No. 218

April 1998

Discussion Papers

Statistics Norway
Department of Coordination and Development

Li-Chun Zhang

A Note on Post-stratification when Analyzing Binary Survey Data Subject to Non-response

Discussion Papers

Discussion Papers No. 218 • Statistics Norway, April 1998

Li-Chun Zhang

A Note on Post-stratification when Analyzing Binary Survey Data Subject to Non-response

Abstract:
In this paper we follow up two notes of Thomsen (1973, 1978) and present some results on the estimation effect of post-stratification when analyzing binary survey data subject to non-response. Using an alternative parameterisation and assuming that the non-response depends on the variable of interest which can not be fully observed, we show that the relative reduction in the bias can be estimated from the response group alone. In addition, the relative bias and variance reduction are both shown to be approximately equal, under certain conditions, to one minus the square of the correlation coefficient between the auxiliary and object variable among the respondents.

Keywords: Post-stratification, non-response, non-ignorable, non-response

Acknowledgement: The author is especially thankful to Ib Thomsen and Jan F. Bjørnstad for discussions and suggestions. Correspondence with Leiv Solheim is gratefully acknowledged.

Address: Li-Chun Zhang, Statistics Norway, P.O.Box 8131 Dep., N-0033 Oslo. E-mail: lcz@ssb.no

Discussion Papers comprises research papers intended for international journals or books. As a preprint a Discussion Paper can be longer and more elaborated than a usual article by including intermediate calculation and background material etc.

Abstracts with downloadable postscript files of
Discussion Papers are available on the Internet: http://www.ssb.no

For printed Discussion Papers contact:

Statistics Norway
Sales- and subscription service
P.O. Box 1260
N-2201 Kongsvinger

Telephone: +47 62 88 55 00
Telefax: +47 62 88 55 95
E-mail: Salg-abonnement@ssb.no

1 Introduction

Non-response, or missing observations, is a common problem with survey data. Thomsen (1973) showed that the bias of the observed sample mean admits a decomposition, $B + A$, of which component B "arises from the fact that different groups in the population have different response rates", whereas A is "due to the biasing effect of non-response within each group". Since component B vanishes with the post-stratified mean, weighting subclass means reduces the bias caused by non-response whenever (i) B and A have the same sign, or (ii) B and A have different signs but $2|A| < |B|$. Notice that the size of the bias, however, is unknown in general since component A depends on the mean within the non-response data, which can not be estimated without further assumptions. While, as explained in Thomsen (1973), the results apply whether the marginal proportions of the subclasses are known or not. Adopting a "broadly defined" (Smith 1991) sense of the term, we simply refer to the method as post-stratification.

In this note, we concentrate on binary data, which allows an alternative resolution of the bias caused by non-response. In particular, it will be shown that it is sometimes possible to assess the bias in both methods based on the response group alone, even though the non-response is assumed to be non-ignorable in the sense of Rubin (1976) and Little and Rubin (1987) such that the mean of the variable to be estimated actually differs from the respondents to the non-respondents. In fact, the relative reduction in the bias due to post-stratification is in certain cases approximately equal to the realtive reduction in the variance. As in Thomsen (1973), we assume simple random sampling throughout.

In the final section the result obtained here are applied to the data of the Norwegian Labour Force Survey (LFS).

2 Alternative resolution of the bias due to non-response

Denote by $U = \{1, ..., N\}$ the population, and by $s = \{1, ..., n\}$ the sample. Assume that we are to estimate the population mean of a binary variable, denoted by $\bar{Y}$; and that auxiliary information is available in the form of a second binary variable denoted by X. In addition, denote by R the response variable such that $R_i = 1$ indicate response of the ith unit and $R_i = 0$ non-response. Thomsen (1973) stratified the sample according to the values of (X, R), and expressed the overall observed sample mean $\bar{y}$ and the post-stratified mean $\bar{y}_{pst}$ as a function of $\bar{y}(X, R)$, with the help of the marginal proportions $n(X)/n$ and $n(X, R)/n(X)$.

