Does International Harmonization of Environmental Policy Instruments Make Economic Sense?

The Case of Paper Recycling in Europe *

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October 16, 1999

Proposed running head: Policy Instruments to Promote Recycling

***** Earlier versions of this paper have been presented in seminars at the Department of Economics, University of Umeå, and at the National Institute of Economic Research, Stockholm, at the Bromarv workshop on forestry economics at the Finnish Forest Research Institute, and at the World Congress of Environmental and Resource Economists in Venice, 1998. The authors would like to thank Runar Brännlund, Lauri Hetemäki, Karl-Gustaf Löfgren, Per-Olov Marklund, Anne Toppinen, and Lars-Erik Öller for their comments. The usual caveat applies. Financial support from the Academy of Finland and the Swedish Council for Forestry and Agricultural Research is gratefully acknowledged.

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Abstract

Harmonization of the instruments used in environmental policy has been considered necessary to guarantee fair competition in international markets. We investigate alternative policy measures for promoting paper recycling in seven European countries and present a theoretical framework for analyzing policy requirements for the minimum amount of recycled material to be used in production. We estimate empirically the technologically feasible input combinations of pulp and waste paper for paper production. We then ”translate” the standard into market-based instruments to illustrate how a common recycling goal could be implemented in different countries through taxes or subsidies. Finally, we discuss the distributional effects of harmonized policy.

Key words: recycling, minimum content requirement, taxes, subsidies, environmental policy harmonization

1 Introduction

Paper recycling entails two key environmental concerns: the conservation of raw materials (energy, forests) and the alleviation of waste disposal problems. Due to these socially attractive features, promoting recycling has become one of the politically most popular environmental objectives. One approach has been to encourage the increased use of waste paper in the manufacture of newsprint and paperboard. In the United States, for example, local and national policies have made a certain recycled content mandatory, and similar policy proposals appear from time to time on the environmental policy agendas of the European Union member states and international organizations.[1] The reasoning is that even if sorting and collection of post-consumer waste are well organized by public authorities, these measures do not necessarily make firms utilize extensively the post-consumer waste collected. Minimum recycled content requirements seem to address exactly the right problem.

However, a minimum content mandate is not an unproblematic policy instrument in an international context.[2] If such an environmental standard is to be introduced in domestic markets, it is felt that foreign competitors should also meet that same standard, because production costs may be higher when recycling technology is used as opposed to conventional technology with virgin, or primary, raw material. The availability of waste, or secondary, material depends on domestic consumption, i.e., the proportion of post-consumer waste which is recyclable. Therefore, the higher the proportion of production which is exported, the more difficult it is to meet the minimum standards of secondary material use by domestic recycled material. The economic availability of secondary material is also affected by collection costs, which differ from country to country according to population density and transport distances. For example, due to a lack of landfill space, densely populated areas in Central Europe have more urgent waste disposal problems than the relatively sparsely populated, forest-rich Scandinavian countries. Since Scandinavia exports about 90 percent of its paper production, meeting a minimum content requirement of recycled material would necessitate a relatively high domestic recovery rate and import of waste paper. This is exactly what happened in Canada when the US legislation setting minimum levels for recycled fiber content was introduced (Roberts and Johnstone, 1996).

Harmonization of policy instruments to promote the use of waste paper may thus have unintended effects on forest management, affect trade patterns significantly, and even change the location of industries. The importance of studying policies that affect input uses is accentuated by the projections which indicate that the world consumption of fiber furnish in paper and paperboard manufacture will increase from 250 million metric tons in 1990 to 400 million metric tons by the year 2010 (FAO, 1997). We examine here whether a specific minimum input requirement for recycled paper is an efficient way to encourage the use of recovered waste. Since we are interested in the policies affecting the use of fiber furnish in paper and paperboard manufacture, we do not consider alternative waste paper uses such as incineration. Consequently, we take the policy objective that more waste paper should be used as an input in paper production as given without claiming that such policies would be socially optimal. We, however, suggest that if the reasons behind needs for a policy intervention are purely environmental, a socially optimal recovery rate and the domestic availability of waste paper in different paper producer countries should be investigated in order to determine an internationally optimal waste paper utilization strategy. We illustrate the trade effects of harmonization of standards between different countries that trade with each other but in which the urgency of a given environmental problem differs. We consider input taxes and subsidies as alternative policy instruments to investigate how they could be used to promote recycling and to illustrate the distributional effects of harmonization.

Several of the papers in the literature that analyze ”green” policies to promote recycling are relevant to the present study. Fullerton and Wu (1996) study different policy instruments in a theoretical general equilibrium framework but do not include international trade in their analysis. Conrad (1997) develops a production theory of a firm with recycling activities and compares policy instruments to promote waste recycling *within* the firm without considering the use of post-consumer waste, which may be a more challenging goal in practice. The empirical work by Weaver et al (1997) seeks to minimize the environmental impacts of paper product life cycles and illustrates the trade implications for Europe. They use operational research techniques and do not aim at maximizing social welfare or consider different policy instruments for optimal recycling. Our purpose is to capture some of the interesting features of all of these papers. Analytically, the spirit of our theoretical model on which the policy instruments analysis is based comes closest to that of Bhagwati and Srinivasan's (1969) paper on non-economic objectives of trade policy. Given the recycling target as a non-economic objective, we compare empirically different policies for reaching the common recycling goal to evaluate the effects of harmonization.

The paper is organized as follows. First, we discuss the current state of waste paper recovery and raw material use in Europe and show that if the use of recycled material in paper production is to be encouraged for environmental reasons, the policy instruments for this purpose need to be improved to take into account country-specific features. The next section presents the analytical framework for our policy comparisons. Using aggregate production data for seven European countries, we estimate the technologically feasible input combinations of pulp and waste paper for paper production. Given that currently the input choices within individual industries are freely optimized, we impose a common standard for, or a minimum content requirement on, waste paper input to see the extent of relative changes in input uses which this policy measure would imply for each country. We then ”translate” the standard into market-based instruments to illustrate how a common recycling goal could be implemented in different countries by taxes or subsidies. Finally, we contrast the trade and distributional effects of a harmonized policy with our alternative policy design which acknowledges country-specific differences in paper trade in order to promote paper recycling.

2 Current input choices and a need for environmental policy intervention

The bulk of the fiber furnish used for manufacturing paper and paperboard consists of waste paper and wood pulp.[3] The use of waste paper, in particular, has increased globally for four main reasons: good price competitiveness of recycled fiber, technological progress, regulations influencing demand for recovered paper, and the environmental concerns of waste disposal affecting the paper recovery sector. However, the composition of fiber furnish still reflects to a major extent the domestic supply of these inputs in each country. This is shown in Figure 1, which illustrates the use of wood pulp and waste paper in the production of paper and paperboard in Europe. At the one extreme are the large producers, such as Finland and Sweden, which use mainly virgin fiber; at the other are the small producers, such as Denmark, Greece and the Netherlands, which rely extensively on recycled fiber.

From the recycling point of view, the important factors are the paper and board consumption and production volumes as such, since they affect the geographical distribution of waste paper. Table I displays consumption and production data for paper, pulp and waste paper in Europe. As will become evident below, the share of domestic consumption of paper, and hence the domestic generation of waste paper, play an important role when considering recycling policies in different European countries.

