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Abstract

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The increasing use of waste paper in the production of paper products has had a large effect on the forest industry and on the structure of aggregate production. One of the most surprising results was reached in that in a Nordic type of economy where forestry is important, recycling requirements may cause an expansion in the forestry sector. This is certain, the case if capital is not mobile internationally; and in this case we may observe even an expansion of paper production, otherwise the production of all types of pulp expands. This may hold also when capital is mobile.

Pentti Forsman – Pertti Haaparanta* – Tarja Heinonen**

Economics Department
8.3.1993

Waste Paper Recycling and the Structure of Forest Industry

in the Nordic forest industry. This shift would imply that the capital intensity from the forest sector declines and, hence, that welfare declines, ceteris paribus. The proper analysis of welfare issues would take into account the effects of the recycling but these effects are not clear. If different types of paper require different structural changes, the shift in the types of paper being the highest recycling requirements, though this result depends on assumptions regarding relative capital intensities of production. If they do not differ between production processes of various types of paper, then it certainly holds.

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Abstract

The increasing use of recycled fibres in paper production may have large effects on the forest industry and on the structure of aggregate production. One of the most surprising results was reached is that in a Nordic type of economy where forestry is important, recycling requirements may cause an expansion in the forestry sector. This is certainly the case if capital is not mobile internationally and in this case we may observe even an expansion of paper production; otherwise the production of all types of pulp expands. This may hold also when capital is mobile internationally. In this case paper production ceases but production of pulp based on recycled paper may increase. As the latter case seems to be closer to the situation prevailing in Europe, we expect recycling to create a structural change in the Nordic forest industry. This shift from refined paper products towards the production of pulp would be a turnaround in particular in the Finnish forest industry policy, as in the last decades the trend has been just the opposite. This shift would imply that the export revenues from the forest sector decline and, hence, that welfare declines, *ceteris paribus*. The proper analyses of welfare issues would take into account the reduction in pollution due to the recycling but these issues are not dealt with in this paper. In addition we showed that if different types of paper face differing recycling requirements then we would expect a large structural change in paper production. We may see the cessation of production of the types of paper facing the highest recycling requirements, though this result depends on assumptions regarding relative capital intensities of production. If they do not differ between production processes of various types of paper then it certainly holds.

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1 Introduction

Environmental issues have become topical in the last few years. Attention has been paid to e.g. recycling of materials and production processes. In this paper we analyse the impact of recycling requirement on forest industry in a Nordic type of economy. The production of paper using recycled fibres together with virgin wood fibres has become technically easier in the last decade (Sörman, 1991).

Demand for paper products which contain recycled fibres has increased in many countries. These products are perceived as more environmental friendly than paper which is made of virgin fibres. The available landfill sites to dump waste have been running out, and this together with consumers' pressure has hastened reforms on legislation to increase the recovery of waste paper. It has been estimated that 15 per cent of the trash in the landfills is discarded newspapers.

There is also an economic incentive to use waste paper in paper production. Waste paper is cheap in comparison with virgin wood prices. According to Ekono (1991a), the cost of recycled fibre is 70 % of mechanical fibres. Compared to chemical pulp, the cost advantage of recycled fibre is even larger. These changes in input composition may have large impacts on countries like the Nordic countries, whose major export industry is paper industry.

In addition, populations in the Nordic countries (Finland, Norway and Sweden) are small and scattered. This makes it impossible to collect waste paper to the extent that would satisfy technically and economically grounded requirement of recycled raw materials. It means that a substantial amount of Nordic paper may have to be brought back from the densely populated Western Europe. It may be uneconomic to transport waste papers long distances and it is difficult to compensate this disadvantage in other production costs. Therefore it seems likely that the investments of the Nordic forest industry firms will be largely directed to the Central and Western Europe, close to the sources of waste paper. Even if the legislation would allow solely virgin wood based paper qualities, the producers still face the shift in consumer demand.

In this paper we discuss the changes in paper demand and production requirements, and assess the structural development of the production of pulp and paper. First we describe the situation in the paper and pulp market especially from the Nordic viewpoint. Then we analyse the potential development of the paper and pulp industry in a framework which is familiar from the theory of international trade. The Nordic countries are small open economies where raw wood is an abundant natural resource. Therefore the model we use in the analysis is that of a small economy. We examine two alternatives of openness: one in which capital is internationally mobile and another in which it is not mobile. This allows us to examine the incentives to locate production abroad.

2 Structural changes in the paper and pulp market

The world market of pulp and paper has experienced both drastic structural changes and cyclical swings in the last few years. Environmental preferences of consumers have created a pressure to change the process of pulp and paper manufacturing and the products. Environmental viewpoint has been emphasised also in legislation. Several US states impose a minimum recycled fibre content in newsprint, Japan has launched its Recycle 55 Plan, and the EC, headed by Germany, is planning to increase the recovery of waste paper (Sutton and O'Brian, 1991). In Germany a decree is considered that would require the paper producers, the importers, and the distributors to cycle up to 70 per cent of the writing and printing paper.