Considering non-response as dependent on (X, Y), we cross-classify the population according to

(X,Y) instead. Denote by $q_{ij} = N_{ij}/N$ the population proportion of $(X,Y) = (i,j)$ for $i,j = 0,1$, and r_{ij} the non-response rate within the population group $(X,Y) = (i,j)$. The population and the expected sample has the following distribution:

	$Y=1$		$Y=0$	
	$R=1$	$R=0$	$R=1$	$R=0$
$X=1$	$q_{11}(1-r_{11})$	$q_{11}r_{11}$	$q_{10}(1-r_{10})$	$q_{10}r_{10}$
$X=0$	$q_{01}(1-r_{01})$	$q_{01}r_{01}$	$q_{00}(1-r_{00})$	$q_{00}r_{00}$

The population mean $\bar{Y}$ is given as $p = q_{11} + q_{01}$, and the marginal proportion of $X = 1$ as $q = q_{11} + q_{10}$. Given non-response, i.e. $s = (s_r, s_{mis})$ where s_r denotes the response group and s_{mis} the non-response group with the respective size n_r and $n - n_r$, the observed sample mean is given as $\bar{y} = [n_r(1,1) + n_r(0,1)]/n_r$, where $n_r(i,j)$ denotes the size of the subsample $(X,Y) = (i,j)$ within the response group s_r, and

$$(1) \qquad E[\bar{y} - p|n_r] = \frac{\sum_{i,j} q_{i1}q_{j0}(r_{j0} - r_{i1})}{\sum_{i,j} q_{ij}(1 - r_{ij})} = \frac{p(\sum_i q_{i0}r_{i0}) - (1-p)(\sum_i q_{i1}r_{i1})}{E[n_r]/n} = E[\bar{y} - p].$$

While the first equation expresses the bias as a function of pairwise difference in response rates, the second one specifies the contribution of each subsample (X,Y).

Post-stratification further divides the response group into $s_r = (s_{r,1}, s_{r,0})$ with the respective size $n_{r,1}$ and $n_{r,0}$. The post-stratified mean is $\bar{y}_{pst} = qn_r(1,1)/n_{r,1} + (1-q)n_r(0,1)/n_{r,0}$, and

$$(2) \qquad E[\bar{y}_{pst} - p|(n_{r,1}, n_{r,0})] = \frac{q_{11}q_{10}(r_{10} - r_{11})}{E[n_{r,1}]/n} + \frac{q_{01}q_{00}(r_{00} - r_{01})}{E[n_{r,0}]/n} = E[\bar{y}_{pst} - p].$$

This provides an alternative expression of component A (Thomsen 1973) under the present settings. In case q is unknown and is estimated by n_1/n where n_1 is the size of the sample post-stratum $X = 1$, the result is valid under suitable regularity conditions.

Notice that while the values of (1) and (2) are unknown in general, one sometimes can be quite certain about their signs. For instance, if it known that, conditional to $X = i$, $Y = 1$ leads to lower non-response rate, then $\bar{y}_{pst}$ is upward biased according to (2).

In contrast to the bias, Thomsen (1978) derived in "a second note" the respective approximate variances of $\bar{y}$ and $\bar{y}_{pst}$, which can be estimated from the observed sample directly regardless of the values of r_{ij}. It was noted that the variance reduction is often not noteworthy unless with known population marginal proportions of the post-strata. With the present notations and ignoring the finite population correction factors, these are given as

$$Var(\bar{y}) = E[n_r(1,1) + n_r(0,1)] \cdot E[n_r(1,0) + n_r(0,0)]/E[n_r]^3$$

$$Var(\bar{y}_{pst}) = q^2 E[n_r(1,1)] \cdot E[n_r(1,0)]/E[n_{r,1}]^3 + (1-q)^2 E[n_r(0,1)] \cdot E[n_r(0,0)]/E[n_{r,0}]^3,$$

In particular, the ratio of the variances, denoted by $\eta = Var(\bar{y}_{pst})/Var(\bar{y})$, describes the estimation effect of the post-stratification on the variance.

3 Ignorable and non-ignorable non-response

Basically, with auxiliary information X being available, non-response is ignorable if R is independent of Y given X, whereas it is non-ignorable if R remains dependent of Y despite the knowledge of X. With the present notation, ignorable non-response implies $r_{i0} = r_{i1}$ for $i = 0, 1$. It follows from (2) that the post-stratified mean is in such cases unbiased, whereas the sample mean remains biased. Indeed, its bias can simply be estimated by $\bar{y} - \bar{y}_{pst}$.

