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# **Who Benefits from Quality Labelling? Segregation Costs, International Trade and Producer Outcomes**

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**Segregation Costs, International Trade and Producer Outcomes**

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## **Abstract**

This paper analyses the impact of quality based labelling on product prices, factor allocation and the resulting effects on producers within the context of an international trading system. A general equilibrium model, calibrated to 1998 data, describes United States and European Union labelling regimes for genetically modified agricultural products. The results indicate that the labelling choice of trade partners have large distributive impacts within national economies, as well as across countries and highlight the importance of using general equilibrium framework to understand the system wide impacts of labelling policies that differentiate products based upon quality characteristics. These results are essential for policy makers seeking to understand the global and domestic economic implications of environmental labelling systems.

**Keywords:** Labelling, international trade, political economy, general equilibrium, biotechnology.

## **Who Benefits from Quality Labelling?**

### **Segregation Costs, International Trade and Producer Outcomes**

#### **1. Introduction**

Labelling regulations have been proposed as potential solutions to many international environmental policy conflicts. Advocates of labelling argue that consumers have the right to know about the environmental quality impacts of their consumption choices even when these impacts occur outside the borders of their domestic home. Armed with this information consumers can consider environmental consequences of their consumption choices, and thus a market for differentiated goods may develop in which higher quality goods (for example, environmentally friendly or GM-free) are sold at higher prices than low quality goods. Examples of these price premiums occur in different types of quality-differentiated markets. For example, in the late 1980's dolphin-safe tuna was sold for \$400/ton more than tuna caught using fishing techniques that threatened dolphins [15]. In the US, in 1999 price premiums for non-GM soybeans were about 2-3 percent of the price of GM soybeans[11]. Consumer willingness to pay for perceived high quality characteristics creates the opportunity for product differentiation, however a complex system of economic interactions will determine the size of the price premium and the distributive impacts of product differentiation.

The relative prices will depend upon a variety of economic conditions including consumer perception of the value of quality characteristics, who bears the costs of segregating products, and, for goods traded on the international market, whether trading partners have also adopted labelling regulations. Furthermore, the relative prices and price premiums determine which producers capture the benefits

from price differentials and which producers suffer from decreases in final good prices or increases in intermediate good prices. The effects of segregation are felt broadly through the economy regardless of which sector pays for the segregation initially.

A diverse literature has arisen relating to the effects of labelling regimes on prices. Much of the research focuses on the consumers' willingness to pay for additional quality (see for example 23, 17, and 2). To a lesser extent the literature also explores the incentives for producers to adopt labelling in order to reap the benefits of price premiums (see for example 19) and the potentially perverse outcomes on environmental condition associated with eco-labelling regimes [16, 20]. In most cases, however, the research has ignored the general equilibrium economic impacts of resource re-allocation generated by labelling requirements and thus does not explore the distributive consequences of these policies.

When differentiated products are traded on the international market the policy choices of trading partners will influence the relative prices of the differentiated products. Nimon and Beghin provide a stylized analysis of the impact of eco-labels in the international trade context focusing on the dynamic of North-South trade [18]. They find that there are strategic incentives for countries to adopt eco-labels in order to differentiate the quality attributes of their products and reach target consumer markets. While Nimon and Beghin highlight the potential strategic nature of labelling policy decisions within the international trading system, their analysis ignores the role of mobile and fixed factors in determining the distribution of impacts among producers.

The goal of this paper is to analyse the impact of quality based labelling on product prices, factor allocation and the resulting effects on producers within the context of an international trading system. The analysis is based upon a model,

developed in detail in Jackson (2002), that was initially applied to labelling regimes for the genetically modified (GM) content of agricultural products [13]. The general equilibrium model, calibrated to 1998 data, is used to examine trade between the EU and US; two markets that differ dramatically in attitudes towards and production of GM products. While the model does not explicitly examine eco-labelling regimes, by highlighting the importance of quality attributes and international regulatory environment, the analysis provides insights into labelling policies that differentiate products based upon the environmental impacts of their production.

This paper will examine how regulatory frameworks and costs associated with segregation interact to influence relative prices.<sup>1</sup> The paper focuses on the impact of mandated labelling policies rather than upon the use of labels as a strategic choice by producers to access new markets. This focus leads to the adoption of a model in which producers are perfectly competitive. While this assumption probably does not fully characterize the dynamics of eco-labelling, the analysis described below provides a first step in understanding the impacts on prices of labelling systems within the international trade context.