Because of current heavy investments in paper production, excess capacity is dominating the market situation in several grades for many years to come. Especially some pulp-based papergrades are suffering from oversupply. In this situation very low pulp prices are enhancing the competitive position of non-integrated paper producers. Oversupply is problematic in particular for countries which are heavily dependent on forest industry's exports (see Table 1 which summarizes production and exports in the world).

Table 1 **Production and exports of pulp, paper and paperboard in 1990, 1000 m.t.**

	Production		Exports	
	Pulp	Paper and paperboard	Pulp	Paper and paperboard
North America	15 356	88 431	13 387	17 263
Europe	12 957	68 057	7 982	31 581
Nordic countries	5 812	19 352	4 924	15 647
Finland	1 790	8 781	1 475	7 633

In densely populated countries increasing use of cheap waste paper becomes a competitive advantage. The problem for the Nordic producers is aggravated, as public sector subsidises the collection of paper for recycling in some countries, e.g. in the U.S.A. and Germany. The existence of the forest industry, at least with its current structure may be at stake in the Nordic countries.

In the 1980s world waste paper consumption grew by 5.2 per cent per annum, which was 2 per cent per annum higher than paper and board output. Globally waste paper accounts for approximately 34 per cent of the paper and board industry's fibre use. It is clear that the capacity of waste paper based production increases also in the 1990s faster than the total pulp, paper and paperboard

capacity. Some experts have estimated that in 1990–1995 consumption of wastepaper grows substantially, by around 37 % (Payne, 1992).

For the Nordic paper producers the shift in demand creates considerable pressures. The Nordic countries are the biggest net exporters of paper and paperboard in the world (Ekono, 1991). The amounts of paper that are consumed in these countries are small relative to the amounts produced. The situation is the same in the pulp market: The Nordic countries together account for nearly two thirds of all the woodpulp produced in Western Europe but for only 46 per cent of woodpulp consumption.

In 1989 Sweden recovered 47 % of the paper it consumed, while the corresponding figure for Norway was 27 % and for Finland 24 % (Ekono, 1991a). If the Nordic countries aim at reaching the average European level in the use of recycled fibre, they will have to import approximately 7.5 million tonnes of the raw material annually (Ekono, 1991b).

So far the Nordic producers have benefited from integration of their pulp mills with the paper mills (Figures 1 and 2). However, excluding fiber cost, the gross savings of a Scandinavian integrated mill compared to Central European non-integrated producers are estimated to be only 30–60 \$ per ton for uncoated woodfree paper grades (Kannisto and Rennel, 1991). With so small cost-saving the company is, hence, approximately indifferent between an investment in a new paper mill close to a pulp mill, and an investment in Central Europe close to the customer.

If the increasing use of waste paper is taken into account, the Scandinavian integrated mills are not more cost-efficient than their Central European competitors (Kajaste 1992). Especially, if the use of waste paper is made obligatory, the Nordic mills may become unprofitable. These disadvantages should, in principle, be reflected in wood prices. In practice, a large drop in stumpage prices can have an adverse effect on the supply of roundwood. It means that forest industry must pay more for the domestic wood or import roundwood at the high level of domestic capacity utilization.

How much does the increasing use of recycled fibres affect the price of virgin fibre and the competitive advantage of the Nordic paper? Since each successive recycling worsens the quality of a given batch of fibres, some demand will persist for virgin fibres based products in the foreseeable future even though the share of the virgin fibres is likely to diminish. Therefore the demand for virgin fibres does not cease but it must adjust to a lower level than today.

3 The model

The model we use to analyze the impacts of paper recycling has four production sectors, paper, pulp, recycled fibre and the production of all other goods. The markets are assumed to be perfectly competitive and the prices of the goods are assumed to be determined in the world market. Hence, the model is a variant of the models used in international trade theory, see e.g. Dixit and Norman (1980).

Primary inputs to the production are capital, labour, and timber. Capital and labour are mobile between sectors. We have divided the discussion in two parts depending on whether capital is internationally mobile or immobile. This section deals with the case of capital immobility, the next section with capital mobility. In addition, we have studied the case where different types of paper, with differing recycling requirements are produced. This is dealt with in section 6. In modelling we use the following strategy: We assume that initially all the four goods are produced. Then we ask what type of production structure is compatible with the competitive equilibrium when the recycling requirement is imposed.

Assume that paper is produced with a production process using virgin fibre, recycled fibre, capital, and labour as inputs. If the paper industry is competitive (which it may not be) with p as the price of paper, the equilibrium in the paper production is given by

$$p \leq c_p(p_s, p_r, w, r) \quad (1)$$

with equality if paper is produced. Here p_s denotes the price of virgin pulp, p_r the price of pulp made of recycled paper, w the wage rate, r the capital rental, and c_p is the unit cost of producing paper.

If the requirement is imposed that paper production should use pulp made of recycled paper more than would otherwise occur at prevailing prices, the unit cost of production can be derived from the program

$$\text{minimize } p_s S_p + p_r R_p + wL_p + rK_p \quad (2)$$

such that (a) $f(S_p, R_p, L_p, K_p) \geq 1$ and (b) $R/S \geq a$.