The extent of waste paper recycling in each country is generally described using two indicators: the waste paper *recovery* rate and the waste paper *utilization* rate. It should be noted that waste paper consumption refers to the volumes used in the production of new paper and board, whereas waste paper recovery equals waste paper consumption minus imports plus exports of waste paper. The waste paper recovery rate (to be denoted by a) is defined as the ratio of waste paper recovery to total domestic paper and board consumption. The utilization rate (m) is defined as the ratio of waste paper consumption to total paper and board production. In Europe, the recovery rate increased from 40 percent in 1989 to 49 percent in 1996 and is expected to reach 55 percent in 2005. The utilization rate increased from 36 percent in 1989 to 44 percent in 1996.

National variations in these rates are considerable, however, as can be seen in Table II. For our analysis, it is important to recognize that low utilization rates do not necessarily mean that the country is not recycling a large share of its paper consumption. For example, at 17 percent, Sweden's utilization rate is among the lowest, while its recovery rate – 66 percent – is among the highest. If the policy goal is a high utilization rate, this indicates the importance of waste paper imports for high-volume paper-exporting countries. The opposite is true for countries such as Greece, Italy, and Spain, which import a large share of the paper they use: the utilization rates are high even though the recovery rates are low.

The other two ratios in Table II indicate whether a country is a net exporter (or importer) in its trade of paper and waste paper. The parameter g captures the ratio of paper consumption to paper production, and w is the ratio of waste paper consumption to waste paper recovery. If $g(w)$ exceeds 1, the country is a net importer of paper (waste paper). In 1996, for example, Austria, Finland and Sweden were net exporters of paper and net importers of waste paper, whereas Belgium, Germany and the United Kingdom were net importers of paper and net exporters of waste paper.

Given the current production and consumption structure of paper and paperboard in Europe, the harmonization of policy instruments to promote utilization of waste paper is not necessarily a straightforward task. It is crucial to take into account country-specific differences in the domestic consumption and production of paper and paperboard, which affect, on the one hand, the domestic availability of waste paper and, on the other, the seriousness of the disposal problems where waste paper is concerned.

The point of departure for our analysis is that harmonized standards do not automatically acknowledge the country-specific differences described above. We show that the commonly used utilization rate measure m (conventionally defined as the ratio of waste paper consumption to total paper and board production, r/Y) is not an appropriate measure if the need for a policy intervention is initially motivated by waste management problems. The utilization rate measure m conceals the domestic availability of waste paper. If the domestic availability of waste paper is explicitly taken into account, the utilization rate can be expressed as $m = r / Y = (a\, g Y) / Y = a\, g$, or as a product of a, the recovery rate, and g, an adjustment parameter capturing the ratio of paper consumption to paper production in a country. Consequently, an environmental objective seeking to promote the input use of recovered waste paper (WP) in paper production can be expressed as a restriction:

$r^3 = m*Y = a*g*Y$ = (WP recovery/paper cons.)* (paper cons./paper prod.)*paper prod.
= WP recovery

In other words, we suggest that a goal for increased input use of waste paper should be related to the amount of domestically recoverable material, which potentially would end up in landfills, if the utilization of waste paper were not actively promoted.[4]

It should be emphasized that we do not claim that the waste paper recovery rate a should necessarily be common to all countries. In each country, the waste paper recovery should be at a level where the social marginal net benefit from recycling is zero. Therefore, an optimal policy should be based on an optimal a which should be determined by taking into account environmental considerations.[5] While a standard for a captures the environmental goal, we find that the geographical distribution of virgin and recycled raw material (as reflected by g) should be acknowledged as well. By decomposing the waste paper utilization rate m to $a*g$ we will show below that *even if* the environmental goal a were common, m as a policy goal and as a standard would differ from country to country due to g

3 Input use optimization under alternative policy goals

In this section, we present an analytical framework for the empirical estimations and analysis of policy implications. We have an industry which can use both recycled material (waste paper), r, and virgin resources (wood pulp), v, as raw material. For illustrative purposes, we assume that these are the only variable inputs used and that the industry production function, for a fixed level of capital $\bar{k}$, can be represented by $f(v, r; \bar{k})$. Taking the production level, Y, as given, an objective of the representative industry will be to minimize costs. The Lagrangian then becomes $L = p_v v + p_r r + l(Y - f(\cdot))$ where p_v is the price of virgin material, p_r is the price of recycled material and l is the Lagrangian multiplier. The necessary conditions are

$$\frac{p_v}{p_r} = \frac{f_v}{f_r} \text{ and } Y = f(v, r; \bar{k}) \tag{1}$$

which indicate that the optimal amount of virgin and recycled material used in production is determined by the relative input prices. We can now consider two intervention cases where non-economic, i.e., environmental objectives for the use of recycled material are imposed.

3.1 Minimum content requirement

To promote the use of recycled paper, a minimum content requirement could be implemented for the industry such that the use of recycled inputs should be at least a certain minimum proportion b of the use of virgin material. Formally, the industry would face a constraint $(r / v) \geq b$. Given that the purpose would be to increase the utilization of recycled waste from the initial level, the constraint would be binding with a strict equality. The Lagrangian would have an additional constraint, or $L = p_v v + p_r r + l(Y - f(\cdot)) + d_1(bv - r)$, where d_1 is a multiplier, or a shadow price reflecting the impact of the minimum content requirement. The necessary conditions would read

$$\frac{p_v + d_1}{p_r - d_1} = \frac{f_v}{f_r} \text{ and } Y = f(v, r; \bar{k}). \tag{2}$$

Compared to the conditions presented in equation (1), these imply that the additional environmental objective has an effect on the relative shadow prices that favors the use of secondary material by increasing the cost of virgin material and decreasing the cost of recycled material.

3.2 Utilization rate target

An alternative policy measure to promote the use of recycled material would be a target for utilization of waste, whereby recycled input use should be a certain fraction of the production of final goods, $(r/Y) \geq m$. The amount of recovered waste that would potentially go to landfills (if not for input use) is $r = a\,gY$, where g is the share of paper consumption of domestic production and a the waste recovery rate. Then, the utilization rate target decomposed as $m = a\,g$ would take into account country-specific differences in g.[6] Consequently, the Lagrangian $L = p_v v + p_r r + l(Y - f(\cdot)) + d_2(Y - (r/a\,g))$ would include a multiplier d_2 capturing the shadow price of the utilization rate target for recycled material. The necessary conditions would read

$$\frac{p_v}{p_r - \dfrac{d_2}{a\,g}} = \frac{f_v}{f_r} \quad \text{and} \quad Y = f(v, r; \bar{k}). \qquad (3)$$

Compared to equation (2), the optimal utilization rate policy would not involve the price of virgin material; only the price of recycled inputs. The optimal rate of subsidy would be $d_2 / a\,g$ per unit of recycled input.

3.3 Illustration

The effects of the above non-economic policy objectives imposed as standards in different types of countries are illustrated in Figure 2 with an industry production isoquant, $\bar{Y} = f(v, r; \bar{k})$. The cost-minimizing input combination is determined by the price ratio of the inputs (p_v / p_r), initially at point A for a given producer country. Point A lies on the line b_A, along which the input ratio is constant when the output level is changed.