Meanwhile, the simplest non-ignorable non-response here is to assume that R is independent of X given Y, which implies that $r_{i0} = r_0$ and $r_{i1} = r_1$ for $i = 0, 1$. It follows from (1) that the bias in $\bar{y}$, denoted by b_{srs}, is now given by

$$b_{srs} = \frac{(r_0 - r_1)p(1-p)}{E[n_r]/n} = \frac{r_0 - r_1}{(1-r_0)(1-r_1)} \cdot \frac{1}{n}\{\frac{E[n_r(-,1)]E[n_r(-,0)]}{E[n_r]}\}, \tag{3}$$

where $n_r(-,j) = n_r(1,j) + n_r(0,j)$ for $j = 0, 1$. Whereas the bias in $\bar{y}_{pst}$, denoted by b_{pst}, is similarly given by (2) as

$$b_{pst} = \frac{r_0 - r_1}{(1-r_0)(1-r_1)} \cdot \frac{1}{n}\{\frac{E[n_r(1,1)]E[n_r(1,0)]}{E[n_{r,1}]} + \frac{E[n_r(0,1)]E[n_r(0,0)]}{E[n_{r,0}]}\}. \tag{4}$$

In other words, the ratio of the bias, denoted by $\gamma = b_{pst}/b_{srs}$ or $A/(B+A)$ in the notation of Thomsen (1973), can be estimated from the response group alone. Since $\bar{y} - \bar{y}_{pst}$ is an estimate of $b_{srs} - b_{pst}$, a bias-correcting estimator is now given as

$$\bar{y}_{adj} = -\frac{\hat{\gamma}}{1-\hat{\gamma}}\bar{y} + \frac{1}{1-\hat{\gamma}}\bar{y}_{pst}. \tag{5}$$

To actually apply $\bar{y}_{adj}$, one must check on the non-response assumption $r_{i0} = r_0$ and $r_{i1} = r_1$ for $i = 0, 1$, e.g. through the goodness-of-fit from a model point of view. More explicitly, consider the sample as having been generated under the model where $P[(X,Y) = (i,j)] = q_{ij}$ and $P[R = 0|(X,Y) = (i,j)] = r_{ij}$, and thereby obtaining the likelihood function proportional to $P[(X,Y,R)]$ on which the statistical inference can be based. However, one must keep in mind that a good fit alone is not enough to establish the validity of the model. For instance, the ignorable non-response model $r_{i0} = r_{i1}$ always fits perfectly to the data, i.e. reproducing the data exactly. On the other hand, it is probably reasonable to accept a bad fit as the convincing evidence *against* the non-response assumption. In any case, the results above suggest a general methodology for the full adjustment of the bias, i.e. to find some "instrumental" variable X which, while being reasonably correlated with Y — so that $1 - \hat{\gamma}$ is not too close to zero, is however independent of, or "non-informative" on, non-response R conditional to Y.

It is interesting that, under the present non-response assumptions, $\gamma = \eta$ provided $E[n_{r,1}]/E[n_r] = q$ and $E[n_{r,0}]/E[n_r] = 1 - q$, i.e. the ratio of the bias equals to the ratio of the variances. Since $q = E[n_1]/n$, the equality holds approximately in cases where the non-response is not too severe. In addition, it is sometimes the case that $q \doteq p$, such as when X is provided by a similarly defined variable available from other sources or simply the variable Y some short while ago. If this approximate equality holds also within the response group, we obtain

$$(6) \qquad \gamma \doteq \eta \doteq 1 - \rho_r^2 \qquad \rho_r = \frac{E[n_r(1,1)] \cdot E[n_r] - E[n_r(1,-)] \cdot E[n_r(-,1)]}{\sqrt{\{E[n_r(1,-)] \cdot E[n_r(0,-)]\}\{E[n_r(-,1)] \cdot E[n_r(-,0)]\}}},$$

where ρ_r is the correlation coefficient between X and Y among the respondents. Having estimated (ρ_r, γ, η), one can easily check whether the (6) holds in a given situation.

4 An example: the Norwegian LFS

Post-stratification has long been applied in connection with the LFS in a number of countries. By exploiting the high correlation between the Register-based Employment/Unemployment Status and the LFS Employment/Unemployment Status, post-stratification can greatly reduce the variance of the level-estimators (e.g. Djerf 1997). Meanwhile, since one can be quite certain that the Employment rate is lower among the non-respondents, also when conditional to each state of the Register-based Status, the non-response in the LFS is most likely non-ignorable. Proceeding under the assumption that the LFS non-response (denoted by R) is indenpendent of the Register-based Employment Status (denoted by X) conditional to the LFS Employment Status (denoted by Y), we may apply the results above and study the effect on bias-reduction *via* post-stratification.