Here $f(S_p, R_p, L_p, K_p)$ is the constant returns-to-scale production function for paper. S_p denotes pulp input, R_p the recycled pulp input, L_p labour and K_p capital. If the constraint (b) is effective, the unit cost of production is

$$c_p(p_s + ap_r, w, r) \quad (3a)$$

and

$$c_p(p_s + ap_r, w, r) > c_p(p_s, p_r, w, r) \text{ holds.} \quad (3b)$$

Pulp is produced with timber, capital, and labour. Equilibrium in pulp production requires that

$$p_s \leq c_s(v, w, r) \quad (4)$$

with equality if pulp is produced. Here v denotes stumpage price and c_s is the unit cost in pulp production. Equilibrium in the production of recycled pulp is obtained when

$$p_r \leq c_r(q, w, r) \quad (5)$$

in which q denotes the cost of recycled paper and c_r is the unit cost of producing recycled pulp.

Finally, all other goods are produced with capital and labour. Using them as the numeraire, in equilibrium

$$1 \geq c(w, r) \text{ holds.} \quad (6)$$

To specify the equilibrium, further assumptions about the formation of prices must be made. In product markets we assume that the country is small, i.e. p , p_s and p_r are given parametrically by the world markets. Further we assume that the price of recycled paper is given by the world market. This assumption is not essential for most of the results and is made for analytic simplicity. Yet, it holds for the Nordic countries, which import recycled paper. All the other inputs are supplied domestically only, although this assumption is relaxed for capital later. Given these assumptions, in equilibrium the following must hold.

$$(\partial c_p / \partial w) Q_p + (\partial c_s / \partial w) Q_s + (\partial c_r / \partial w) Q_r + (\partial c / \partial w) Q = L. \quad (7a)$$

$$(\partial c_s / \partial v) Q_s = T \quad (7b)$$

$$(\partial c_p / \partial r) Q_p + (\partial c_s / \partial r) Q_s + (\partial c_r / \partial r) Q_r + (\partial c / \partial r) Q = K \quad (7c)$$

where Q_p = production of paper

Q_s = production of pulp

Q_r = production of recycled pulp

Q = production of other goods

L = supply of labour

T = supply of timber

K = supply of capital.

We assume that all inputs are domestically in fixed supply, i.e. L , T , K are exogenous.

In the equilibrium without recycling requirements we assume that all goods are produced. It is assumed that paper production is the most capital intensive industry, i.e. it has the highest capital per labour ratio. Pulp production comes next, then comes recycled paper, and finally the other goods. This seems to be the most realistic assumption. E.g. in Sweden for which data was available in all industries concerned, the capital-labour ratio was in 1988 as follows:

$$\frac{(K/L) \text{ paper}}{(K/L) \text{ industry}} = 1.9, \quad \frac{(K/L) \text{ paper}}{(K/L) \text{ metal industry}} = 2.4$$

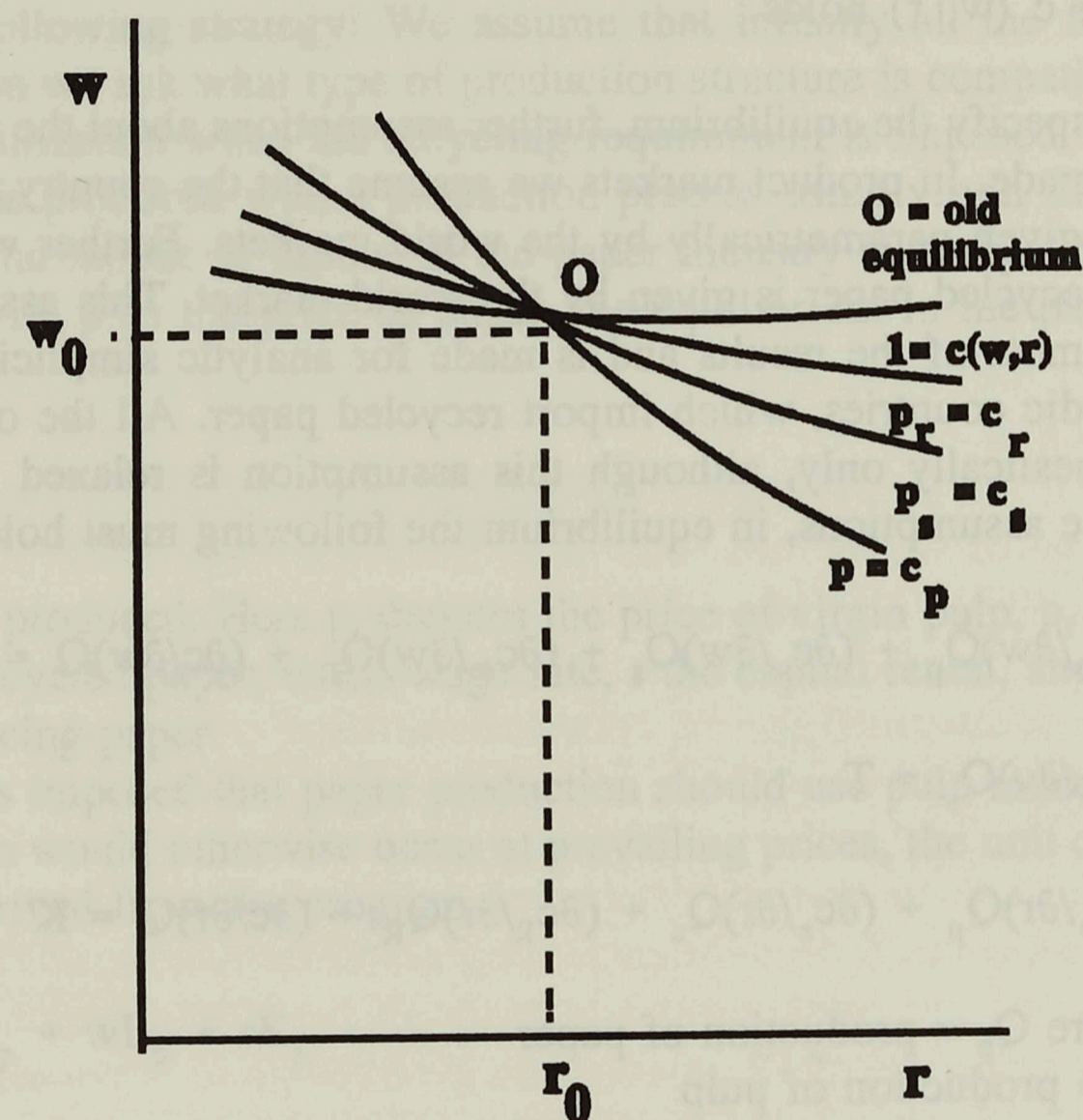
(OECD: Production database).