The paper proceeds as follows. Section 2 defines the analytical model of international trade in products differentiated by GM. Next, section 3 describes results, highlighting the impact of segregation costs and regulatory regimes on prices premiums and thus on the distribution of producer benefits within the two economies. The results represent a stylised version of global economy and suggest an alternative

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<sup>1</sup> The paper focuses on the current generation of GM crops – those that alter the productive characteristics of commodity crops. The next generation of GM crops will include products that offer explicit benefits to consumer benefits. For example, they may include health-improving characteristics or they may have longer shelf life. The analysis for these types of crops will differ. The direction of the price premiums between GM and non-GM crops will be reversed because consumers will be willing to pay extra to consume the GM products with enhanced consumption characteristics.

method for analysing the global impacts of labelling to identify quality characteristics. The concluding section, Section 4 discusses the policy implications of the research results and provides suggestions for further research.

## **2. A Model of Quality Differentiated Goods**

The model described below can describe an economy with labelling and an economy without labelling and is based upon a model developed in detail in Jackson 2002 [13]. Two critical features of the model capture the unique system of economic interactions related to GM labelling. First, primary producers use additional labour when labelling is required. Second, the model assumes that consumers care about quality attributes associated with GM products. Appendix 1 provides details of model specification.

### *Production*

Production is structured as a simple Viner-Ricardo economy with seven sectors. Each sector uses labor and a fixed factor, hence there are eight factors of production: labor and seven others corresponding to the seven sectors in the economy. Labour moves freely between sectors and sector labour demand is defined for sector. Each sector also uses one fixed factor which might be land or other sector specific capital. The fixed factors are assumed to be exogenously determined, while labour distribution is endogenous to the model.

Production in each economy is split between industrial (sector 1), three primary agricultural production (sectors 2, 3, and 6) and three marketed agricultural production (sectors 4, 5, and 7). The three types of marketed agricultural production represent traditional corn and soy products (C/S), GM C/S products, and all non-C/S



agricultural production.<sup>2</sup> The marketed agricultural products use primary agricultural products as inputs. Specifically, good 2 is an intermediate input in the production of good 4, good 3 is an intermediate input in the production of good 5 and good 6 is an intermediate input in the production of good 7. All production functions are assumed to be Cobb-Douglas.

The analytical structure of the model supports the definition of sectoral GDP functions, which in turn can be used to describe returns to fixed factors. Returns to fixed factors can be used a proxy for rents accrued to each sector and may be written

$$R_j = R_j(w, p_j) \quad \text{for } j=1,2,3 \text{ and } 6 \quad (1)$$

$$R_j = R_j(w, p_{mj}, p_j) \quad \text{for } j=4,5, \text{ and } 7 \quad (2)$$

When an economy is not segregating GM from non-GM products, farmers sell primary agricultural products mixed together to the agricultural marketers. The agricultural marketers in turn sell a final mixed product for a single price. In contrast when a country requires labelling of GM products, primary agricultural producers use labour to segregate the traditional from the GM agricultural varieties. The assumption that segregation activities occur in the primary agricultural production sectors reflects the costs to the economy of segregation and can be thought of as the effort necessary to preserve product identity in the marketing chain. Agricultural marketers purchase segregated inputs and produce a GM and a non-GM final good. These differentiated products are then sold to the agricultural marketers for different prices.

### *Consumption*

In the case of GM crops, labels can either identify products whose GM content surpasses a specified level, or they can identify products whose GM content falls

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<sup>2</sup> Corn and soy are described separately from other agricultural products because these products were

below a specified level. Drawing on Lancaster's classic treatment of consumption choices based upon characteristics rather than goods agricultural products have two characteristics that are important to consumers: taste and "quality." [14] Taste can be thought of as the classic consumption good characteristic. The taste of GM and traditional agricultural products are identical and consumers gain more utility by consuming more. Quality is directly related to the GM content of foods. As GM content increases, quality decreases. Hence, including quality in the utility function captures consumers' ambivalence towards GM foods. (Or, in the context of eco-labels this structure allows consumers to express their preferences for goods that have been produced using environmentally friendly production methods.) With labelling, consumers have complete information about the GM content of agricultural products and have access to pure traditional crops. They can avoid consuming GM crops or if they are unconcerned about GM content, they can choose the cheaper GM product.