We illustrate with the data of the first quarter in 1995 from the Norwegian LFS:

$X=1$			$X=0$		
$(Y,R)=(1,1)$	$(Y,R)=(0,1)$	$R=0$	$(Y,R)=(1,1)$	$(Y,R)=(0,1)$	$R=0$
12881	1158	518	1829	6726	796

First of all, a simple calculation based on these data gives us $\hat{\eta} = 0.494$, i.e. an estimated 50% reduction in variance due to post-stratification w.r.t. the Register-based Employment Status, which is consistent with the findings presented in Djerf (1997). Also, $\hat{\rho}_r = 0.716$ and $1 - \hat{\rho}_r^2 = 0.487 \doteq \eta$. All the estimates here are obtained by replacing $E[n_r(i,j)]$ with $n_r(i,j)$.

Now, applying the results on the bias, we obtain $(\bar{y}, \bar{y}_{pst}, \bar{y}_{adj}) = (0.651, 0.645, 0.640)$ with the known $q = 0.613$ in the population, and $(\bar{y}, \bar{y}^*_{pst}, \bar{y}^*_{adj}) = (0.651, 0.642, 0.634)$ now with $\hat{q}^* = 0.609$ estimated from the sample. Whereas $\hat{\gamma} = 0.487 = 1 - \hat{\rho}_r^2$ in both cases. Notice that the difference between $\bar{y}_{pst}$ and $\bar{y}^*_{pst}$ is doubled into that between $\bar{y}_{adj}$ and $\bar{y}^*_{adj}$ through the term $1/(1 - \hat{\gamma})$, which indicates the sensitivity of $\bar{y}_{adj}$ towards the stochastic variation in the estimation of $(\gamma, b_{srs} - b_{pst})$.

We then evaluated the non-response assumption $r_{i0} = r_0$ and $r_{i0} = r_1$ for $i = 0, 1$ from a model perspective as explained earlier. More explicitly, we calculated the maximum likelihood estimates applying the EM algorithm, which gives us $(\hat{q}_{11}, \hat{q}_{01}, \hat{r}_1, \hat{r}_0) = (0.559, 0.078, 0.029, 0.099)$. The deviance, i.e. twice the difference between the maximum attainable log-likelihood and the fitted log-likelihood, was zero so that these also yielded the perfect fit to the data. Notice that, from the model perspective, we have $\bar{y}_{mod} = \hat{q}_{11} + \hat{q}_{01} = 0.637$. To check whether the perfect fit could be attained with any choice of X, we have also fitted the model where X was set to be Sex instead. Using the known $q = 0.503$ in the population, we obtained $(\hat{q}_{11}, \hat{q}_{01}, \hat{r}_1, \hat{r}_0) = (0.363, 0.307, 0.082, 0.000)$ with deviance 10.3, so that we can be quite sure that the non-response assumption does not apply to Sex. (Post-stratification w.r.t. Sex gives $\hat{\eta} = 0.987$, i.e. with practically no effect on the variance.)

To summarize the above findings, we do not recommend bias-correction *via* $\bar{y}_{adj}$ for the Norwegian LFS due to its sensitivity towards the non-response assumption as well as the uncertainty in the estimation of $(\gamma, b_{srs} - b_{pst})$. For instance, it is probable in the case of LFS that non-response is indeed severer among the subsample $(X, Y) = (0, 0)$ than among $(X, Y) = (1, 0)$, in which case R is not strictly independent of X conditional Y, though model fitting seems to suggest a very weak additional dependence in the eventual case. In contrast, it is likely a robust assessment that, using Register-based Employment Status, post-stratification results into about 50% of reduction in both the variance and the bias caused by non-response, of which the latter has taken into consideration the "non-ignorability" of the non-response.

References

Djerf, K. (1997). Effects of post-stratification on the estimates of the Finish Labour Force Surveys. *The Journal of Official Statistics* **13**, 29–39.

Little, R. and D. Rubin (1987). *Statistical Analysis with Missing Data*. New York: Wiley.

Rubin, D. (1976). Inference and missing data. *Biometrika* **63**(3), 581–92.

