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Framework for cost-benefit analysis of forest conservation in southern Finland

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Abstract

This paper provides a theoretical model for cost-benefit analysis of increased forest conservation in southern Finland. First, the cost-benefit rule is derived to make visible the exact components that should be considered in the cost-benefit analysis. In a second part we apply a multimarket equilibrium model to connect the theoretical results of cost-benefit rule to empirically estimable models. Results indicate that the forest owners benefit from forest conservation in addition to the valuation of amenity values, also as producers gaining producers surplus from forest biodiversity production. If industry can import wood to substitute the decrease in the domestic supply, then their losses are not significant. If, however, importing is impossible, effect o increased conservation on producers surplus of forest industry may be substantial. The presented models are static, but possibility to apply a dynamic model could be examined.

Keywords cost-benefit rule, forest conservation, multimarket model

1. Introduction

This paper presents a theoretical framework for the cost-benefit analysis of forest conservation in southern Finland. A purpose is to derive a cost-benefit rule for a complex project of forest conservation, and link theory and empirical assessment of benefits and costs of conservation. A focus in this paper is on defining the costs and benefits, other than existence values of forest biodiversity, so that they are in accordance with the cost-benefit rule and the existence values that have already been estimated with contingent valuation method (CVM).

The forest conservation will generate costs presumably via direct compensations for forest owners for setting their forests aside of commercial use and via the reduction in timber and pulp wood supply. If the forest conservation project is large enough, the reduction in the supply could increase the timber prices and cause repercussion effects on other closely related markets and affect profits of the industries. The companies' profits end up as income to the households, and together with other income, prices of the forest products and value of the increased environmental amenity, they compose the welfare of a household (Johansson 1993). The values of environmental amenity, in other words the benefits of the forest conservation, are also various; forests produce market and non-market goods, and goods which can either be consumed or which have only existence value. The purpose of this study is to construct the cost-benefit analysis so that it would be in accordance with the economic theory. Though the cost-benefit analysis has been applied to examine the welfare effects of different environmental changes, the scientific cost-benefit analysis has not been applied to assess the large scale conservation of boreal forests so that market effects are also taken into account.

Programme for conservation of forests in southern Finland has been one of the most discussed environmental and forest policy issues recently in Finland. Impacts of forest conservation on profitability of forestry and forest industries, on employment and on rural economies have been a major concern in the preparation of the programme. However, sufficient research based knowledge on welfare effects of forest conservation in Finland has been lacking. Welfare effects, however, should be known when the decisions on the programme of biodiversity conservation in southern Finland are made in year 2007 after the experimental stage of the programme 2003-2006.

General equilibrium cost-benefit rules show how to build a cost-benefit analysis so that all the important benefits and costs are considered (Johansson, 1993). There are, however, only few studies that have explicitly derived the cost-benefit rule and shown that the considered costs and benefits are those that should be compared to assess the social welfare effects of a project. Recently Håkansson et al. (2004) applied this approach to link the theory to the empirical application about the salmon-hydropower conflict in Sweden.

Costs of economic effects of forest conservation in Finland have been studied (Mäki-Hakola, 2004; Leppänen et al., 2003; Linden and Uusivuori, 2002), but the results are not applicable as such for cost-benefit analysis because they are not theoretically justified counterparts for benefits from a stated preference study. They have, however, brought up important factors that have effect on the consequences of forest conservation, for example possibility to import of pulp wood and saw timber, mainly from Russia, and the importance of the conservation method. If the conservation is based on the voluntary conservation contracts, the effect of conservation on timber market is smaller than the effect if the conservation is carried out with the traditional methods, in which state buys land from the owner (Mäki-Hakola, 2004). Forest industry may also compensate the lower supply of wood and increased prices by importing more. If the importing is possible and the cost of importation is low enough, then the firms are more independent on domestic timber prices and the decreasing welfare effect of forest conservation is not as substantial as if the importation price is high (Mälkönen, 2004). In addition, if forest industry is able to import also saw timber besides pulp wood that has constituted the major part of the import, then the effect of conservation is aimed at forestry and the forest industry is not affected (Mäki-Hakola and Toropainen, 2005).