Consumers choose a vector of demand goods to maximize utility. Consumers in each country are assumed to have quasi-homothetic preferences and thus may differ in the amount of GM content they consume [5]. Arguments of the utility functions are the vector of demand for final goods ( $x$ ) and quality ( $Q$ ). Quality affects utility through the consumption of final goods, and in the labelling case. Recall that sector 7 is marketed GM agricultural products. Then, quality may be represented as

$$Q = Q(x_7)$$

In contrast, in the non-labelling case, quality may be represented as

$$Q = Q(x_m)$$

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the first widely adopted GM varieties. For example, in 1998 the more than 40 percent of total US soy acreage and nearly 20% of corn acreage were planted in GM varieties [1]

where  $x_m$  represents demand for the non-labelled mixture of marketed GM and non-GM product ( $x_m = x_4 + x_7$ ). Both quality functions are continuously decreasing, linear functions of final goods. Utility may be written,  $U_i = U_i(x, Q)$  where  $U_i(x, Q)$  is strictly increasing in all arguments.

### *Trade Labelling Equilibria*

Three types of trade equilibria can be calculated from the above model. These are : neither country labelling, both countries labelling and the case where countries adopt different labelling approaches. With the calibration to data, this last equilibrium can describe two different cases – one with the US labelling and the EU not labelling and one with the EU labelling and the US not labelling. The equilibrium conditions define all prices, labour wages, and returns to fixed factors.<sup>3</sup> (See [13] for a complete definition of equilibrium conditions.)

At an equilibrium, the price premium is the difference between the price for the final high quality and low quality good. While this model does not lead to closed form solutions for this function, the simulations reported below demonstrate the effects of exogenous segregation costs and trading relationships on this price premium.

### *The Data*

The model is calibrated to 1998 US, EU and World data from a variety of sources.<sup>4</sup> Production elasticities are assumed to be the same within both countries.

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<sup>3</sup> In the world market when countries are pursuing mixed labelling strategies (ie. One country labelling while the other country mixes traditional and GM products) the mixed product is treated as a GM product. The mixed product produced by the non-labelling country is sold for the same final price on the world market as the pure GM product produced by the segregating country.

<sup>4</sup> Data was collected from the following sources: 3,4, 6,7, 8,9, 10, 12, 21, and 22. Data is calculated for the European Union as represented by 15 members: France, Germany, Italy, the Netherlands, Belgium, Luxemburg, United Kingdom, Ireland, Denmark, Spain, Portugal, Greece, Austria, Finland and Sweden.

Demand elasticities are the same across physical products but differ in relation to quality preferences. In the simulations the US consumer is assumed not to place any value on the quality characteristics ( $\epsilon_{p_{US}}=0$ ). The EU, on the other hand, gains utility from increased quality ( $0 < \epsilon_{p_{EU}} < \epsilon_m$ ). Because data on quality preferences did not exist at the time of this modelling exercise, this parameter ( $\epsilon_{p_{EU}}$ ) is synthesized and sensitivity analyses are conducted to ensure that the chosen parameter is reasonable. These demand assumptions lead to a specialization in consumption where the US consumers consume only the relatively cheaper GM products if given the choice, and the EU consumers choose the more expensive non-GM products.

All elasticities are the same as in the non-segregated model but an additional elasticity is used to calculate the joint-output function that is used to capture the segregation process for GM and non-GM agricultural production. The model is solved for a range of costs in order to examine the impact of costs and regulatory structure. In this model the cost parameter ( $s$ ), influences all final and intermediate good prices as well as wages.

### **3. Results**

The following analysis focuses on the effects of regulatory frameworks and the costs of segregation on prices of segregated goods and returns to fixed factors at the industry level. While the model assumes that the costs of segregation are born initially by primary agricultural producers, due to the general equilibrium nature of the model, the effects of these costs can be traced through the economy to other sectors. The analysis focuses on presenting the effects on relative prices of GM and non-GM crops with the aim of inferring effects on economic groups of changes in costs. The

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<sup>4</sup> Labor elasticity ( $\alpha$ ) for sector 1 in both countries is .67. Labor elasticity ( $\beta$ ) for sectors 2, 3, and 6 in both countries is .35. Labor elasticity ( $\delta_1$ ) for sectors 4, 5, and 7 in both countries is .26. Intermediate

determinants of prices are suppressed in the following discussion to simplify notation. In the following discussion GM crops are referred to as low quality and non-GM crops as high quality reflecting the assumptions about consumer preferences in the EU.

### *Price Premia*

Figure 1 illustrates how the price premiums change with respect to increasing costs in the three labelling scenarios: US labelling, EU labelling and both labelling. Two features are immediately evident from this figure. First, the size of the price premiums varies substantially across the different labelling regimes. The largest price premium is obtained when only the US is labelling, the lowest when both countries are labelling.

Second, the relationship of price premiums with the cost parameter varies among the labelling regimes. When only the US is labelling, price premiums decline monotonically with respect to increasing  $s$ . When only the EU is labelling price premiums exhibit a concave relationship with  $s$ . Finally when both countries segregate the price premium increases monotonically as  $s$  increases. The relationship between high quality and low quality product prices and costs underlie these results for the price premiums (See table I). The following analysis describes variations in the price-cost relationships among the three labelling scenarios.