Smith, T. (1991). Post-stratification. *The Statistician* **40**, 315–23.

Thomsen, I. (1973). A note on the efficiency of weighting subclass means to reduce the effects of non-response when analyzing survey data. *Statistisk tidskrift*, 4:278–83.

Thomsen, I. (1978). A second note on the efficiency of weighting subclass means to reduce the effects of non-response when analyzing survey data. *Statistisk tidskrift*, 3:191–6.

Recent publications in the series Discussion Papers

124 J. Aasness, E. Eide and T. Skjerpen (1994): Criminometrics, Latent Variables, Panel Data, and Different Types of Crime

125 E. Biørn and T.J. Klette (1994): Errors in Variables and Panel Data: The Labour Demand Response to Permanent Changes in Output

126 I. Svendsen (1994): Do Norwegian Firms Form Extrapolative Expectations?

127 T.J. Klette and Z. Griliches (1994): The Inconsistency of Common Scale Estimators when Output Prices are Unobserved and Endogenous

128 K.E. Rosendahl (1994): Carbon Taxes and the Petroleum Wealth

129 S. Johansen and A. Rygh Swensen (1994): Testing Rational Expectations in Vector Autoregressive Models

130 T.J. Klette (1994): Estimating Price-Cost Margins and Scale Economies from a Panel of Microdata

131 L.A. Grünfeld (1994): Monetary Aspects of Business Cycles in Norway: An Exploratory Study Based on Historical Data

132 K.-G. Lindquist (1994): Testing for Market Power in the Norwegian Primary Aluminium Industry

133 T.J. Klette (1994): R&D, Spillovers and Performance among Heterogenous Firms. An Empirical Study Using Microdata

134 K.A. Brekke and H.A. Gravningsmyhr (1994): Adjusting NNP for instrumental or defensive expenditures. An analytical approach

135 T.O. Thoresen (1995): Distributional and Behavioural Effects of Child Care Subsidies

136 T.J. Klette and A. Mathiassen (1995): Job Creation, Job Destruction and Plant Turnover in Norwegian Manufacturing

137 K. Nyborg (1995): Project Evaluations and Decision Processes

138 L. Andreassen (1995): A Framework for Estimating Disequilibrium Models with Many Markets

139 L. Andreassen (1995): Aggregation when Markets do not Clear

140 T. Skjerpen (1995): Is there a Business Cycle Component in Norwegian Macroeconomic Quarterly Time Series?

141 J.K. Dagsvik (1995): Probabilistic Choice Models for Uncertain Outcomes

142 M. Rønsen (1995): Maternal employment in Norway, A Parity-Specific Analysis of the Return to Full-Time and Part-Time Work after Birth

143 A. Bruvoll, S. Glomsrød and H. Vennemo (1995): The Environmental Drag on Long- Term Economic Performance: Evidence from Norway

144 T. Bye and T. A. Johnsen (1995): Prospects for a Common, Deregulated Nordic Electricity Market

145 B. Bye (1995): A Dynamic Equilibrium Analysis of a Carbon Tax

146 T. O. Thoresen (1995): The Distributional Impact of the Norwegian Tax Reform Measured by Disproportionality

147 E. Holmøy and T. Hægeland (1995): Effective Rates of Assistance for Norwegian Industries

148 J. Aasness, T. Bye and H.T. Mysen (1995): Welfare Effects of Emission Taxes in Norway

149 J. Aasness, E. Biørn and Terje Skjerpen (1995): Distribution of Preferences and Measurement Errors in a Disaggregated Expenditure System

150 E. Bowitz, T. Fæhn, L. A. Grünfeld and K. Moum (1995): Transitory Adjustment Costs and Long Term Welfare Effects of an EU-membership – The Norwegian Case

151 I. Svendsen (1995): Dynamic Modelling of Domestic Prices with Time-varying Elasticities and Rational Expectations

152 I. Svendsen (1995): Forward- and Backward Looking Models for Norwegian Export Prices

153 A. Langørgen (1995): On the Simultaneous Determination of Current Expenditure, Real Capital, Fee Income, and Public Debt in Norwegian Local Government

154 A. Katz and T. Bye(1995): Returns to Publicly Owned Transport Infrastructure Investment. A Cost Function/ Cost Share Approach for Norway, 1971-1991