As estimates for existence values of forest biodiversity, this study will use the benefit estimated based on a mail survey that was conducted in 2002 to value the forest conservation in southern Finland. The preliminary analysis produced fairly high willingness-to-pay (WTP) measures for increased conservation using the DC-CV (Lehtonen et al. 2003). The results, however, indicated that due to preference uncertainty and respondents' willingness to support forest conservation even at high level of personal costs, traditional welfare measures used in the preliminary analysis might differ from the actual willingness to pay. To improve the accuracy of the willingness to pay estimates we have analysed possibilities of applying different distributional assumptions (Lehtonen et al. 2005a) and allowing respondent uncertainty (Lehtonen et al. 2005b). The results of these CV studies show that the estimation method and assumptions have significant effects on the WTP estimates. The estimates used in the cost-benefit analysis must therefore be very carefully chosen. Probably a sensitivity analysis and use of lower and upper bound estimates should be recommended.

The article is organized as follows. The next section presents the general equilibrium cost-benefit rule for forest conservation. In the third Section we present the multimarket model for estimating the costs of forest conservation and in the fourth Section we outline the empirical estimation of the costs and benefits needed for cost-benefit analysis. The final Section discusses briefly the problems of the current version of the paper and the conclusions that can be made based on the results.

2. The Cost-Benefit Rule

In this part we derive the cost-benefit rules for increased forest conservation. The presented cost-benefit framework is static, but later the possibility of dynamic modelling will be examined. The society benefits from the forest conservation because people value forests as recreation areas, producers of pleasant scenery and habitats for endangered species, among other things. The effects of the conservation on the forest industries' profits, on the other hand, generate the costs of the conservation. These benefits and costs are compared to each other in according to cost-benefit rule. The derivation of cost-benefit rule for forest conservation follows Johansson (1993) book, especially the sections 3.4 and 5.3, and related appendices.

Assume an economy consists of a representative household and a representative firm. The representative household receives positive utility from consumption (x) and from biodiversity and amenity values of forests (z). The consumption and biodiversity services the consumer can fund by exogenous income (y), incomes received from firms' profits (p), and from selling pulpwood, timber and forest biodiversity conservation with prices (w_{pw}, w_{st}, w_{cons}), respectively. Thus the forest owner receives compensation w_{cons} for each forest hectare z that is set aside of commercial use. The price of compensation is dependent on the prices of timber and pulp wood, because they have effect on the forest owner's willingness to supply forest for biodiversity conservation.

In Finland, the conservation has traditionally been carried out by strictly buying the forests from the private owners and prohibiting all commercial use. This strategy is, however, very expensive especially in the southern Finland where are the most productive forest areas of the country. Conservation contracts for certain periods of time, for example for 20 or 30 years, have been proposed as a new method for forest conservation. A forest owner could voluntarily do the contract and get monetary compensation for the biodiversity conservation and the ownership of the land would remain at the initial owner. Thus the production of biodiversity could be a possible option for producing timber for forest industry. In this cost-benefit analysis we assume that the conservation is carried out with the conservation contracts, and the forest owners receive compensation for conserving forests.

If a representative household, who owns forest and sells pulpwood, timber and biodiversity, and values non-timber amenities, would be better of after the change in the level of forest conservation, then the project would be socially desirable. This criterion is based on potential Pareto principal which does not require that the losses of some households would be compensated by the gaining households (Johansson 1993). Household may also work for forest industry and a part of household income would then consist of wage from the forest industry. Wage rate and the supply of labour could be added to the model as arguments on the vector of factors of production and their price, but in this paper the labour is excluded to simplify the model. The household in equation (1) maximises its utility:

$$U = U(x, z) \tag{1}$$

$$s.t.\, y + \pi + w^*(K_f - z) + w_{cons}(w)z - C - px = 0 \tag{2}$$

where K_f is the initial forest endowment of the representative forest owner and it can be used for timber production or for supply of biodiversity, *z*. *C* is a tax increase to cover the substitution costs for forest owners. Term $(K_f - z)$ denotes the supply of pulp wood and timber of the forest owner; the supply is directly dependent on the size of the conservation project. In addition, amenity values, z in the equation (1), depend directly on the supply of biodiversity of this project.