The equilibrium stumpage price can then be read from the equation

$$p_s = c_s(v_0, w_0, r_0) \quad (8)$$

where w_0 and r_0 are the equilibrium wage and capital rental. The equilibrium is now determined by equations (1), (3)–(8), and is depicted in Graph 1.

Graph 1



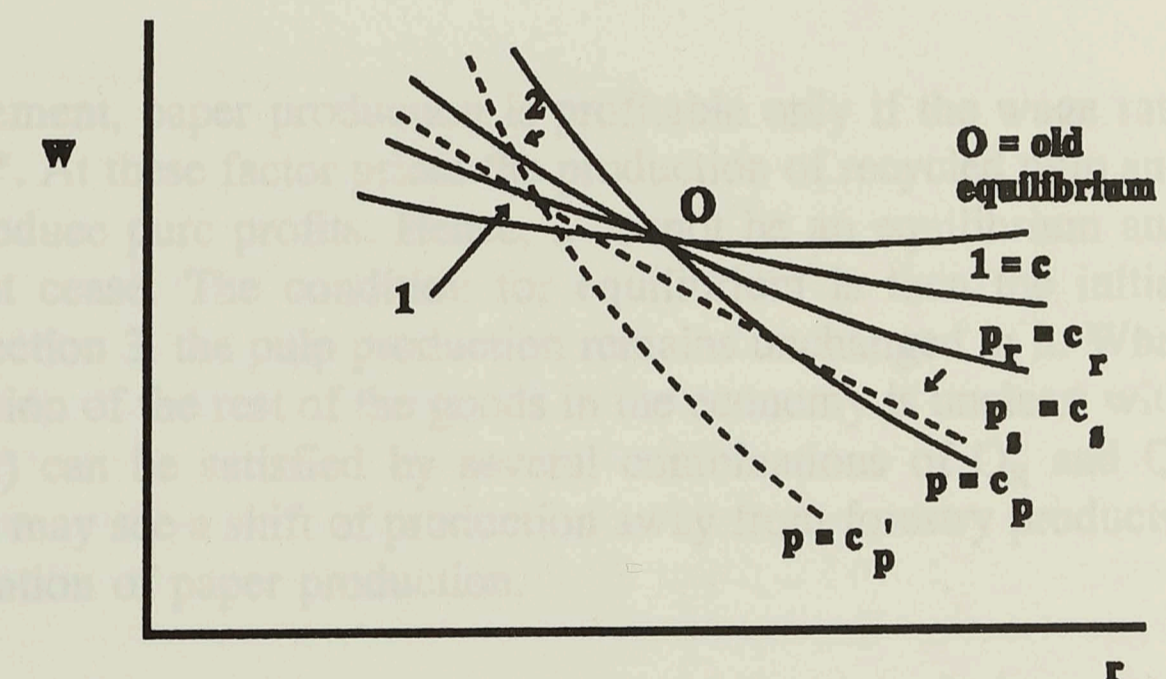
The slope of the unit cost curve measures the capital intensity of production (see Dixit and Norman (1980) for the properties of cost functions). Since we have assumed that all goods are produced in the initial equilibrium the only possible equilibrium is at point 0 where all unit cost curves cross.