#### Case 1: US Labelling

When only the US is segregating, prices of both high quality and low quality final goods decrease with increasing costs (Table I).

$$\frac{dp_j}{ds} < 0 \text{ for } j = 4 \text{ and } 7$$

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input elasticity ( $\delta_2$ ) for sectors 4, 5, and 7 in both countries is .26.

Given the decreases in premiums over the range of costs examined, this result indicates that the price for high quality good ( $p_4$ ) is more sensitive to changes in costs than the price for low quality products ( $p_7$ ).

To understand this result, first consider the cost impacts of the initial adoption of labelling on the high quality product. In the general equilibrium framework, adding segregation costs alters the distribution of labour across sectors. In the world market, the high quality good is entirely produced by the US and only demanded by the EU consumer. Wages increase in the US where US labour moves out of the manufacturing and final high quality sectors and into intermediate good production and the production of final low quality products. The contracting effect of decreased labour to final high quality production is compensated for by the decrease in intermediate good prices due to the expansion of the intermediate goods market. Wage decreases in the EU causes a decrease in income, however the demand-side effects are smaller than the supply effects. Hence the total effect of increased US segregation costs on the world market for high quality good is lower equilibrium price ( $p_4$ ) and a higher market demand for high quality products relative to the non-labelling case.

For the low quality product the equilibrium effects are complicated by the fact that the world market contains product from both the US and the EU. As segregation costs (in the US) increase, EU labour moves out of agriculture into manufacturing. With this labour reallocation, agricultural production within the EU contracts. At the same time, in the US production of low quality good is expanding due primarily to decreased prices of low quality intermediate goods. Since the EU produces low quality goods at a much smaller scale than the US, the expansion in the US dominates the world market and the world market price for low quality final good ( $p_7$ ) decreases.

## Case 2: EU Labelling

In contrast to the previous case, when only the EU labels the relationship of final good prices to costs differs between goods (Table I). As costs increase,  $p_7$  decreases monotonically.

$$\frac{dp_7}{ds} < 0 \text{ for all } s$$

In the US the prices for high quality and low quality products are the same and that the mixed marketed agricultural product is treated as a low quality product on the world market. Since both decreasing primary agricultural product prices and increasing wages influence low quality product supply in the US, it is clear from these results that the decreases in intermediate prices dominate the effect of increasing wages leading to an expansion in supply.

In this case the price premium exhibits a convex shape over the range of costs examined. Since,  $p_7$  decreases monotonically as costs increase, the convexity of the price premium curve must be driven by the price for high quality products ( $p_4$ ).

Simulations reveal that in the EU

$$\frac{dp_4}{ds} > 0 \text{ for low } s$$

$$\frac{dp_4}{ds} < 0 \text{ for high } s$$

For low costs, the price premium increases, since  $p_4$  is increasing over this range of  $s$  and  $p_7$  is decreasing. At higher cost levels the price premium decreases because for each incremental increase in costs  $p_4$  decreases more than  $p_7$ .

Why do prices behave this way? The joint production function describes segregation by the EU primary agricultural producers. In this calibrated model the EU low quality agricultural production is only a small fraction of the total primary

agricultural production. The primary production sector attracts an increasing amount of total labour as segregation costs increase. Production requires labour for segregation activities and productive activities. Totally differentiating the labor demand in the segregating sector we see that

$$\frac{dv_{Lseg}}{ds} = \frac{dv_{LS}}{ds} - \frac{dv_{L2}}{ds} - \frac{dv_{L6}}{ds}$$

where  $v_{Lseg}$  represents the labour allocated to segregation rather the production activities. At low costs ( $s < s^*$ ) simulations reveal

$$\frac{dv_{LS}}{ds} > \frac{dv_{L2}}{ds} > 0 \text{ and } \frac{dv_{Lseg}}{ds} > 0$$

In contrast for high  $s$  ( $s > s^*$ )

$$\frac{dv_{L2}}{ds} > \frac{dv_{LS}}{ds} > 0 \text{ and } \frac{dv_{Lseg}}{ds} < 0$$

The effect of  $\frac{dv_{L6}}{ds}$  on these relationships is negligible due to the small scale of production of low quality crops.