Utilising the necessary conditions for interior solution and substituting the demand and supply functions to (1) yields an indirect utility function

$$V(p, w, w_{cons}, Y + \pi - C, z), \tag{3}$$

where *p* is the price of market goods and *w* is a vector of input prices including the price of pulp wood and timber, *Y* is an exogenous income, $\pi = f(p,w,w_i)$ is forest sectors profits where w_i denotes import price of timber, and *z* is a vector of public goods provided by the forests, in this case the level of forest conservation.

Compensating variation (*CV*) indicates the value of a project, i.e. the amount of money that household pays to remain at the same level of utility after the project than they were before it. Thereby, the compensating variation of a large complex project can be written:

$$V(p^1, w^1, w_{cons}, Y^1 + \pi^1 - CV - C, z^1) = V(p^0, w^0, Y^0 + \pi^0, z^0) \tag{4}$$

We assume that the representative does not receive any monetary compensation for forest conservation at the initial state (right hand side), but after the conservation project a forest owner may earn by conserving a part of the forest estate. Because of this compensation from forest conservation that the representative household gets, in addition to the benefits from the entire conservation project of forests, we must add a term of costs, *C*, to avoid double counting of the benefits of forest owners.

The total differential of indirect utility function is:

$$dV = V_y dY + V_y dp + V_y (K_f - z)dw + V_y z(\partial w_{cons} / \partial w)dw + V_y z w_{cons} - V_y x dp$$
$$+ V_z dz - V_y dC - V_y dCV = 0 \tag{5}$$

where V_y is the marginal utility of exogenous income evaluated at initial level of prices. Dividing through by V_y converts the measure (5) from units of utility to monetary units:

$$dV / V_y = dy + dp + (K_f - z) dw + z(\partial w_{cons} / \partial w)dw + z dw_{cons} - xdp + (V_z / V_y)dz$$
$$- dC - dCV = 0 \tag{6}$$

where dp can be derived from the profit function of the representative forest industry firm. The profit function is:

$$p = pF(K_f - z + I, K) - w(z)(K_f - z) - w_i I - K \tag{7}$$

where I is the import of pulp wood and timber.
Totally differentiating (7), using the necessary conditions for interior solution and suppressing K yields:

$$dp = x^s dp - (K_f - z)^d dw - I^d dw_i + \begin{bmatrix} (z - K_f)(\partial w / \partial z) + w(z) + \\ p(F(K_f - z + I) / \partial z) \end{bmatrix} dz = 0 \tag{8}$$

where superscripts s and d refer to supply and demand, respectively. Substituting (8) into (6) and denoting the supply and demand terms of (6) with corresponding superscripts produces

$$dV / V_y = \left[(V_z / V_y + (z - K_f)(\partial w / \partial z) + w(z) + p(F(K_f - z + I) / \partial z) \right] dz$$
$$+ dy + x^s dp - (K_f - z)^d dw + (K_f - z)^s dw + z(\partial w_{cons} / \partial w)dw \tag{9}$$
$$+ z^s dw_{cons} - dC - x^d dp - dCV = 0$$

$$dV / V_y = (x^s - x^d)dp - \left[(K_f - z)^d - (K_f - z)^s \right] dw + z(\partial w_{cons} / \partial w)dw + z^s dw_{cons} - I^d dw_i + dy$$
$$+ \left[(V_z / V_y) + w(z) + (z - K_f)(\partial w / \partial z) + p\left[\partial F(K_f - z + I) / \partial z \right] \right] dz - dC - dCV = 0 \tag{10}$$

If prices adjust so that supply and demand equals, the first two terms on the left hand side of the equation (10) will vanish. Change in exogenous lump-sum income y is suppressed, because income is assumed to be constant over the change in forest conservation. Solving the equation for dCV yields

$$dCV = z^s dw_{cons} + z(\partial w_{cons} / \partial w)dw - I^d dw_i - dC$$
$$+ \left[(V_z / V_y) + w(z) + (z - K_f)(\partial w / \partial z) + p\left[\partial F(K_f - z + I) / \partial z \right] \right] dz \tag{11}$$