4 Recycling requirement when capital is not mobile internationally

When the recycling requirement is imposed, then, in terms of Graph 1, the unit cost curve for paper production shifts to the left: wages or capital costs must decline for the paper production to remain profitable. With this shift there are two possible equilibria of interest (shown in graph 2):

If paper production is to continue, the new equilibrium is at point 1. In the equilibrium pulp is produced and the timber supply is utilized. In equilibrium 1 the economy produces paper, pulp and recycled pulp, while the production of all the other goods ceases. Real wages and stumpage prices are higher than in the initial equilibrium, while capital rental has decreased. This implies that capital intensity of production decreases and thus with (7), it is clear that paper production declines and the production of recycled pulp increases (implying increased imports of recycled paper if the country is importing it). Since the stumpage price has increased, it is natural to assume that there is some substitution away from the use of timber in pulp production. The impact is not clear, though, since w and r change simultaneously. If this is the case, then pulp production increases also. Thus, the equilibrium entails a complete specialization of the economy in the production of forest products, but increasingly in the production of various types of pulp.

Graph 2



It might seem that another possible equilibrium is at point 2, involving specialization in paper and pulp production. In it stumpage prices remain unchanged while real wage increases and capital rental declines. But there exist levels of production Q_p and Q_s such that (7) are satisfied for the factor prices at 2 only by a coincidence. One cannot rule out, however, the possibility that equilibria (to the left of point 1 along the $p = c_p'$ curve) involving specialization in paper and pulp production exist, with the stumpage price adjusting accordingly.

The other basic equilibrium in addition to 1 is that the economy remains at 0. Then naturally factor prices remain unchanged while paper production ceases. With unchanged factor prices pulp production remains also unchanged. Equations

(7) then imply that (by the Rybczynski type of argument), the production of recycled pulp increases while the production of other goods diminishes: the cessation of paper production releases relatively more of capital than labour for the production of goods other than paper, and this benefits the production of the relatively more capital intensive of the produced goods.

All in all then, and somewhat paradoxically, the imposition of the recycling requirement leads the economy to specialize more in forestry products than it did before. The structure of production switches towards the production of various types of pulp. This result, however, depends crucially on the assumption that the production of goods other than paper and pulp are less capital intensive than the production of pulp and paper. Were this not the case, e.g., were the production of pulp less capital intensive (but paper still the most capital intensive) then we would see a specialization away from the production of forestry products. This alternative does not seem to be realistic, however.

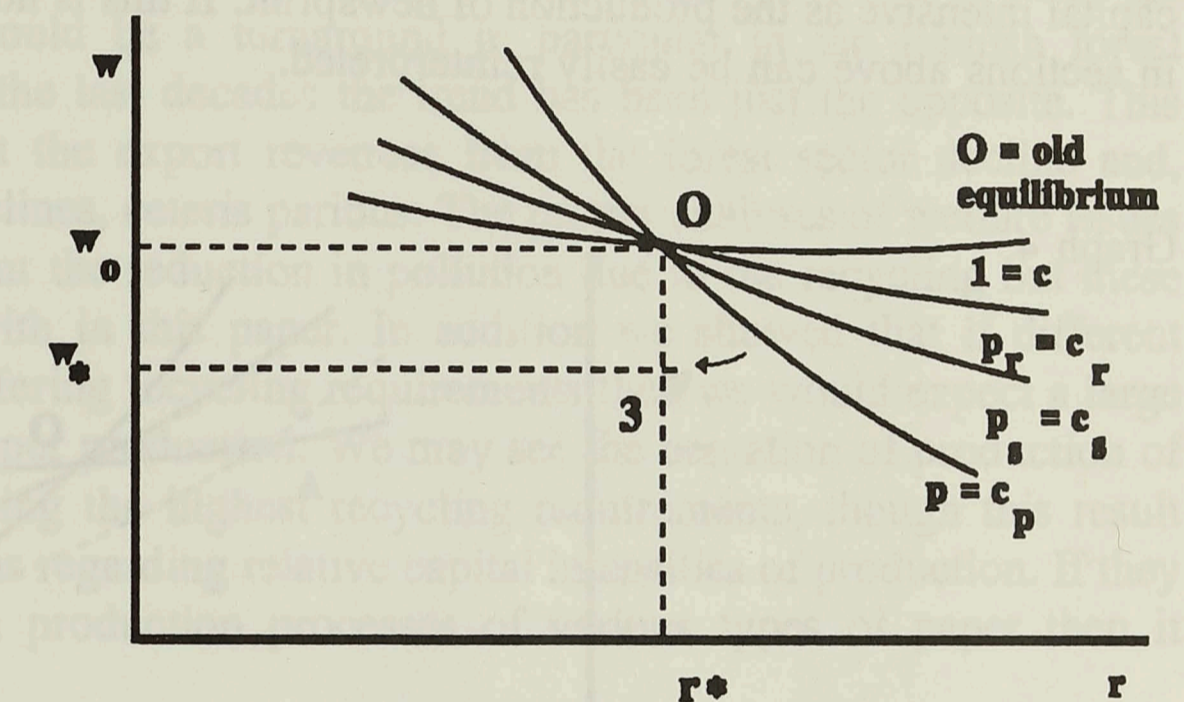
5 Recycling requirements when capital is internationally mobile

When capital is freely mobile, then it can be assumed that the capital rental is fixed by the world markets, i.e.

$$r = r^* = \text{the world market capital rental.} \quad (9)$$

With this the capital market equilibrium (7c) is redundant. The equilibria with recycling can be analyzed with the help of Graph 3.