155 K.O. Aarbu (1995): Some Issues about the Norwegian Capital Income Imputation Model

156 P. Boug, K. A. Mork and T. Tjemsland (1995): Financial Deregulation and Consumer Behavior: the Norwegian Experience

157 B.E. Naug and R. Nymoen (1995): Import Price Formation and Pricing to Market: A Test on Norwegian Data

158 R. Aaberge (1995): Choosing Measures of Inequality for Empirical Applications

159 T.J. Klette and S.E. Førre (1995): Innovation and Job Creation in a Small Open Economy: Evidence from Norwegian Manufacturing Plants 1982-92

160 S. Holden, D. Kolsrud and B. Vikøren (1995): Noisy Signals in Target Zone Regimes: Theory and Monte Carlo Experiments

161 T. Hægeland (1996): Monopolistic Competition, Resource Allocation and the Effects of Industrial Policy

162 S. Grepperud (1996): Poverty, Land Degradation and Climatic Uncertainty

163 S. Grepperud (1996): Soil Conservation as an Investment in Land

164 K.A. Brekke, V. Iversen and J. Aune (1996): Soil Wealth in Tanzania

165 J.K. Dagsvik, D.G. Wetterwald and R. Aaberge (1996): Potential Demand for Alternative Fuel Vehicles

166 J.K. Dagsvik (1996): Consumer Demand with Unobservable Product Attributes. Part I: Theory

167 J.K. Dagsvik (1996): Consumer Demand with Unobservable Product Attributes. Part II: Inference

168 R. Aaberge, A. Björklund, M. Jäntti, M. Palme, P. J. Pedersen, N. Smith and T. Wennemo (1996): Income Inequality and Income Mobility in the Scandinavian Countries Compared to the United States

169 K. Nyborg (1996): Some Norwegian Politicians' Use of Cost-Benefit Analysis

170 E. Berg, S. Kverndokk and K. E. Rosendahl (1996): Market Power, International CO_2 Taxation and Petroleum Wealth

171 R. Aaberge, U. Colombino and S. Strøm (1996): Welfare Effects of Proportional Taxation: Empirical Evidence from Italy, Norway and Sweden

172 J.K. Dagsvik (1996): Dynamic Choice, Multistate Duration Models and Stochastic Structure

173 J.K. Dagsvik (1996): Aggregation in Matching Markets

174 H.C. Bjørnland (1996): The Dynamic Effects of Aggregate Demand, Supply and Oil Price Shocks

175 A. Bruvoll and K. Ibenholt (1996): Future Waste Generation. Forecasts Based on a Macroeconomic Model

176 T. Fæhn and L. A. Grünfeld (1996) Recent Leaps Towards Free Trade. The Impact on Norwegian Industry and Trade Patterns

177 R. Barrell and K. A. Magnussen (1996): Counterfactual Analyses of Oil price Shocks using a World Model

178 E. Bowitz and S. I. Hove (1996): Business cycles and fiscal policy: Norway 1973-93

179 H.C. Bjørnland (1996): Sources of Business Cycles in Energy Producing Economies: The case of Norway and United Kingdom

180 K. Nyborg (1996): The Political Man and Contingent Valuation: Motives Do Count

181 E. Berg, S. Kverndokk and K.E. Rosendahl (1996): Gains from Cartelisation in the Oil Market

182 R. Aaberge and I. Aslaksen (1996): Decomposition of the Gini Coefficient by Income Components: Various Types of Applications and Interpretations

183 B. Bye (1996): Taxation, Unemployment and Growth: Dynamic Welfare Effects of "Green" Policies

184 T.J. Klette and F. Johansen (1996): Accumulation of R&D Capital and Dynamic Firm Performance: A Not-so-fixed Effect Model

185 B. Bye (1996): Environmental Tax Reform and Producer Foresight: An Intertemporal Computable General Equilibrium Analysis

186 S. Grepperud (1997): Soil Depletion Choices under Production and Price Uncertainty

187 N.M. Stølen and T. Åvitsland (1997): Has Growth in Supply of Educated Persons Been Important for the Composition of Employment?