If a firm can increase import to cover the decreased timber supply, then last term of the equation (11) vanishes and the increased conservation does not have an effect on production of the firm. Integrating the remaining terms between initial and final levels of each changing variable produces the desired cost-benefit rule[1]:

$$CBR = \int_{z^0}^{z^1} \{[V_z(\cdot)/V_y(\cdot)] + w(z) + (z - K_f)(\partial w/\partial z)\}dz$$
$$+ \int_{w^0_{cons}}^{w^1_{cons}} z^s dw_{cons} + \int_{w^0}^{w^1} z(\partial w_{cons}/\partial w)dw - \int_{w^0_i}^{w^1_i} I^d dw_i - dC \qquad (12)$$

where V_z/V_y is the change in the utility of a household caused by the change in the level of conservation expressed in monetary units, in other words the willingness to pay for increased conservation. The last term in the integral respect to z is the change in the raw material costs of the industry caused by the conservation. In addition, forest owners' welfare is increased by the producers surplus that they earn from the conservation, plus the increasing effect of higher timber prices on the price that the forest owners get from the conservation. The welfare is on the other hand decreased by the area under the demand curve for imported raw material I^d, i.e. change in producer surplus caused by importing. If the conservation des not have any effect on import prices, then the change in producers surplus caused by importing is zero. dC is a tax increase that is equal to the direct costs of implementing conservation, i.e. the amount money that the forest owners get from biodiversity conservation. The project is socially profitable if CBR > 0.

When the project affects prices, we need to use compensated equilibrium prices. Accordingly, when assessing large changes in z

$$V_z = V_z[p^*, w^*, Y^* + \pi^* - CV^*, z] \qquad (13)$$

$$V_y = V_y[p^*, w^*, Y^* + \pi^* - CV^*, z] \qquad (14)$$

where $p^*=p(z)$, $w^*=w(z)$, $Y^*=Y(z)$, $\pi^*=p^*x(p^*,w^*)-w^*K_f(z)$, and $CV^*=CV(z)$ is such that the household stays at the initial level of utility after change in forest conservation. The same applies also to the other terms of the CBR. This further illustrated in the next Section that considers multimarket model of forest industry.

3. The Multimarket Model of Forestry Sector

The method to assess the costs of conservation is based on multimarket welfare measurement techniques by Just, Hueth and Schmitz (1982). It provides a good approximation of full general equilibrium model if the sector of interest is sufficiently

[1] The current version of the CBR includes some terms that are not in accordance with the expectations and thus the derivation of the CBR requires some more consideration.

autonomous and the price repercussions stay largely within the sector (Brännlund and Kriström 1993,1996).

In the multimarket equilibrium model for Finnish forestry sector we begin with considering three separate but intimately related industries: pulp industry, sawmills and forestry. Increased forest conservation affects the timber stock of forestry that has an effect on the supply of saw timber and pulp wood (Das et al. 2003, Leppänen et al. 2003).

The decision makers are sawmills, pulp industry and forest owners. Markets are competitive. The model estimates the effects of increased forest conservation in short run, because the capital stocks of each decision maker are fixed. Industry can import both timber and pulp wood from abroad to cover the decreased supply from domestic market.

A profit function of a representative sawmill is as follows:

$$p^{s} = p^{s}(P, w_{st}, w_{i}; \bar{K}_{s}), \tag{15}$$

where P is price of sawn wood, w_{st} is price of saw timber, w_{sti} is the price of imported saw timber, and $\bar{K}_s$ is a fixed capital stock of sawmill industry. A supply function for sawn wood and demand functions for saw timber from domestic and import market are derived applying Hotelling’s lemma

$$S_s(P, w_{st}, w_{sti}; \bar{K}_s) = \frac{\partial p^{s}}{\partial P} \tag{16}$$

$$D_{st}(P, w_{st}, w_{sti}; \bar{K}_s) = -\frac{\partial p^{s}}{\partial w_{st}}. \tag{17}$$

$$D_{sti}(P, w_{st}, w_{sti}; \bar{K}_s) = -\frac{\partial p^{s}}{\partial w_{sti}} \tag{18}$$