Graph 3

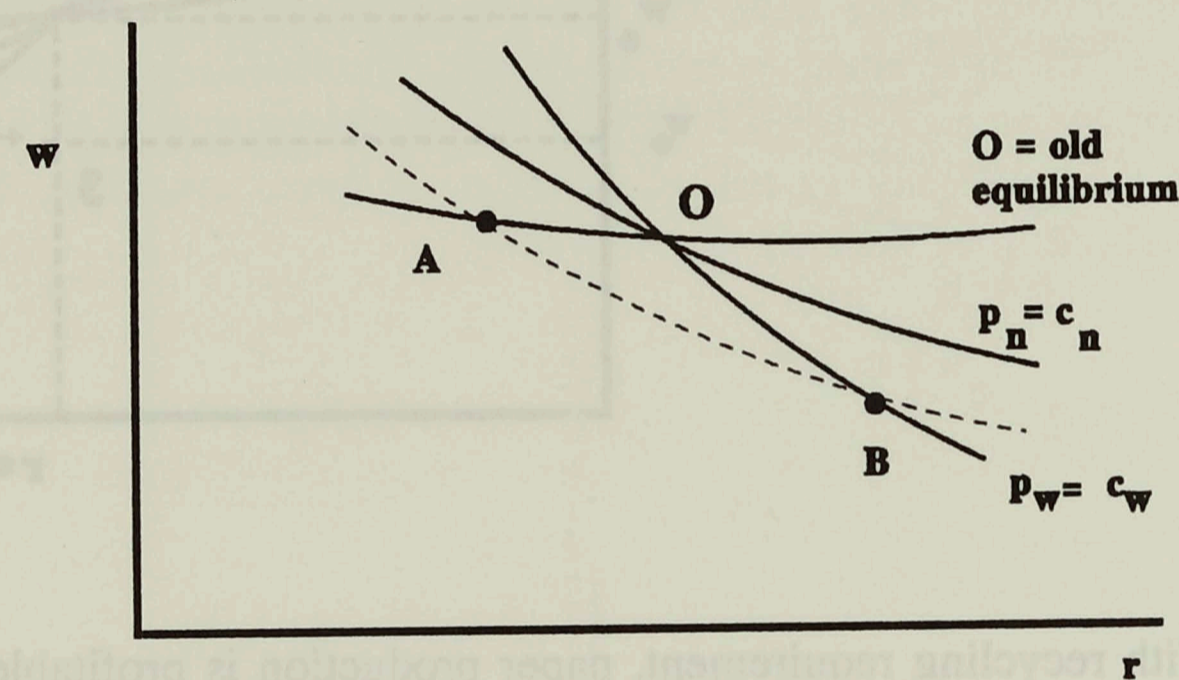


With recycling requirement, paper production is profitable only if the wage rate declines from w_0 to w^* . At these factor prices the production of recycled pulp and other goods would produce pure profits. Hence, 3 cannot be an equilibrium and paper production must cease. The condition for equilibrium is then the initial equilibrium 0. As in section 3, the pulp production remains unchanged in it. What happens to the production of the rest of the goods in the economy is unclear: with Q_s given by (7b), (7a) can be satisfied by several combinations of Q_R and Q . Hence, in this case we may see a shift of production away from forestry products, in addition to the cessation of paper production.

6 Recycling with differing paper qualities and recycling requirements

Finally, one should study the effects of recycling when paper is produced in different qualities and when the different qualities have differing recycling requirements. Currently newsprint and tissue paper face stricter demands for use of recycled pulp than e.g. woodfree paper. To see the implications of this consider the case of three products: woodfree paper products, newsprint and all other products. The initial equilibrium is given by point O in graph 4. It is the intersection of the curve $p_w = c_w$, the equilibrium for woodfree paper production, $p_n = c_n$, the equilibrium for newsprint production, and $1 = c$, the equilibrium for other products. We assume that the production for the woodfree paper is at least as capital intensive as the production of newsprint. If this is not the case, the analysis in sections above can be easily reinterpreted.