To underline the importance of g in choosing appropriate policy instruments, let us consider the maximum physical amount of r in each country, i (i = d, f or domestic and foreign, respectively). The domestic availability of waste paper depends on the share of domestic consumption, g_i, of production, Y, and the waste recovery rate, $a\,(0 < a < 1)$; the maximum amount of secondary material available in each country is then $a\,g_i Y$ at a given production level $Y = \bar{Y}$. If a country exports more (consumes less) of its own production than a foreign competitor does, less secondary material is available in domestic markets. In other words, even if two different countries produced at the same production level and they had a certain common waste recovery rate, a, which would reflect the environmental goal of recycling, the maximum amounts of recycled material available for each country would differ as depicted on the vertical axis of Figure 2, i.e., $r_C = a\, g_f Y$ for the foreign competitor and $r_B = a\, g_d Y$ for the domestic producer when $g_f > g_d$.

Consider now a case where a minimum content requirement $(r = bv)$ for secondary material use is introduced. Let us assume that the stringency of the common standard is motivated by the seriousness of waste disposal problems and, hence, the abundance of waste paper in the domestic market of the foreign competitor. The new standard can be depicted by input ratio line b_C which corresponds to waste paper input use $r = r_C = a\, g_f Y$ at the given production level The industries in both countries would be expected to move on the isoquant from the initial equilibrium A to point C, if the same harmonized standard were applied in both countries. However, even if the waste paper recovery rate α were *the same* in both countries, there would be less secondary material available domestically and hence the domestic production could only reach point B, with $r = r_B = a\, g_d Y$, which lies on input ratio line b_B. In order to reach C, an amount $r_C - r_B$ of recyclable waste should be imported. In other words, a policy goal that determines input ratios should not be the same in the two countries with different g even if the waste recovery rate α were identical (i.e., $b_C > b_B$). Alternatively, if market-based instruments were used, the intervention input combinations could be reached by promoting the use of recycled input by a subsidy d_1, and by taxing the primary input by d_1, as equation (2) suggests. The stringency of b would determine the subsidy levels needed.

An alternative policy measure which corresponds to $r = b_C v$, at a given production level, is a utilization rate target $r = r_C$. Recall that the input use goal is determined according to the environmental concerns in the country with g_f $(> g_d)$, i.e., $r_C = mY = a\, g_f \overline{Y}$. As described by equation (3) the target suggests a subsidy for recycled input only, but the outcome of the policy intervention would be the same as in the case of a minimum content requirement. Again, if differences in g were not acknowledged, the country with less waste paper could only meet the utilization target by importing waste paper. However, given that a were to capture the environmental goal for recycling, an optimal subsidy would mean that different countries would use different proportions of recycled material in production, since the subsidy, $d_2 / (a\, g_i)$, would depend on g_i .

In sum, for a certain minimum content requirement there is a corresponding utilization target, and both instruments can be used as standards to promote the input use of waste paper. We have emphasized that these instruments conceal the environmental origin of the need for policy intervention: the abundance of waste paper that creates waste management problems. We point out that the utilization rate, m, can be defined in two alternative ways: 1) as the ratio of waste paper consumption to total paper and paperboard production $(m = r / Y)$, or 2) as the product of the waste paper recovery rate and the share of domestic paper and paperboard consumption in production (i.e., $m = r / Y = a\, g$, because $r = a\, g Y$). The latter acknowledges country-specific differences in paper trade, or the domestic availability of waste paper. This distinction is important to recognize to analyze further the effects a policy intervention may have on waste paper trade.

Of course, if the availability of waste paper is a constraining factor, it is possible to adjust the production level instead of importing waste paper. In Figure 2 this can be seen as a shift from isoquant $\bar{Y}$ to $\bar{Y}_r$ and to point D, given that the constraint $r = r_B = a\, g_d Y$ would be binding. It is even likely that strict standards lead to relocation of industries. The question is whether increasing trade in waste paper or relocation of industries solve the landfilling problems in the most efficient way internationally.

Using the analysis of this section for framing the empirical comparison of harmonized standards for paper recycling in Europe, we can summarize as follows. The starting point is that the generation of waste paper differs between countries, and, hence, the urgency of solving the associated environmental problems by increasing utilization of waste paper varies as well. Therefore, if harmonized standards are used, trade flows of waste paper and location of paper production are also affected. Our framework translates administrative standards into terms of market-based economic instruments, i.e., taxes and subsidies on inputs. This also makes it possible to analyze the distributional effects of harmonized standards. In the next section, we analyze the impacts on different countries when industries move from the initial equilibrium A to policy (or relocation) equilibrium B or C (or D) as depicted in Figure 2.

4 Empirical analysis

4.1 Data, model specification and estimation

To study empirically the effects of policy instruments on input choices in the European paper and paperboard branch, we estimate a production function for the industry; production is represented by a family of isoquants in input space, where each isoquant corresponds to a country-specific level of output. The data sample used in this study is based on an unbalanced panel containing annual data from 7 European countries over the period 1989-96, comprising 52 observations[7]. The countries included are Austria, Finland, France, Germany, Italy, Netherlands, and Sweden – the producers for which consistent data series on all the explanatory variables needed were available. Since the paper and board production of these countries amounts to 81 percent of Europe's total production[8], the data set should give a fair representation of the production technology in Europe.

The data consist of observations on paper and paperboard (Y) produced, fibers (virgin wood, V, recycled paper, R), capital (K), and number of employees (L). For wood input we use as a proxy consumption of pulp, and for recycled paper input we use consumption of waste paper. Data units are in 1000 tons for paper and paperboard production and fibers, million ECUs for the capital stock and 100 employees for the labor input. The capital stock is calculated using the perpetual inventory formula:

$$K_t = (1-d)K_{t-1} + I_{t-1} \qquad (4)$$

where subscript t indicates time period, d a constant rate of depreciation, and K and I capital stock and investment at a given time, respectively[9].

We estimate a representative industry production function using a flexible translog specification, which is a local second order approximation of any arbitrary function. To reduce the number of parameters to be estimated, each variable was multiplied by $(1/L)$, the transformed variables being denoted by y, k, r and v. In essence this imposes a restriction of constant returns to scale, or homogeneity of degree one, on the production function.

The model was specified as (ignoring time and country subscripts for simplicity):

$$\ln y = \ln a_0 + a_v \ln v + a_r \ln r + a_k \ln k + 1/2\, b_{vv} (\ln v)^2 + b_{vr} \ln v \ln r + b_{vk} \ln v \ln k + 1/2\, b_{rr} (\ln r)^2 + b_{rk} \ln r \ln k + 1/2\, b_{kk} (\ln k)^2 + g_{FI} D_{FI} + g_F D_F + g_G D_G + g_S D_S + e \quad (5)$$

where dummy variables for the four most significant producer countries, Finland (denoted by D_{FI}), France (D_F), Germany (D_G) and Sweden (D_S) are included.[10] It is interesting to note that these countries have high waste paper recovery rates (from 41 to 71 percent), but their waste paper utilization at current production differs substantially (from 6 to 60 percent). The following restrictions on the estimated parameters follow from the assumption of linear homogeneity of the production function:

$$a_v + a_r + a_k = 1 \qquad b_{vv} + b_{vr} + b_{vk} = 0$$
$$b_{rr} + b_{rv} + b_{rk} = 0 \qquad b_{kk} + b_{kv} + b_{kr} = 0 \quad (6)$$

The translog is symmetric, meaning that $b_{ij} = b_{ji}$.