188 T.J. Klette and Z. Griliches (1997): Empirical Patterns of Firm Growth and R&D Investment: A Quality Ladder Model Interpretation

189 J. Aune, S. Glomsrød, V. Iversen and H. Wiig (1997): Structural Adjustment and Soil Degradation in Tanzania. A CGE-model Approach with Endogenous Soil Productivity

190 E. Biørn and T.J. Klette (1997): Panel Data with Errors-in-Variables: A Note on Essential and Redundant Orthogonality Conditions in GMM-estimation

191 L. Belsby and B.K. Wold (1997): Primary Schooling in Zambia Squeezed at Community and Household Level

192 E. Bowitz and Å. Cappelen (1997): Incomes Policies and the Norwegian Economy 1973-93

193 S. Glomsrød, M.D Monge A. and H. Vennemo (1997): Structural Adjustment and Deforestation in Nicaragua

194 F. Johansen and T.J. Klette (1997): Wage and Employment Effects of Payroll Taxes and Investment Subsidies

195 T. Fæhn (1997): Non-Tariff Barriers - the Achilles' Heel of Trade Policy Analysis

196 R. Aaberge and A. Langørgen (1997): Fiscal and Spending Behavior of Local Governments: An Empirical Analysis Based on Norwegian Data

197 A.C. Hansen and H.K. Selte (1997): Air Pollution and Sick-leaves - is there a Connection? A Case Study using Air Pollution Data from Oslo

198 E. Holmøy and T. Hægeland (1997): Aggregate Productivity Effects of Technology Shocks in a Model of Heterogeneous Firms: The Importance of Equilibrium Adjustments

199 E. Berg, P. Boug and S. Kverndokk (1997): Norwegian Gas Sales and the Impacts on European CO_2 Emissions

200 H.C. Bjørnland (1997): Estimating Core Inflation – The Role of Oil Price Shocks and Imported Inflation

201 R. Aaberge, A. Björklund, M. Jäntti, P.J. Pedersen, N. Smith and T. Wennemo (1997): Unemployment Shocks and Income Distribution. How Did the Nordic Countries Fare During their Crises?

202 L. Brubakk (1997): Estimation of Price Elasticities from Norwegian Household Survey Data

203 J. Aasness and L. Belsby (1997): Estimation of Time Series of Latent Variables in an Accounting System: Petrol Consumption of Norwegian Households 1973-1995

204 A. Rygh Swensen (1997): Change in Regime and Markov Models

205 K. Nyborg and I. Spangen (1997): Cost-Benefit Analysis and the Democratic Ideal

206 L. Belsby and J.F. Bjørnstad (1997): Modelling and Estimation Methods for Household Size in the Presence of Nonresponse: Applied to The Norwegian Consumer Expenditure Survey

207 K.O. Aarbu and T.O. Thoresen (1997): The Norwegian Tax Reform; Distributional Effects and the High-Income Response

208 T. Hægeland and T.J. Klette (1997): Do Higher Wages Reflect Higher Productivity? Education, Gender and Experience Premiums in a Matched Plant-Worker Data Set

209 J. Gjerde, S. Grepperud and S. Kverndokk (1998): Optimate Climate Policy under the Possibility of a Catastrophe

210 T. Eika and K.A. Magnussen (1998): Did Norway Gain from the 1979-85 Oil Price Shock?

211 K.O. Aarbu and J.K. MacKie-Mason (1998): Why Some Corporations Pay More Tax than Necessary

212 R. Aaberge (1998): UMP Unbiased Tests for Multiparameter Testing Problems with Restricted Alternatives

213 M. Søberg (1998): "EPA's New Emissions Trading Mechanism: A Laboratory Evaluation" – A Comment

214 K. Nyborg (1998): Non-Verifiable Emissions, Voluntary Agreements, and Emission Taxes

215 H. C. Bjørnland (1998): Economic Fluctuations in a Small Open Economy - Real versus Nominal Stocks

216 L.C. Zhang (1998): Post-Stratification and Calibration – A Synthesis

217 R. Aaberge and Y. Zhu: The Pattern of Household Savings during a Hyperinflation. The Case of Urban China in the Late 1980s

218 L.C. Zhang (1998): A Note on Post-stratification when Analyzing Binary Survey Data Subject to Non-response

Discussion Papers

B

Returadresse:
Statistisk sentralbyrå
Postboks 8131 Dep.
N-0033 Oslo

Statistics Norway
Research Department
P.O.B. 8131 Dep.
N-0033 Oslo

Tel.: + 47 - 22 86 45 00
Fax: + 47 - 22 11 12 38

ISSN 0803-074X

Statistics Norway
Research Department