A pulp firm produces pulp and uses pulp wood produced by the forest owners as well as imported pulp wood as raw material. A profit function of a representative pulp firm is as follows:

$$p^{s} = p^{s}(P, w_{pv}, w_{pvi}; \bar{K}_s), \tag{19}$$

where P is the price of pulp, w_{pv} is the price of pulp wood, w_{pvi} is the price of imported pulp wood and $\bar{K}_s$ is a fixed capital stock of pulp industry. A supply function for pulp and demand functions for domestic and imported pulp wood are derived applying Hotelling’s lemma

$$S_p(P, w_{pv}, w_{pvi}; \bar{K}_p) = \frac{\partial p^{p}}{\partial P} \tag{20}$$

$$D_{pv}(P, w_{pv}, w_{pvi}; \bar{K}_p) = -\frac{\partial p^{p}}{\partial w_{pv}}. \tag{21}$$

$$D_{pvi}(P, w_{pv}, w_{pvi}; \bar{K}_s) = -\frac{\partial p^{p}}{\partial w_{pvi}} \tag{22}$$

Forest owner produces saw timber, pulp wood and biodiversity. So the profit function is

$$p^{f} = p^{f}(w_{st}, w_{pv}, w_{cons}; \bar{K}_f) \tag{23}$$

where K_f is the fixed forest capital.

The supply functions for saw timber and pulp wood, and a supply function for forest conservation are again deriver applying Hotelling's lemma:

$$S_{st}(w_{st}, w_{pv}, w_{cons}; \bar{K}_f) = \frac{\partial p^{f}}{\partial w_{st}} \tag{24}$$

$$S_{pv}(w_{st}, w_{pv}, w_{cons}; \bar{K}_f) = \frac{\partial p^{f}}{\partial w_{pv}} \tag{25}$$

$$S_{cons}(w_{st}, w_{pv}, w_{cons}; \bar{K}_f) = \frac{\partial p^{f}}{\partial w_{cons}} \tag{26}$$

Thus the market equilibrium conditions for domestic and imported saw timber and pulp wood, and biodiversity are

$$\sum_{i=1}^{m} D_{st}^{i}(P_s, w_{st}, w_{sti}; \bar{K}_s) = \sum_{i=1}^{n} S_{st}^{i}(w_{st}, w_{pv}, w_{cons}; \bar{K}_f), \tag{27}$$

$$\sum_{i=1}^{l} D_{pv}^{i}(P_p, w_{pv}, w_{pvi}; \bar{K}_s) = \sum_{i=1}^{n} S_{pv}^{i}(w_{st}, w_{pv}, w_{cons}; \bar{K}_f) \tag{28}$$

$$\sum_{i=1}^{m} D_{sti}^{i}(P_s, w_{st}, w_{sti}; \bar{K}_s) = S_{sti} \tag{29}$$

$$\sum_{i=1}^{l} D_{pvi}^{i}(P_p, w_{pv}, w_{pvi}; \bar{K}_s) = S_{pvi} \tag{30}$$

$$D_{cons} = \sum_{i=1}^{n} S_{cons}^{i}(w_{st}, w_{pv}, w_{cons}; \bar{K}_f) \tag{31}$$

where m and l are number of sawmills and pulp firms, respectively, and n is a number of forest owners. Demand for biodiversity conservation is not defined by the markets; it is dependent on the ecological conditions and political decisions. Supply of biodiversity conservation can, however, be derived from the profit function of the forest owner. The price for biodiversity conservation is thus defined as a combination of market conditions and political decisions. Supply of the imported wood is taken exogenous in this model. Thereby, equilibrium prices are:

$$w_{st}^* = w_{st}^*(P_s, P_p, w^*_{sti}, w^*_{pvi}, w_{cons}, \bar{K}), \tag{32}$$

$$w_{pv}^* = w_{pv}^*(P_s, P_p, w^*_{sti}, w^*_{pvi}, w_{cons}, \bar{K}) \tag{33}$$