A series of model diagnostics and specification tests were applied to check the econometric reliability of the estimation results; test results are reported in Table III. As regards the functional form of the production, an F-test favored the translog specification compared to the Cobb-Douglas, which would have restricted the cross-product terms between the inputs to zero (Functional form test A). An F-test indicated that the use of four dummy variables is justified to capture variations in the intercepts between the selected countries (Heterogeneity test B). Since we use pooled cross-section and time series data, there is reason to expect heteroscedasticity. White's test (Heteroscedasticity test C) indicated that heteroscedasticity is not a problem when transformed variables are used (Model 2; y, k, r, v) instead of using labor, L, as a separate variable (Model 1; Y, K, L, R, V). The transformation could, however, generate endogeneity problems, since the multiplicative variable $(1/L)$ now appears on both sides of the estimated equation. To test for endogeneity, the Hausman test (test D) was applied; this indicated that the null of exogeneity can not be rejected, but the test seems to be very sensitive to the specification of the instrument used, as is usual. The assumption of CRS was tested using an F- test (test E). The null hypothesis of CRS could not be rejected.

4.2 Results

The OLS coefficient estimates for the model in equation (5) are reported in Table IV. The t-values indicate statistically significant relationships between output and fiber uses. In particular, the coefficients for v and r as well as the cross-term vr and the second-order term rr are significant at the 5 percent level, but the coefficients including the capital stock variable are not. The results show that the conventional goodness-of-fit statistic R^2 is high, 0.99.

Using the estimated coefficients, the isoquants for the benchmark countries can be depicted in pulp/recycled fiber space for given country-specific average capital stocks. As a visual check Figure 3 suggests that the production functions are well behaved. The translog function is, however, only a local approximation, which means that it does not necessarily satisfy the restrictions for production functions globally. Therefore, we need to examine monotonicity and convexity, i.e., that output increases monotonically with all inputs and that the isoquants are convex. As regards convexity, the bordered Hessian matrix of first and second partial derivatives needs to be negative definite for the isoquants to be strictly convex. If at least one b_{ij} is not equal to zero, there exist combinations of inputs where neither monotonicity nor convexity is satisfied. However, there can be well-behaved regions that are large enough so that the translog function is a good representation. For a presentation of how to check these criteria, see Berndt and Christensen (1973 pp. 84-85).

The monotonicity condition was verified for all the existing combinations of inputs in all the countries, with the exception of waste paper in Finland. For all the countries the bordered Hessian analysis rejected the *strict* convexity requirement due to the fact that the third determinant is approximately zero. In other words, the isoquants proved to be convex, instead. Again, the only exception was Finland, for which the convexity condition was not fulfilled. A scatter plot of observations revealed that the estimated translog function is not a representative approximation in the input region where only a small amount of recycled fiber is used. This explains why the estimated translog function does not seem to be well behaved in the case of Finland, where the level of recycled paper input use is low. Therefore, we cannot derive reliable estimates for Finland in illustrating the price effects and policy implications in the following discussion.

4.3 Estimated economic effects of different policies

The first-order conditions are used to calculate the magnitude of the effects of imposing standards for use of waste paper in the pulp and paper industries in the selected European countries. Recall that a cost-minimizing optimum for input uses is

$$\frac{p_v}{p_r} = \frac{\partial Y / \partial v}{\partial Y / \partial r} \qquad (7)$$

which corresponds to the following technical rate of substitution between r and v in the case of the translog production function

$$TRS = \frac{\partial Y / \partial v}{\partial Y / \partial r} = \frac{r}{v} * \frac{\alpha_v + \beta_{vr}(\ln r) + \beta_{vv}(\ln v) + \beta_{vk}(\ln k)}{\alpha_r + \beta_{vr}(\ln v) + \beta_{rr}(\ln r) + \beta_{rk}(\ln k)} \qquad (8)$$

where the capital stock variable k is fixed at the country-specific mean value level. To illustrate the outcomes of alternative policies for promoting recycling, we will use the estimated isoquants of two of the most significant producer countries representing different trade patterns: Germany (imports paper and exports waste paper) and Sweden (exports paper and imports waste paper). For each country we will compare the initial, currently observed input combination (denoted by point A) to those input combinations which are imposed by a common harmonized European standard (point B) or by a country-specific maximum potential recycling target (point C); see Figures 4a-b and Tables V and VI.[11]

Recall that the utilization rate target was defined as a certain share of waste paper in production, or $m = r/Y = \alpha\gamma$, and the corresponding minimum content requirement is determined by calculating the ratio for recycled and virgin inputs, $\beta = r / v$ at the given output level (isoquant). First, we need to determine a relevant policy point of reference B. Since Germany is the only one of these three countries which exports waste paper, it is reasonable to expect that it faces the strongest pressure to promote domestic utilization of waste paper. During the data period considered here, the mean utilization rate in Germany was $m = 0.53$. Therefore, we have chosen a slightly higher common utilization rate target of $m = 0.60$ and corresponding minimum content requirements to illustrate the effects for each country.[12] Next, it is interesting to compare how these "administrative" targets for the use of recycled material could be reached with market-based instruments, i.e., by affecting the input prices instead of quantities. Our comparison also clarifies why the governments of the countries concerned may have different interests and strategies for promoting recycling.

We start with Sweden, the country for which the proposed recycling standards would have the most dramatic consequences.[13] The initial Swedish fiber use is 1248 tons of waste paper and 7526 tons of pulp.[14] The technical rate of substitution at point A is calculated as $TRS = p_v / p_r = 0.88$, which indicates that the use of waste paper as a raw material is a more expensive option. If a utilization rate target of $m = 0.60$ were implemented, the input combination would correspond to point B at the current Swedish output level indicated in Figure 4a. Consequently, the technical rate of substitution at the new equilibrium would equal 1.30 and fiber uses should be adjusted to 5367 tons of waste paper and 3121 tons of pulp. In other words, the use of waste paper would increase more than fourfold and the use of virgin fiber would be reduced to less than half of the initial amount.

Instead of imposing standards, taxes and subsidies could be used as economic instruments, as derived in section 3. Sweden could reach the utilization rate target, or point B, by subsidizing waste paper such that the subsidized price ($p_r - d/a\,g$ in equation (3)) would be 30 percent lower than the initial price. Alternatively, a corresponding minimum content requirement could be translated to a simultaneous use of taxes and subsidies as shown in equation (2). Sweden could reach B by taxing virgin fiber such that the price of pulp ($p_v + d_1$) would ultimately increase 27 percent and by subsidizing waste paper such that the final price ($p_r - d_1$) would be 14 percent lower.