### Case 3: Both Countries Labelling

When both countries segregate prices for high and low quality intermediates and final goods increase at low costs and decrease at higher costs (Table I). Nevertheless, the price premium between final goods increases over the range of costs examined. This implies that at low costs, the price of the high quality good is increasing more for each incremental change in costs than the low quality good. At higher costs, this relationship is reversed – the price for low quality good is decreasing more for each incremental change in costs than the price for the high quality good.

$$\frac{dp_4}{ds} > \frac{dp_7}{ds} \text{ for low } s$$



$$\frac{dp_4}{ds} < \frac{dp_7}{ds} \text{ for high } s$$

Prices of intermediate goods, except for the price for high quality goods in the EU ( $p_{62}$ ), also have a similar relationship with  $s$ .

Prices of intermediate goods in the US are closer to each other than prices of intermediate goods in the EU. Also the prices for low quality intermediates are higher in the US than in the EU while the prices for high quality intermediates are higher in the EU. These price differences reflect the input demand of agricultural marketers for intermediate inputs. In the EU, low quality production represents only a small share of the total agricultural production.

Table II highlights the expansion and contraction effects of costs on the various sectors of the economy. At low costs, as costs increase nearly all the sectors related to labelling contract, while at high costs increasing costs lead to expansion of these sectors.<sup>5</sup> As in the previous case these effects are related to the distribution of labour among segregation and production activities.

### *Sectoral Returns to Fixed Factors*

This section describes three types of distributive impacts: the distribution of sectoral fixed factor returns between GM and non-GM goods, between primary and marketing sectors, and between the same sectors in different economies. As described above, the returns to fixed factors change depending upon which labelling scenario is in place and the costs of segregation. These characteristics alter economic relationships differently. The labelling scenario creates an abrupt change in product classification and hence in demand effects. After a country has committed to a labelling strategy the costs affect returns incrementally. In all simulations, except one,

the level of segregation costs does not affect whether a sector benefits or loses from a labelling choice as compared to the case where neither country is labelling.

By decomposing returns to fixed factors in relation to costs it is possible to identify which sectors benefit from increased costs and which experience decreasing returns. Totally differentiation of equations 1 and 2 indicates the effect of marginal changes in the cost parameter on fixed factor rentals,

$$\frac{dR_j}{ds} = \frac{\partial R_j}{\partial w} \frac{dw}{ds} + \frac{\partial R_j}{\partial p_j} \frac{dp_j}{ds} \text{ for } j=1, 2, 3, \text{ and } 6$$

$$\frac{dR_j}{ds} = \frac{\partial R_j}{\partial w} \frac{dw}{ds} + \frac{\partial R_j}{\partial p_{mj}} \frac{dp_{mj}}{ds} + \frac{\partial R_j}{\partial p_j} \frac{dp_j}{ds} \text{ for } j=4,5, \text{ and } 7$$

The effect of changes in wages and prices on returns to fixed factors can also be determined analytically as mentioned in section 2. In all sectors increases in final agricultural good prices lead to increased sectoral returns. Increases in final good prices have positive impacts on intermediate good prices. Since intermediate goods are inputs in the final good sector and outputs in the intermediate good sector, the price effect of intermediate good prices is negative on the returns to final good sectors and positive on the returns to intermediate good sectors.

Tables III, IV and V represent the relative returns to the fixed factors in each sector in the US and the EU under the three different labelling scenarios relative to the case in which neither country labels. These relative returns are reported for low values of  $s$  ( $s=.01$ ) and high values of  $s$  ( $s=.2$ ). In both countries, the sectors that benefit from labelling differ depending upon the labelling choices of trading partners.

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<sup>5</sup> The exception is the GM intermediate production in the EU which is a relatively small user of labor and therefore does not play a large role in determining the general equilibrium outcome.

### Case 1: US segregating (Table III)

When the US is labelling and the EU is not labelling, the high quality primary and marketing sectors (sectors 2 and 4) in the US benefit substantially as compared to the case when neither country labels. These returns are driven by the large price increase for high quality goods in this scenario. The sectors associated with low quality product production (sectors 6 and 7) experience lower fixed factor returns than in the case when neither country is labelling.

In the EU all sectors associated with the labelling (2,4,6 and 7) experience lower fixed factor returns than in the case where neither country labels. Recall that in the EU high and low quality goods are sold for the same price because producers are not segregating these products. Therefore the sectors associated with production of high quality goods do not benefit from higher prices in the same way that they do in the US segregated economy.

As costs increase fixed factor returns to the US high quality production sectors and the low quality intermediate production sector decrease, while returns to fixed factors in production of the final low quality good increase as costs increase. (The returns in this case are still less than the returns in the case when neither country is labelling.) At higher costs more of the cost burden is shifted to the producers of the high quality. Although the EU is not incurring the direct segregation costs, all EU sectors associated with experience decreasing returns to fixed factors with increasing costs.