$$w_{sti}^* = w_{sti}^*(S_{sti}, P_s, w_{st}^*(w_{cons}, \cdot), \bar{K}) \tag{34}$$

$$w_{pvi}^* = w_{pvi}^*(S_{pvi}, P_p, w_{pv}^*(w_{cons}, \cdot), \bar{K}) \tag{35}$$

$$w_{cons}^* = w_{cons}^*(D_{cons}, w_{st}^*(w_{cons}, \cdot), w_{pv}^*(w_{cons}, \cdot), \bar{K}) \tag{36}$$

and aggregate profit functions of sawmill and pulp industries, and the forest owners are:

$$Ap^s = Ap^s(P_s, w_{st}^*(w_{cons}, \cdot), w^*_{sti}(w_{cons}, \cdot); \bar{K}_s) \tag{37}$$

$$Ap^p = Ap^p(P_p, w_{pv}^*(w_{cons}, \cdot), w^*_{pvi}(w_{cons}, \cdot); \bar{K}_p) \tag{38}$$

$$Ap^f = Ap^f(w_{st}^*(w_{cons}, \cdot), w_{pv}^*(w_{cons}, \cdot), w_{cons}; \bar{K}_f). \tag{39}$$

where $\cdot$ refers to all relevant parameters.

Forest conservation is assumed to be voluntary for forest owners, and they receive monetary compensation for each conserved hectare. The price of compensation is defined based on supply from the forest owners' side, and political decision on the demand side. The possibility to earn money by selling biodiversity conservation presumably decreases the supply of pulp wood and timber to the forest industry. The decreased supply raises the prices of timber, and has effect on forest industries profits. The welfare impact of the change in the level of conservation can be measured with the change in aggregated profits

$$\Delta Ap = \Delta(Ap^s + Ap^p + Ap^f) = \Delta Ap^s + \Delta Ap^p + \Delta Ap^f \tag{40}$$

where

$$\Delta Ap^s = \int_{w_{cons}^0}^{w_{cons}^1} \frac{\partial Ap^s}{\partial w_{cons}}(P_s, w_{st}^*(w_{cons}, \cdot), w^*_{sti}(w_{cons}, \cdot); \bar{K}_s) dw_{cons}$$

$$= \int_{w_{cons}^0}^{w_{cons}^1} \left\{ -D_{st}(w_{st}^*, \cdot) \frac{\partial w_{st}}{\partial w_{cons}} - D_{sti}(w_{sti}^*, \cdot) \frac{\partial w_{sti}}{\partial w_{cons}} \right\} dw_{cons}, \tag{41}$$

$$\Delta Ap^{p} = \int_{w^0_{cons}}^{w^1_{cons}} \left\{ -D_{pv}(w^*_{pv},\cdot)\frac{\partial w_{pv}}{\partial w_{cons}} - D_{pvi}(w^*_{pvi},\cdot)\frac{\partial w_{pvi}}{\partial w_{cons}} \right\} dw_{cons} \text{, and} \tag{42}$$

$$\Delta Ap^{f} = \int_{w^0_{cons}}^{w^1_{cons}} \frac{\partial Ap^{f}}{\partial w_{cons}} (w^*_{st}(w_{cons},\cdot), w^*_{pv}(w_{cons},\cdot), w_{cons}; \bar{K}_f) dw_{cons}$$

$$= \int_{w^0_{cons}}^{w^1_{cons}} \left\{ S_{st}(w^*_{st},\cdot)\frac{\partial w_{st}}{\partial w_{cons}} + S_{pv}(w^*_{pv},\cdot)\frac{\partial w_{pv}}{\partial w_{cons}} + S_{cons}(w^*_{st}, w^*_{pv}, w_{cons}; \bar{K}_f) \right\} dw_{cons} . \tag{43}$$