Graph 4



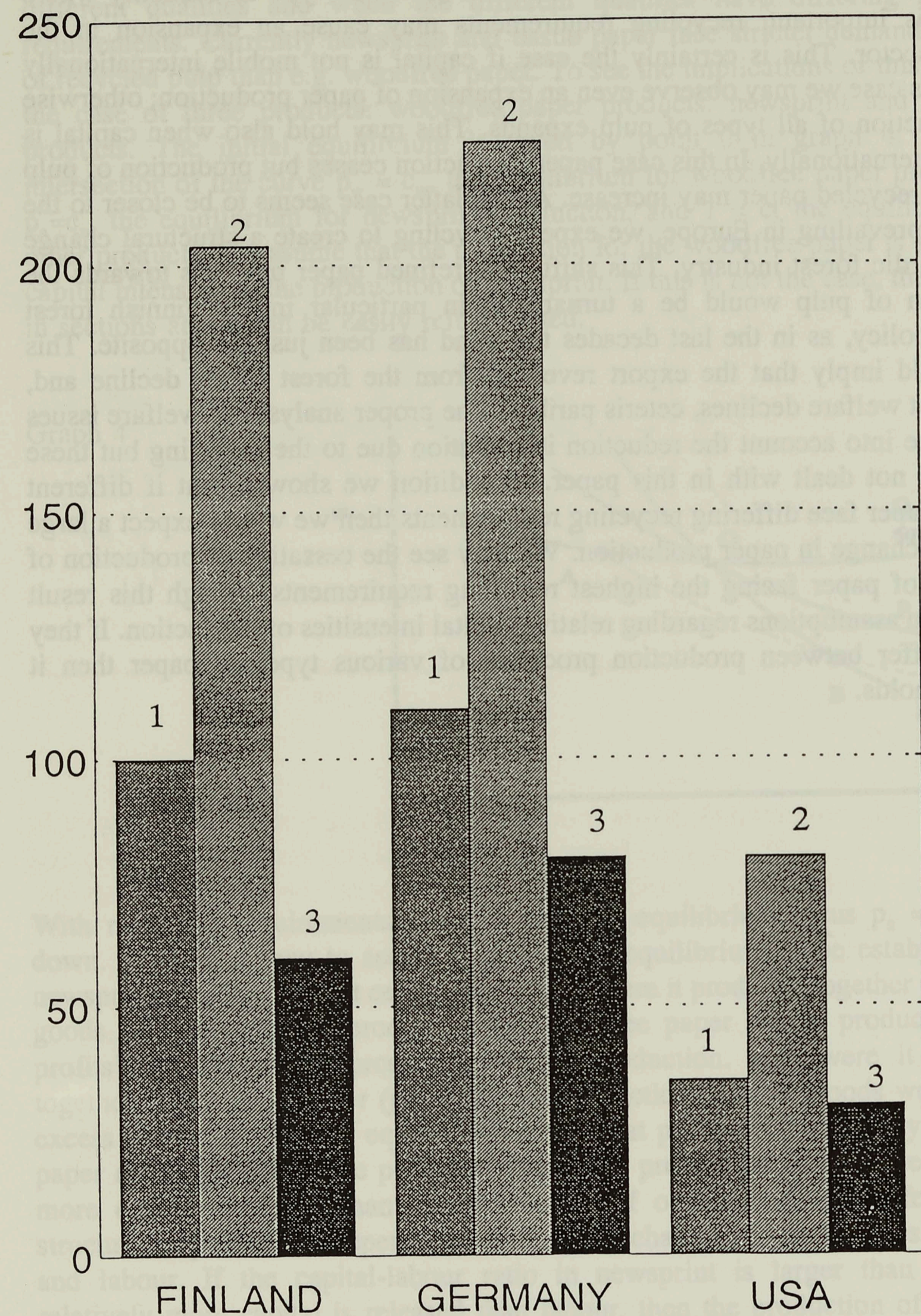
With recycling requirements on newsprint the equilibrium locus $p_n = c_n$ shifts down. Then it is easy to see that in the new equilibrium to be established the newsprint production must cease completely. Were it produced together with other goods (at point A) the production of woodfree paper would produce "excess profits" pulling all resources towards its production. And were it produced together with coated paper (point B), the production of other goods would show excess profits. Hence, the equilibrium remains at point O but now only woodfree paper and other goods are produced. Since the production of woodfree paper is more capital intensive than the production of other goods the effect on the structure of production depends on the relative changes in the supplies of capital and labour. If the capital-labour ratio in newsprint is larger than unity i.e. relatively more capital is released than labour, then the production of woodfree paper expands relatively more than the production of woodfree goods and vice versa if the capital labour ratio in newsprint production is less than unity.

On the basis of section 4 above, it is clear that were the assumption about capital intensities changed, i.e. were we to assume that woodfree production is (strictly) less capital intensive than newsprint production the results may change. In particular it may happen that in the new equilibrium the production of both types of paper continues and the production of other goods ceases.