Decomposing these returns by the effect of costs on the fixed factor returns in the low quality good sector indicates that intermediate price effects on fixed factor returns dominate the final good and wage effects.

$$\frac{dR_7}{ds} = \frac{\partial R_7}{\partial w} \frac{dw}{ds} + \frac{\partial R_7}{\partial p_6} \frac{dp_6}{ds} + \frac{\partial R_7}{\partial p_7} \frac{dp_7}{ds} \quad (3)$$

Simulations show that  $\frac{dw}{ds} > 0$ ,  $\frac{dp_6}{ds} < 0$ , and  $\frac{dp_7}{ds} < 0$ . From assumptions on production functions,  $\frac{\partial R_7}{\partial w} < 0$ ,  $\frac{\partial R_7}{\partial p_6} < 0$ , and  $\frac{\partial R_7}{\partial p_7} > 0$ . Therefore, the wage effect is negative, the intermediate price effect is positive and the final price effect is negative. However according to simulations the left hand side of this equation is positive ( $\frac{dR_7}{ds} > 0$ ) therefore the effect of costs on sectoral returns to the low quality good sector

must be dominated by the intermediate price effect. In contrast, in the EU, simulations indicate that  $\frac{dw^{EU}}{ds} < 0$ ,  $\frac{dp_6}{ds} < 0$ ,  $\frac{dp_7}{ds} < 0$ , and  $\frac{dR_7}{ds} < 0$ . Therefore, in the case of the EU, the returns to sector 7 are dominated by the final good price effects.

#### Case 2: EU segregating (Table IV).

The returns to intermediate and final high quality goods sectors in the EU and to final low quality goods sector (sectors 2, 4, and 7) increase relative to the no labelling case. In contrast to the results when only the US labels, the final low quality good sector in the labelling economy (in this case the EU) obtains positive benefits from labelling. The price for intermediate low quality goods drops, while the price of intermediate high quality goods increase relative to the no labelling scenario.

Again focusing on the returns to final low quality goods we can determine the effect of costs on relative returns after the EU has committed to labelling. In this case, simulations show that in the EU  $\frac{dw}{ds} > 0$ ,  $\frac{dp_6}{ds} < 0$ , and  $\frac{dp_7}{ds} < 0$ . From assumptions

on production functions,  $\frac{\partial R_7}{\partial w} < 0$ ,  $\frac{\partial R_7}{\partial p_6} < 0$ , and  $\frac{\partial R_7}{\partial p_7} > 0$ . Therefore, the wage effect is negative, the intermediate price effect is positive and the final price effect is negative. Again according to simulation results, the left hand side of this equation is positive ( $\frac{dR_7}{ds} > 0$ ) therefore the cost effect on sectoral returns to the low quality good sector must be dominated by the intermediate price effect. The results for the low quality good sector in the US are similar to the EU low quality final good sector in the previous scenario.

Finally simulations of this scenario indicate that the returns to fixed factors in the high quality good sectors (2 and 4) increase at low costs and decrease at high costs. These results can also be decomposed.

$$\frac{dR_4}{ds} = \frac{\partial R_4}{\partial w} \frac{dw}{ds} + \frac{\partial R_4}{\partial p_2} \frac{dp_2}{ds} + \frac{\partial R_4}{\partial p_4} \frac{dp_4}{ds}$$

From the simulations we know that at low costs,  $\frac{dR_4}{ds} > 0$ ,  $\frac{dp_2}{ds} > 0$  and  $\frac{dp_4}{ds} > 0$ ,

while at higher costs,  $\frac{dR_4}{ds} < 0$ ,  $\frac{dp_2}{ds} < 0$  and  $\frac{dp_4}{ds} < 0$ . Because the EU is incurring

the original segregation costs, the simulations show, as expected,  $\frac{dw}{ds} > 0$ . Therefore,

combining these results, we can see that the cost effect on fixed factor returns in the high quality final good sector is dominated at low costs by the final price effect. At higher costs, the positive impact of decreasing intermediate good prices on returns to fixed factors is outweighed by the negative impact of increasing wages and decreasing final good prices.

Returns to sectors over time will depend upon whether it is assumed that the costs of segregation are increasing or decreasing.<sup>6</sup> In this case, the returns to fixed factors in the low quality final goods sector increase with increasing costs and the returns to fixed factors in high quality final goods sector decrease with increasing costs. This suggests that the high quality agricultural marketers are more burdened than the GM agricultural marketers by segregation costs. However, at the same time, both sectors benefit from segregation, therefore it is not a question of who benefits and who loses from labelling, but rather who benefits more.