The effect of change in forest conservation is presented as a change price of forest conservation. Before the conservation project forest owners do not receive any compensation for forest conservation, i.e. $w^{0}_{cons}= 0$. After implementing the conservation project, a forest owner may sell forest biodiversity conservation for price w^{1}_{cons}. Summing up the changes in aggregate profits assuming that $S_{st}=D_{st}$ and $S_{pv}=D_{pv}$ yields the welfare measure for change in the level of forest conservation:

$$\Delta Ap = \int_{w^0_{cons}}^{w^1_{cons}} \left\{ S^*_{cons} - D_{sti}(w^*_{sti},\cdot)\frac{\partial w_{sti}}{\partial w_{cons}} - D_{pvi}(w^*_{pvi},\cdot)\frac{\partial w_{pvi}}{\partial w_{cons}} \right\} dw_{cons}, \tag{44}$$

where S^*_{cons} is a equilibrium supply function of forest biodiversity and D^*_{pvi} and D^*_{sti} are equilibrium demand functions for imported pulp wood and saw timber, respectively. The integral (44) is thus the area left of the general equilibrium supply curve for forest biodiversity conservation, minus the areas under the equilibrium demand curves for demand of imported pulp wood and timber, and thus the repercussions from the round wood market are taken into account (Brännlund and Kriström 1993)[2].

The change in aggregate profit of pulp industry, saw mills and households that may own forest imply that the positive welfare effect comes from the society's point of view to the forest owners from the higher timber prices and producer surplus from biodiversity production. The negative welfare effect comes from forgone producers surplus if the import prices increase as a result of domestic forest conservation.

[2] Terms that define the change in the aggregate profits should be the same as in CBR except the existence value of forest biodiversity and direct costs of conservation included in CBR. The current results have similarities, but they are not exactly the same. This issue will be further considered.

4. Empirical Specification

The parameters of the profit functions and parameters of the derived supply and demand functions will be estimated using a restricted generalized Leontief profit function model (Brännlund and Kriström, 1996; Williamson et al., 2004). To close the model and to calculate the equilibrium prices for domestic and imported pulp wood, saw timber and forest biodiversity, we need to estimate the supply functions for pulp wood, saw timber and forest biodiversity, and demand functions for domestic pulp wood and timber, as well as demand functions or imported pulp wood and timber. To estimate the equilibrium price for forest biodiversity, we also need to specify the demand for biodiversity conservation. Here we will most likely use different scenarios of moderate increase in forest conservation and extended conservation that would cover approximately 10% of the forested area in southern Finland, while the current conservation covers 1.6%. We also need to do assumptions about the possibility to substitute the decrease in the supply of domestic pulp wood and timber by importing.

Data for estimating the needed supply and demand functions will be yearly data collected from the databases of the Finnish Forest Research Institute and Statistics Finland. Finding data for estimating the supply of forest biodiversity may, however, be more difficult because this kind of a biodiversity value trade has not been applied in large scale in Finland. In a small scale it has been carried out in western Finland for a couple of years as a pilot project, but the number of contracts is so far 64, all the observations are from years 2003 and 2004 and from the same county, and thereby using the data for the forest biodiversity supply function is very likely impossible. If the CBR presented in this paper prove to be correct regarding the need for the function of biodiversity supply, we must somehow solve the problem of supply function with the data that we have at hand. Some insight to the significance of the producers surplus of the biodiversity suppliers may be possible to get from the study of Finnish forest owners hypothetical willingness to accept compensation for conservation contracts (Horne et al. 2004).

The estimation of the demand and supply functions must be done simultaneously or by other method that allows endogenous explanatory variables. Previously, Brännlund and Kriström, 1996, have used iterative seemingly unrelated regressions (SURE) and three-stage least squares (3SLS) and Williamson et al. 2004 have used two-step process of SURE and nonlinear estimation to estimate the parameters for this kind of a model.

5. Discussion

The purpose of this paper was to connect theoretically the cost-benefit rule and measures to value the benefits and costs of increased forest conservation. This goal was not entirely reached, but some conclusions can be drawn: According to cost-benefit rule, the social desirability of the conservation can be assessed by comparing the aggregate willingness to pay for forest conservation, cost of increased factor prices faced by the industries and producers surplus that the forest owners gain from producing biodiversity. If importing possibilities of raw wood are limited, then also foregone producers surplus caused by lower level of production must be taken into account.

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