The problem for Sweden is that the above policies would require such a large amount of waste paper that extensive imports of recycled fiber would be necessary. The potential maximum amount of waste paper available in Sweden can be estimated by increasing the recovery rate to 60 percent (compared to the mean rate of 53 percent). Using the country-specific maxima of $g_{\max}$ and $Y_{\max}$ (.23 and 9354 respectively for Sweden during the data period), the potential maximum recycled fiber amount would be $r = a\,g_{\max} Y_{\max} = 1291$ tons. If this maximum amount of waste paper were used, Sweden would end up on the isoquant at C, which is only slightly above A. However, even if Sweden used all of its potentially recyclable waste paper, it could not meet a common utilization rate target $m = 0.60$ at its current production level. In order to fulfill the policy requirement (corresponding to the line depicted by $b_C = r/v = 1.72$), Sweden would need to import approximately 4000 tons of waste paper to produce at B or, alternatively, to cut its production substantially. At point D, where the domestic waste paper input constraint is binding, Sweden could produce only one fourth of its current output level. This is a purely hypothetical outcome, but it illustrates in a striking way that a well-intentioned harmonization policy may result in wholly unanticipated outcomes if country-specific differences are not taken into account.

Germany represents the other extreme compared to Sweden: large domestic consumption with respect to domestic paper production enables a much larger supply of waste paper (Figure 4b). Initially, Germany produces at point A using 7090 tons of waste paper and 5583 tons of pulp with a technical rate of substitution of $TRS = p_v / p_r = 1.27$. In other words, waste paper is a less expensive raw material than virgin fibers. When the utilization rate target of $m = 0.60$ corresponding to a minimum content requirement of $b_C = 1.72$ is introduced, the input bundle becomes 8198 tons of waste paper and 4778 tons of pulp with $TRS = p_v / p_r = 1.46$. In terms of taxes and subsidies, this point could also be reached if waste paper were subsidized by 11 percent to meet the utilization rate target, or if wood pulp were taxed by 7 percent and waste paper subsidized by 5 percent to meet minimum content requirement. In physical terms, Germany would not have problems in reaching B, since its hypothetical maximum amount of waste paper available is about 11000 tons. (See Table V, panel C.)

In addition, the relative price changes summarized in Table V illustratethe distributional effects of harmonized policy. By increasing the use of recycled paper to point C, country-specific maximum, (Policy II in Table V), France, Germany and Sweden would altogether use approximately as much recycled material as in point B (Policy I). However, relative price changes required in France and Germany would be substantially larger than in Sweden which, in fact, would not have any need to intervene to affect prices. Therefore, to determine an optimal policy, recovery rate α should be chosen socially optimally, and the policy goal and the corresponding price changes would reflect the social net benefits of recycling.

In sum, a common recycling standard, which could easily be justified by a need to harmonize international environmental policy, would have widely varying impacts on input combinations in different producer countries, as illustrated in Figures 4 a-b. When standards are translated into monetary terms, e.g., taxes and subsidies, the effects become most evident.

Table VI summarizes the relative price changes needed for each country to move from the initial input combination A to an input combination B which satisfies the common policy goal of a utilization rate target of $m = 0.60$. Two different policies are a tax solely on virgin wood pulp (corresponding to a common utilization rate target) or, alternatively, a combination of a tax on wood pulp and a subsidy on recycled pulp (corresponding to a common minimum content). As can be seen from Table VI, the policies affecting relative prices would require substantial taxes and subsidies in Sweden, whereas the relative price changes in Germany would not be as dramatic. Also, the changes in volumes of use of wood pulp and recycled pulp reflect the magnitude and direction of price changes. In addition to the fact that Sweden would have to increase heavily its import of waste paper, there would be significant distributional effects; the principal losers would be the Swedish forest owners who supply wood to the pulp and paper industry.

Our calculations are based on estimations for Europe, but the policy relevance of comparing instruments to promote recycling is confirmed by the impact on Canada of the minimum content legislation already adopted in the US. The heated debate on “the garbage crisis” made the US to introduce recycled content legislation which resulted in a “crisis” for the Canadian newsprint industry in the early 1990s (Roberts and Johnstone, 1996). Even with 100 % recovery the Canadian consumers would not be able to generate sufficient waste paper to supply industry requirements at existing levels of exports to the US. The shortfall has been made up by importing waste paper from the US putting firms with high transportation costs at a disadvantage.

5. Conclusions

In recent years, there has been pressure on international policy arenas to encourage paper recycling largely because of environmental concerns. At the same time, international harmonization of environmental standards has been deemed necessary. We argue here that this poses a challenge calling for an appropriate policy measure: both the international and national economic viewpoints should be acknowledged without compromising the initial environmental viewpoints.

The contribution of this paper is to show both analytically and empirically that trade effects can, and should, be taken into account when planning harmonized environmental standards, or administrative instruments, as they are often referred to. The analysis is based on a theoretical model which shows how administrative measures can in fact be translated into market-based, or economic, instruments to promote the use of waste paper in paper and board production. A production function for the European paper and board industry is empirically estimated and the effects of different policy instruments on the input choices of wood pulp and recycled paper are studied.

The administrative instruments analyzed are minimum content requirement and utilization rate target. By translating the two instruments into taxes and subsidies, we show that the administrative instruments do not come without efficiency costs. On the contrary, a common standard corresponds to a wide range of country-specific subsidies and/or taxes. This indicates that the marginal (shadow) costs of implementing a common waste paper utilization goal are different, and a common international standard is not a cost minimizing policy measure for promoting waste paper use.

As a natural explanation for differences in the marginal costs we suggest the domestic availability of waste paper. It is important to study this argument, since it reflects the extent of the environmental problem in each country. We find that countries that export a major part of their production would have to import substantial amounts of waste paper in order to fulfill the administrative policy requirements. The fact that a country has a low utilization rate and a high recovery rate does not necessarily mean that it is not utilizing recovered waste well; large paper exports could be the explanation instead.

Using a common standard as a policy instrument to increase utilization of recovered waste paper is frequently justified by arguments of “fairness”, i.e., both domestic and foreign competitors should meet the same environmental standard. However, our estimations predict significant distributional effects that would result from a well-intentioned common policy. There are two lessons to be learnt from our calculations: first, harmonized policy does not guarantee “fairness” as such (neither “harmonized” environmental benefits nor equal marginal costs) if country-specific features are not taken into account; second, translating the corresponding shadow prices for standards into terms of market-based instruments shows that the efficiency costs of using these administrative instruments for environmental policy may be quite high.

Our analysis reveals the source of distributional effects for a harmonized standard. Therefore, a policy instrument should impose an environmentally justified, recycling goal (such as recovery rate a), but should acknowledge potentially drastic trade impacts by taking into account the geographical distribution of virgin and recycled raw material (as reflected by consumption/production ratio g). If policy instruments to promote recycling result only in increased import/export of waste paper, the green labels used to inform consumers about the recycled material content of paper products may also be telling only half the truth.

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Footnotes:

1. Ecolabelling is already used in some European countries to discriminate in favor of recycled paper products; for example, the Dutch Stichting Milieukeur and the German Blaue Engel award their environmental labels to recycled paper products made of 100 percent recycled paper. Some international organizations also recommend that public agencies purchase environmentally friendly goods: e.g., the United Nations Development Programme (UNDP, 1995) has specified standards for their offices worldwide including, among others, a 50 percent recycled paper minimum-content requirement for paper. For a further discussion of waste paper cycle management incentives, see, e.g., Bertolini (1994).