7 Summary and conclusion

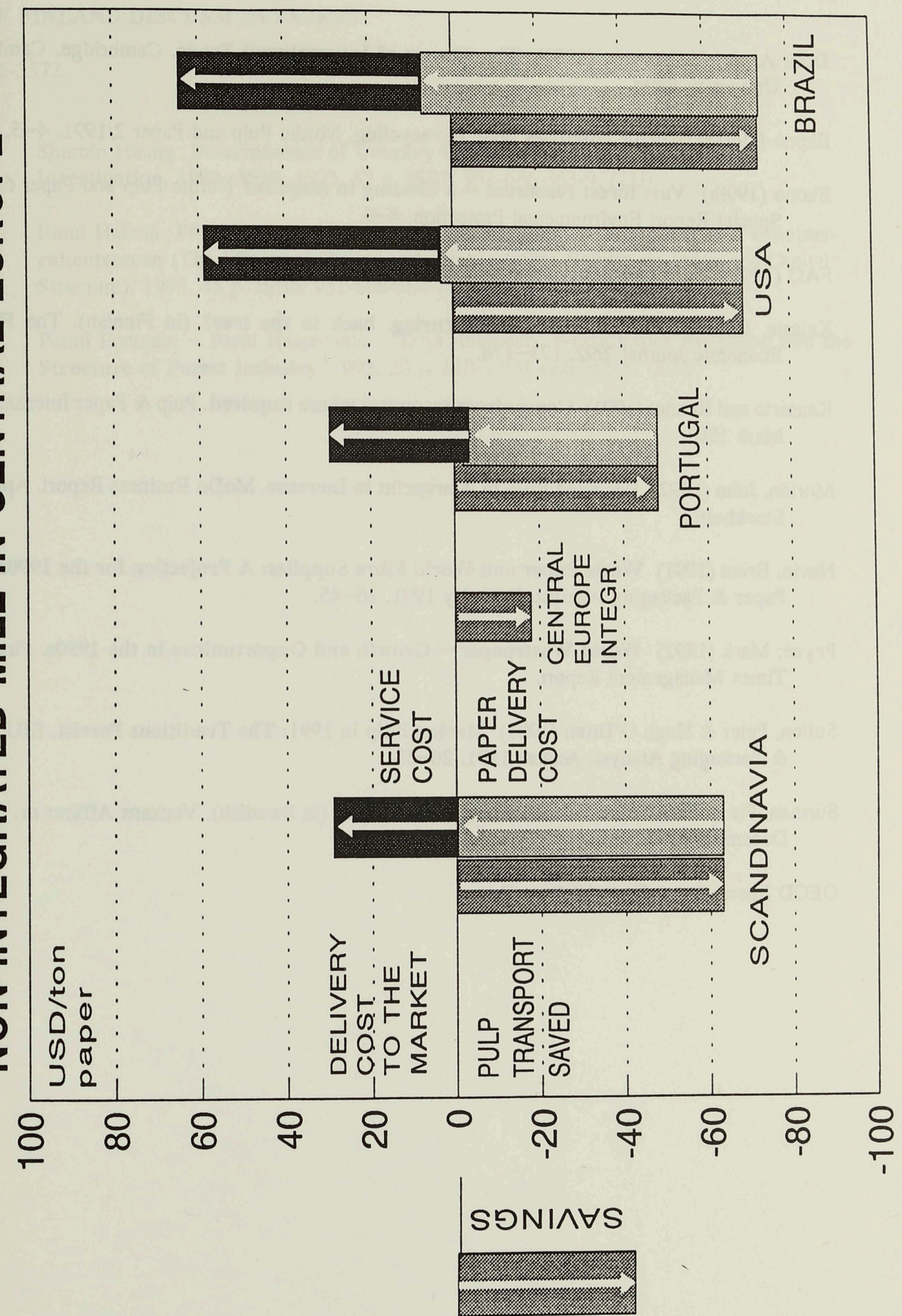
The increasing use of recycled fibres in paper production may have large effects on the forest industry and on the structure of aggregate production. One of the most surprising results was reached is that in a Nordic type of economy where forestry is important, recycling requirements may cause an expansion in the forestry sector. This is certainly the case if capital is not mobile internationally and in this case we may observe even an expansion of paper production; otherwise the production of all types of pulp expands. This may hold also when capital is mobile internationally. In this case paper production ceases but production of pulp based on recycled paper may increase. As the latter case seems to be closer to the situation prevailing in Europe, we expect recycling to create a structural change in the Nordic forest industry. This shift from refined paper products towards the production of pulp would be a turnaround in particular in the Finnish forest industry policy, as in the last decades the trend has been just the opposite. This shift would imply that the export revenues from the forest sector decline and, hence, that welfare declines, *ceteris paribus*. The proper analyses of welfare issues would take into account the reduction in pollution due to the recycling but these issues are not dealt with in this paper. In addition we showed that if different types of paper face differing recycling requirements then we would expect a large structural change in paper production. We may see the cessation of production of the types of paper facing the highest recycling requirements, though this result depends on assumptions regarding relative capital intensities of production. If they do not differ between production processes of various types of paper then it certainly holds.

THE PRICE OF FIBRES INDEX
(Finland, mech. pulp = 100) (Source Jaakko Pöyry)



- 1 Mechanical pulp
- 2 Chemical pulp
- 3 Recycled fibres

DELIVERY COSTS TO THE MARKET COMPARED TO NON-INTEGRATED MILL IN CENTRAL EUROPE



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