren en
R. H. Veenstra
Audit Assurance Model and Bayesian Discovery Sampling

472 Marcel Kerkhofs
Identification and Estimation of Household Production Models

473 Robert P. Gilles, Guillermo Owen, René van den Brink
Games with Permission Structures: The Conjunctive Approach

474 Jack P. C. Kleijnen
Sensitivity Analysis of Simulation Experiments: Tutorial on Regression
Analysis and Statistical Design

475 C. P. M. van Hoesel
An O(n log n) algorithm for the two-machine flow shop problem with
controllable machine speeds

476 Stephan G. Vanneste
A Markov Model for Opportunity Maintenance

477 F. A. van der Duyn Schouten, M. J. G. van Eijs, R. M. J. Heuts
Coordinated replenishment systems with discount opportunities

478 A. van den Nouweland, J. Potters, S. Tijs and J. Zarzuelo
Cores and related solution concepts for multi-choice games

479 Drs. C. H. Veld
Warrant pricing: a review of theoretical and empirical research

480 E. Nijsen
De Miles and Snow-typologie: Een exploratieve studie in de meubel-
branche

481 Harry G. Barkema
Are managers indeed motivated by their bonuses?
Jacob C. Engwerda, André C.M. Ran, Arie L. Rijkeboer
Necessary and sufficient conditions for the existence of a positive definite solution of the matrix equation $X + A^TX^{-1}A = I$

Peter M. Kort
A dynamic model of the firm with uncertain earnings and adjustment costs

Raymond H.J.M. Gradus, Peter M. Kort
Optimal taxation on profit and pollution within a macroeconomic framework

René van den Brink, Robert P. Gilles
Axiomatizations of the Conjunctive Permission Value for Games with Permission Structures

A.E. Brouwer & W.H. Haemers
The Gewirtz graph - an exercise in the theory of graph spectra

Pim Adang, Bertrand Melenberg
Intratemporal uncertainty in the multi-good life cycle consumption model: motivation and application

J.H.J. Roemen
The long term elasticity of the milk supply with respect to the milk price in the Netherlands in the period 1969-1984

Herbert Hamers
The Shapley-Entrance Game

Rezaul Kabir and Theo Vermaelen
Insider trading restrictions and the stock market

Piet A. Verheyen
The economic explanation of the jump of the co-state variable

Drs. F.L.J.W. Manders en Dr. J.A.C. de Haan
De organisatorische aspecten bij systeemontwikkeling een beschouwing op besturing en verandering

Paul C. van Batenburg and J. Kriens
Applications of statistical methods and techniques to auditing and accounting

Ruud T. Frambach
The diffusion of innovations: the influence of supply-side factors

J.H.J. Roemen
A decision rule for the (des)investments in the dairy cow stock

Hans Kremers and Dolf Talman
An SLSPP-algorithm to compute an equilibrium in an economy with linear production technologies
497 L.W.G. Strijbosch and R.M.J. Heuts
Investigating several alternatives for estimating the compound lead
time demand in an (s,Q) inventory model

498 Bert Beutinovil and Jack P.C. Kleijnen
Identifying the important factors in simulation models with many
factors

499 Drs. H.C.A. Roest, Drs. F.L. Tijssen
Beheersing van het kwaliteitsperceptieproces bij diensten door middel
van keurmerken

500 B.B. van der Genugten
Density of the F-statistic in the linear model with arbitrarily
normal distributed errors

501 Harry Barkema and Sytse Douma
The direction, mode and location of corporate expansions

502 Gert Nieuwenhuis
Bridging the gap between a stationary point process and its Palm
distribution

503 Chris Veld
Motives for the use of equity-warrants by Dutch companies

504 Pieter K. Jagersma
Een etiologie van horizontale internationale ondernemingsexpansie

505 B. Kaper
On M-functions and their application to input-output models

506 A.B.T.M. van Schaik
Produktiviteit en Arbeidsparticipatie

507 Peter Borm, Anne van den Nouweland and Stef Tijs
Cooperation and communication restrictions: a survey

508 Willy Spanjers, Robert P. Gilles, Pieter H.M. Ruys
Hierarchical trade and downstream information