2. For references, see, e.g., Grossman (1981) and Beghin and Sumner (1992).

3. In 1994, the composition of fiber furnish in Europe was (figures for North and Central America in parentheses): wood pulp 58.3% (66.9%), other fiber pulp 0.3% (0.4%), and waste paper 41.4% (32.8%).FAO 1997:45.

4. An alternative policy goal could be to increase the input use of waste paper, no matter where the waste paper is generated:

$r^{3}m*Y= a*g*w*Y=$

(WP recovery/paper cons.)* (paper cons./paper prod.)* (WP cons./WP recovery)*paper prod.

= WP consumption

However, our main critique is that if the use of waste paper in paper production is to be encouraged for *environmental reasons* the domestic availability of waste paper reflects the seriousness of the environmental problem in a country. Therefore, a harmonized standard should not principally aim at increasing trade of waste. Technically, it is essential for us to have initially ω=1 to show how much waste paper is available domestically. Then it is possible for us to say that the result of a harmonized standard may be an increase in trade of waste paper, which is perhaps not in the line with the initial environmental goal.

5. To determine the optimal recovery rate for each country could be a subject of a separate study; see, e.g., Huhtala (1997). The point we want to make here is that α plays an important role, if standards for waste paper use are to be promoted for environmental reasons.

6. Recall that the utilization rate is currently measured by μ (Table II), which conceals the effects of trade flows of paper industry products.

7. The panel is unbalanced since data for the Netherlands were only available for four years.

8. This figure is for 1996. All of the aggregate level data for the pulp and paper industry are taken from different issues of Pulp and Paper International.

9. The depreciation rate used is 3 percent. Due to a lack of data we could not empirically estimate the depreciation rate. A study of the Finnish paper industry by Hetemäki (1993) used the procedure presented in Kuh and Schmalensee (1973) to calculate depreciation rates. Hetemäki arrived at a depreciation rate of 3.5 per cent for building structures and 6.9 per cent for equipment and machinery. We believe that even though we had to choose a depreciation rate without an empirical estimation, another rate in this range would not change the point that we want to make. In order to obtain the initial values for the capital stock, we assume that the capital per ton of paper produced is equal for all the countries. This ratio is calculated from Swedish data on the pulp and paper sector. Since the data on investment and labor are only available for the pulp and paper sector as a whole, we assume that these variables are proportional to the production of paper as a share of the production of pulp and paper, and investment and labor are multiplied by this share. This simplifying assumption is made only because of a lack of data.

10. Other specifications were tested before selecting upon a model, e.g., input variables only, fixed effects using period dummies, and both period and country dummies. After applying a battery of statistical tests and careful model diagnostics, the statistical performance of the model presented proved to outperform the other specifications in adequacy.

11. See the Appendix for a description of the calculations used in this section.

12. We made an effort to find the most appropriate parameter value for illustrations of a potential utilization rate target. However, minutes of the meetings of the Eco-Label Competent Bodies (where all European member countries are represented) are confidential during the planning process. In the US, the secondary content requirements vary from 40 % to 80 % (Ruston and Dresser, 1988).

13. This is true also for Finland, which is as large a producer and exporter, but which in fact currently uses relatively less waste paper as raw material.

14. The average values of the data period are used in the calculations.

FIGURES

Figure 1. Share of pulp and waste paper in production of paper and board

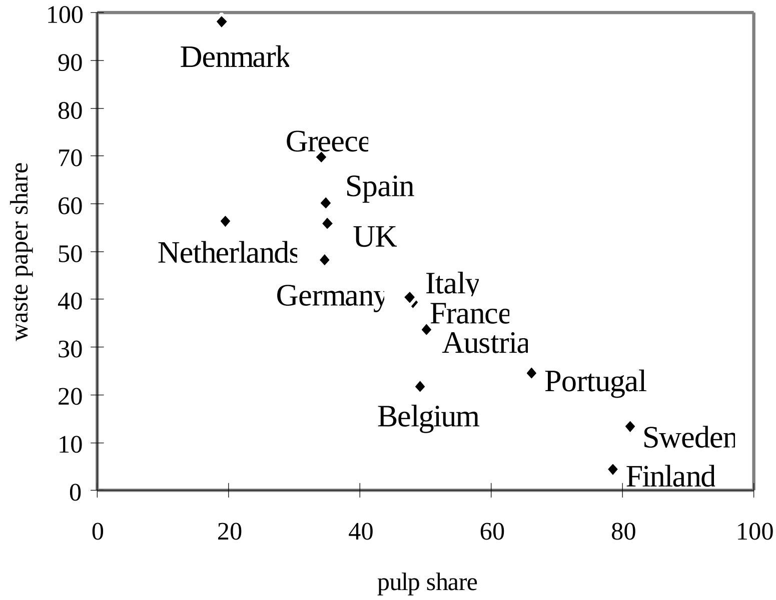


Figure 2. The effects of environmental policy objectives imposed

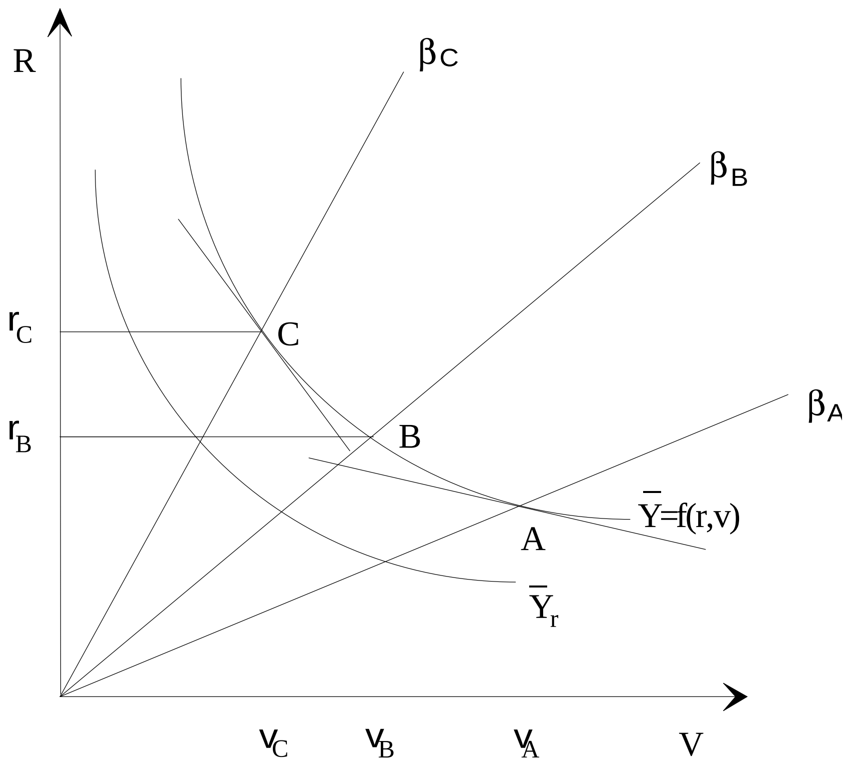


Figure 3. Isoquants for the benchmark countries with production volumes (fitted values)

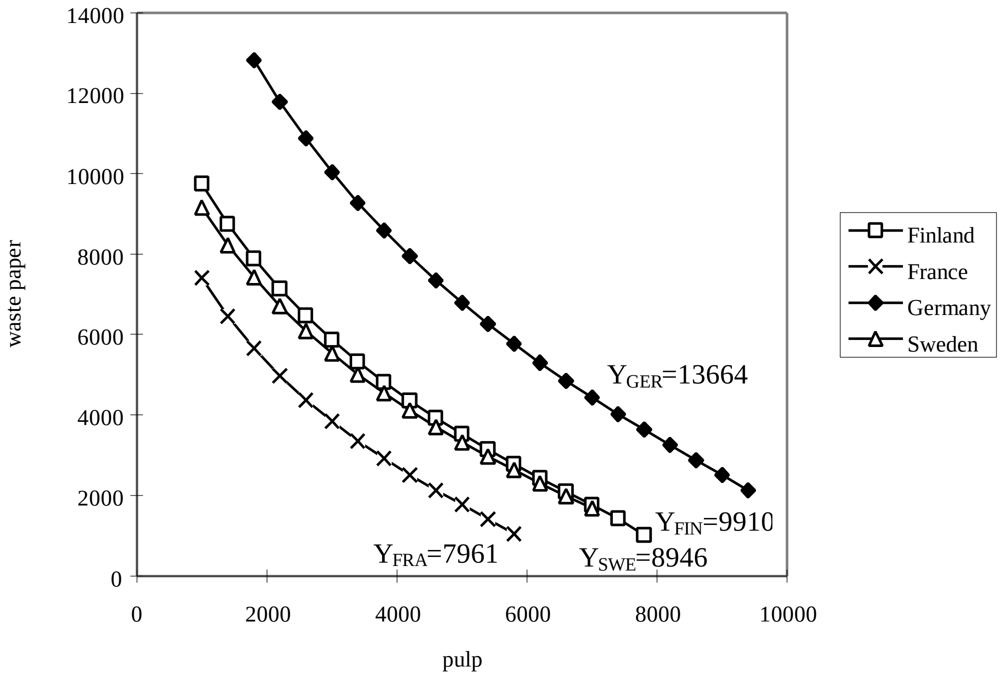


Figure 4a. Comparing policy instruments for Sweden

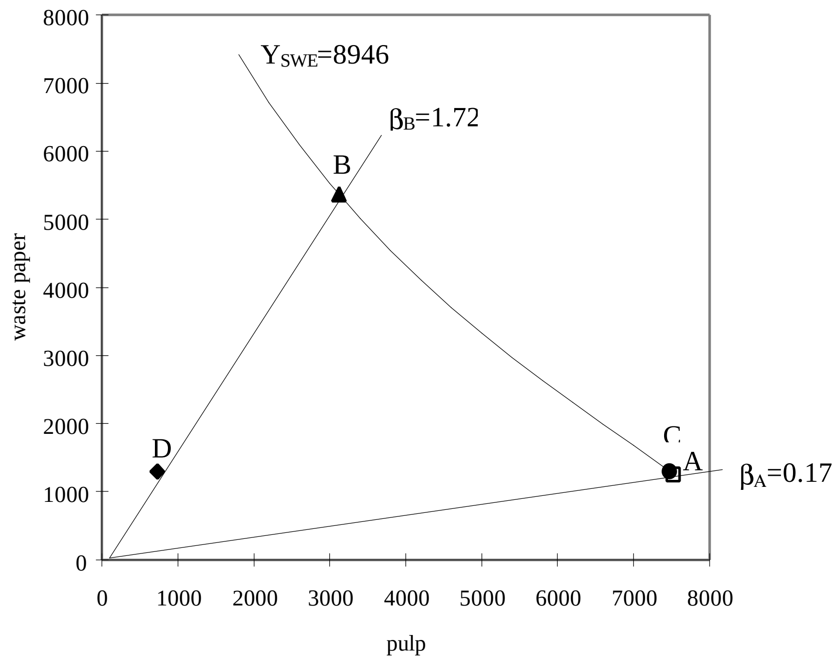
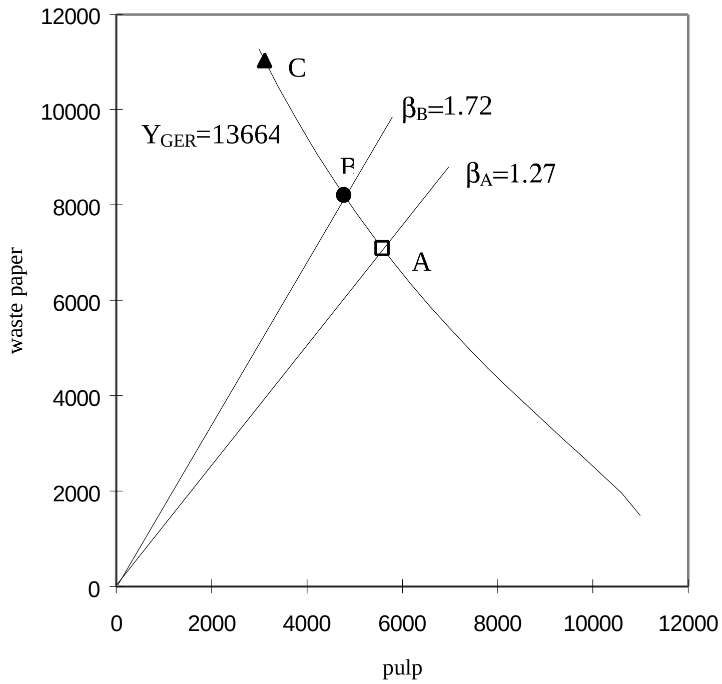


Figure 4b. Comparing policy instruments for Germany



TABLES

Table I Paper, pulp, waste paper consumption, production and recovery 1996 (1000 tons)

Countries	Paper Consumption	Paper production	Pulp consumption	Pulp production	Waste paper consumption	Waste paper recovery
Austria	1446	3653	1832	1550	1537	1054
Belgium	2633	1328	653	383	361	1020
Denmark	1141	322	61	71	395	615
Finland	1634	10442	8184	9676	575	563
France	9382	8531	4100	2517	4192	3857
Germany	15471	14733	5105	1816	8888	10912
Greece	912	352	120	20	307	300
Italy	8250	6954	3309	540	3515	2531
Netherlands	3166	2988	584	125	2106	2056
Portugal	836	1026	679	1594	315	329
Spain	5171	3684	1282	1461	2774	2125
Sweden	1748	9018	7321	9779	1502	1158
UK	11443	6188	2168	575	4323	4551

Source: Pulp and Paper International (1997)

Table II Waste paper recovery and utilization rates 1996

Countries	**Recovery rate (a)**	**Utilization rate (m)**	**Paper consumption/ paper production(g)**	**Waste paper consumption/ waste paper recovery(w)**
Austria	.73	.42	.40	1.46
Belgium	.39	.27	1.98	.35
Denmark	.54	1.23	3.54	.64
Finland	.44	.06	.16	1.02
France	.41	.49	1.10	1.09
Germany	.71	.60	1.05	.81
Greece	.33	.87	2.59	1.02
Italy	.31	.51	1.19	1.39
Netherlands	.65	.71	1.06	1.02
Portugal	.39	.31	.81	.96
Spain	.41	.74	1.37	1.31
Sweden	.66	.17	.19	1.30
UK	.40	.70	1.85	.95

Source: Own construction based on figures from Pulp and Paper International (1997)

Table III Tests of selected hypotheses

Test	Restrictions	Degrees of freedom	Test Statistic	Critical Value 95th percentile F or c^2
A. F-test: Functional form				
H_0: $\beta_{kk}=\beta_{kv}=\beta_{kr}=\beta_{vv}=\beta_{vr}=\beta_{rr}=0$	6	42	39.69	2.33
B. F-test: Heterogeneity				
H_0: $\gamma_{FI}=\gamma_{F}=\gamma_{G}=\gamma_{S}=0$	4	38	5.17	2.62
C. White's heteroscedasticity test				
Model 1				
H_0: Homoscedasticity	-	17	34.41	27.59
Model 2 CRS				
H_0: Homoscedasticity	-	12	16.53	21.03
D. Hausman's endogeneity test				
H_0: Exogeneity	-	14	11.36	23.69
E. F-test: CRS				
H_0: $a_v + a_r + a_k = 1$				
$b_{vv} + b_{vr} + b_{vk} = 0$				
$b_{rr} + b_{rv} + b_{rk} = 0$				
$b_{kk} + b_{kv} + b_{kr} = 0$	4	33	0.71	2.66

Table IV Parameter estimates of translog production function

Parameter	**OLS**	
	Estimate	**t-value**
α_0	0.8521	0.3859
α_v	1.0385*	2.8110
α_r	0.8128*	3.4548
α_k	-0.8795	-0.5843
β_{vv}	0.0929	1.1258
β_{vr}	-0.1524*	-2.3629
β_{vk}	-0.1035	-0.6365
β_{rr}	0.1932*	2.6480
β_{rk}	-0.1374	-1.0075
β_{kk}	0.4896	0.8530
γ_{FI}	0.0969	0.8094
γ_F	-0.0179	-1.4041
γ_G	0.0350*	3.3519
γ_S	0.0440	0.8118

R^2=0,9963

Table V Estimated country specific effects of different policies

The values of R, V and Y are in 1000 tons.	**Finland**	**France**	**Germany**	**Sweden**
mean R (recycled paper)	504	3685	7028	1231
mean V (virgin wood)	7904	4017	5550	7472
mean K (capital)	7288	7225	14863	5755
Y_{fit}	9910	7961	13664	8946
A. Initial position (given Y_{fit} and mean β_i^A)				
β_i^A	0.06	0.92	1.27	0.17
R_i^A	509	3699	7090	1248
V_i^A	7959	4025	5583	7526
μ_i^A	0.05	0.46	0.52	0.14
$\mathbf{P_V^A/P_R^A}$	..	1.09	1.30	0.88
B. Policy I: Common standards				
***Utilization rate target** (common α=0.6 and γ=1)				
$\mu^B = \alpha\gamma = r/Y = 0.60$	5946	4777	8198	5367
R_i^B	3009	3123	4778	3121
V_i^B				
***Minimum content requirement** (corresp. μ^B)	1.98	1.53	1.72	1.72
β_i^B	1.43	1.32	1.46	1.30
$\mathbf{P_V^B/P_R^B}$				
C. Policy II: Country-specific $R_{i,max}$				
(Given a common recovery rate α=0.6, increase the use of recycled paper to country-specific $R_{i,max}$)				
$R_{i,max}=0.6*\gamma_{i,max}*Y_{i,max}$	1050	6456	11031	1291
V_i^C	7863	2027	3114	7477
μ_i^C	0.11	0.81	0.81	0.14
β_i^C	0.13	3.19	3.54	0.17
$\mathbf{P_V^C/P_R^C}$	1.21	1.79	2.00	0.88
D. Policy III: Country-specific $R_{i,max}$	1050	6456	11031	1291

(And requirement β_i^B simultaneously fulfilled)	1.98	1.53	1.72	1.72
V_i^D	531	4219	6413	728
Y_i^D	1779	10642	18277	2143

Table VI Estimated country specific distributional effects

	Finland	**France**	**Germany**	**Sweden**
Use economic instruments to move from A to B				
* Utilization rate target				
subsidize recycled paper (R)	..	17%	11%	30%
* Minimum content requirement				
subsidize recycled paper (R)	..	8%	5%	14%
and tax virgin wood (V)	..	11%	7%	27%
Corresponding changes in raw material Uses when moving from A to B				
ΔR_i (change in recycled fibers)	+5437	+1078	+1108	+4119
ΔV_i (change in virgin wood)	-4950	-902	-806	-4405

The values of ΔR and ΔV are in 1000 tons.

APPENDIX

Calculations for Tables V and VI and Figures 4a and 4b

Initial position, A

Use mean R, V, K to get Y_{fit}, and calculate *b=(mean R/mean V)*. Given Y_{fit} and *b*, derive V_{fit} from the translog function, then $R_{fit} = b\, V_{fit.}$ Substitute V_{fit} and R_{fit} into expression (4) to calculate the technical rate of substitution.

Common standards: utilization rate target and minimum content requirement, B

To recalculate the first-order conditions, solve for *v* from the translog. Then *v* becomes a solution to a second-order polynomial where $A = 1/2\, b_{vv}$, $B = a_v + b_{rv} \ln r + b_{vk} \ln k$,and $C = a_0 + a_r \ln r + a_k \ln k + b_{rr}\, 1/2(\ln r)^2 + b_{rk} \ln r \ln k + b_{kk}\, 1/2(\ln k)^2 - \ln y$. Calculate *r* as *r=a gY*, where *a g* equals 0.6. Substitute *v* and *r* are into expression (4). Use mean input values to get the technical rate of substitution. To see which minimum content requirement corresponds to this utilization rate target, calculate *r/v*.
If we instead use the minimum content requirement as the reference policy: solve for *v* from the translog function by replacing r with *bv*. Then *v* becomes a solution to a second order polynomial $v_m = \frac{-B \pm \sqrt{B^2 - 4AC}}{2A}$ where $A = 1/2\, b_{vv} + b_{vr} + 1/2\, b_{rr}$,
$B = a_v + a_r + a_{rv} \ln B + b_{vk} \ln k + b_{rr} \ln B + b_{rk} \ln k$, and
$C = a_0 + a_r \ln B + a_k \ln k + b_{rr}\, 1/2(\ln B)^2 + b_{rk} \ln B \ln k + b_{kk}\, 1/2(\ln k)^2 - \ln y$.
When *v* has been derived, we can calculate *r* as *r=bv*. Then *v* and *r* are substituted into equation (8) to get the technical rate of substitution (TRS).

To calculate relative prices recall that

Initially A: $TRS_A = \frac{p_v}{p_r} = \frac{f_v}{f_r}$

Policy B: $TRS_B = \frac{p_v + d_1}{p_r - d_1} = \frac{f_v}{f_r}$ or $TRS_B = \frac{p_v}{p_r - \frac{d_2}{a\, g}} = \frac{f_v}{f_r}$

Use then TRS calculated above.