Case 3: Both Segregating (Table V)

Finally, when both countries are labelling, the intermediate good sectors in general bear the original cost of segregation, and segregation leads to benefits in final good sectors. The final high and low quality goods sectors (sector 4 and 7) experience increased returns to fixed factors in both the EU and the US relative to the no labelling case. Only the high quality intermediate good sector in the EU experiences increased returns. The positive relative returns in sector 2 in the EU are related to the scale of production effect discussed in the previous section relative to price changes.

In this scenario, in the US both the high quality and low quality goods have positive returns, but as costs increase the returns to the high quality product increase, whereas the returns to the low quality final good sector decrease.

$$\frac{dR_4}{ds} = \frac{\partial R_4}{\partial w} \frac{dw}{ds} + \frac{\partial R_4}{\partial p_2} \frac{dp_2}{ds} + \frac{\partial R_7}{\partial p_4} \frac{dp_4}{ds}$$

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<sup>6</sup> Either assumption is possible and depends upon, among other factors, the scale of agricultural production of the high and low quality products.

From the simulations we know that at low costs,  $\frac{dR_4}{ds} > 0$ ,  $\frac{dw}{ds} > 0$ ,  $\frac{dp_2}{ds} > 0$  and  $\frac{dp_4}{ds} > 0$ . Assumptions about the production elasticities indicate  $\frac{\partial R_4}{\partial w} < 0$ ,  $\frac{\partial \lambda_4}{\partial p_2} < 0$ , and  $\frac{\partial R_4}{\partial p_4} > 0$ . At low costs, the returns to fixed factors in the high quality final good sector are dominated by the final price effect. At high costs,  $\frac{dR_4}{ds} > 0$ ,  $\frac{dw}{ds} > 0$ ,  $\frac{dp_2}{ds} < 0$  and  $\frac{dp_4}{ds} < 0$ . Therefore, at higher cost levels, the returns to this sector are dominated by the intermediate price effects. In the low quality final good sector returns are dominated at low costs by the intermediate good prices and at higher costs by the final good prices.

In the EU the final good high quality sector experiences decreasing returns to fixed factors with increasing costs whereas the final good low quality sector experiences increasing returns to fixed factors. In the EU, as in the US, the returns to fixed factors for the high quality sector are, at low costs, dominated by the final good price effect and at high costs dominated by the intermediate price effect.

#### **4. Policy Implications**

A common assumption about environmental labelling regimes is that primary agricultural producers will incur increased costs but will be compensated by higher prices for their products. However, the results described above indicate that in the general equilibrium framework the price effects of trading relationships and regulatory behaviour will ultimately determine the relative returns to sectors within and across economies. Depending upon the structure of the economies, the scale of production and domestic and foreign consumer preferences for quality, the economic benefits of

labelling may accrue to sectors (and/or countries) other than those responsible for the initial product segregation. These results are essential for policy makers seeking to understand the global and domestic economic implications of environmental labelling systems.

This model illustrates the importance of the labelling decisions of trading partners, the current cost structure of segregation, and whether these costs are expected to increase or decrease. In some cases increasing costs will lead to a larger price premiums and larger differences among primary good and final good producers. In other cases, costs will have the opposite effect. Therefore, a one-dimensional focus on the cost structure of product differentiation ignores important general equilibrium price effects that ultimately determine distributive impacts.

This analysis is incomplete because it does not include different types of consumers within each country and it assumes that labelling policies are mandated rather than voluntarily adopted. Nevertheless, it provides a preliminary framework for understanding the distributive effects of labelling within international trading systems and helps clarify the relative role of segregation costs and labelling regimes in determining winners and losers. Further research will examine the incentives for political lobbying that arise given the distributive impacts of quality labelling regimes.



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Figure 1:

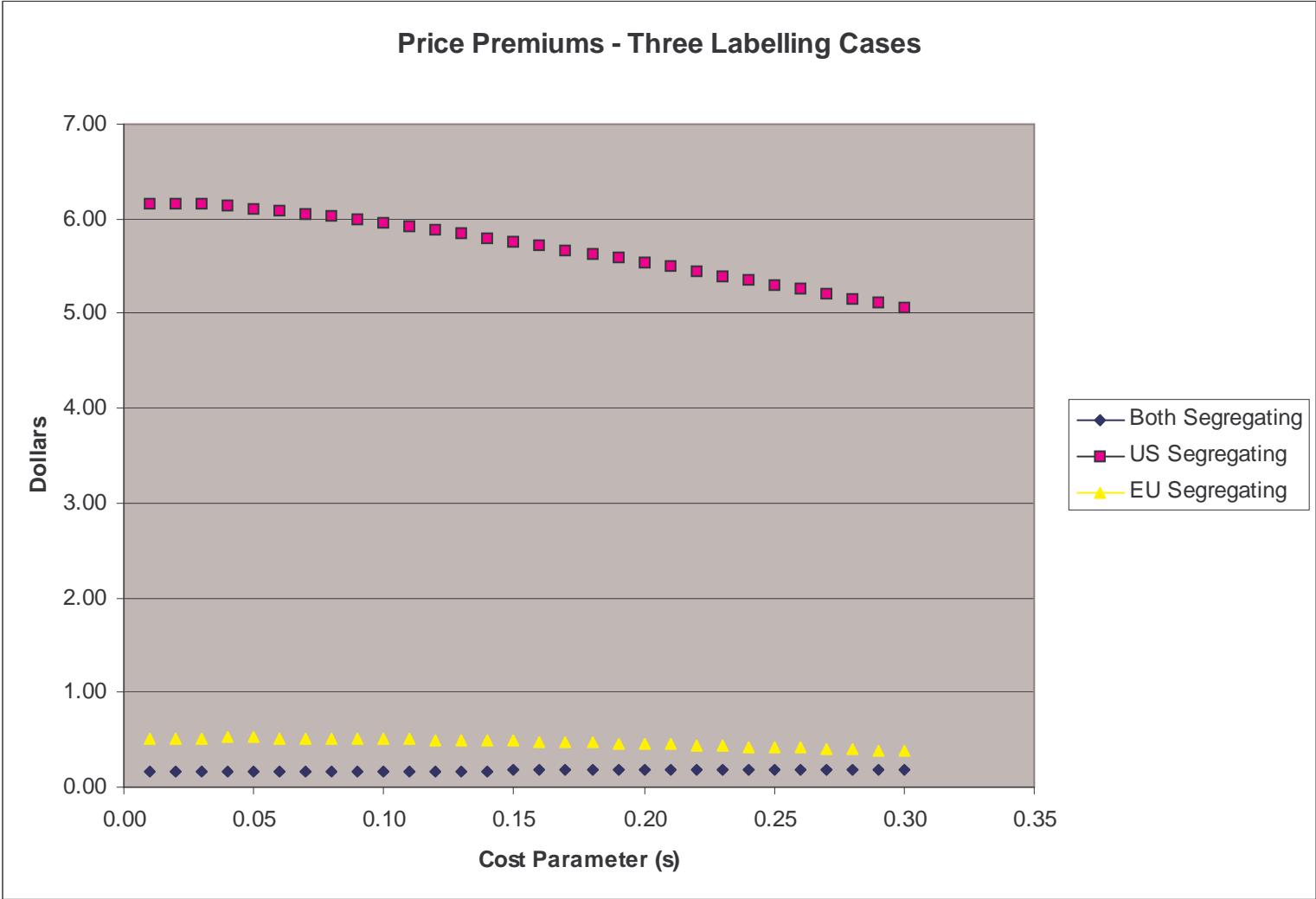


Table I: Relationship of intermediate and final good prices with respect to costs

	$dp_2/ds$		$dp_4/ds$	$dp_6/ds$		$dp_7/ds$
	US	EU	World	US	EU	World
US Segregating	<0 all s	<0 all s	<0 all s	<0 all s	<0 all s	<0 all s
EU Segregating	<0 all s	>0 low s <0 high s	>0 low s <0 high s	<0 all s	<0 all s	<0 all s
Both Segregating	>0 low s <0 high s	>0 low s <0 high s	>0 low s <0 high s	>0 low s <0 high s	<0 all s	>0 low s <0 high s

Table II. Relationship of sector output with respect to costs

	$dy_2/ds$		$dy_4/ds$		$dy_6/ds$		$dy_7/ds$	
	US	EU	US	EU	US	EU	US	EU
US Segregating	>0 all s	<0 all s	>0 all s	<0 all s	>0 all s	<0 all s	>0 all s	<0 all s
EU Segregating	<0 all s	<0 low s >0 high s	<0 for all s	<0 low s >0 high s	<0 all s	>0 all s	<0 all s	>0 all s
Both Segregating	<0 low s >0 high s	<0 low s >0 high s	>0 alls	<0 low s >0 high s	<0 low s >0 high s	> 0 all s	<0 low s >0 high s	>0 all s

Table III. Relative change in returns to fixed factors US segregating - relative to the case when neither country labels.

	US	EU
$R_1$	Low s: -0.004 High s: -0.004	Low s: 0.004 High s: 0.004
$R_2$	Low s: 8.241 High s: 4.337	Low s: -0.802 High s: -0.811
$R_3$	Low s: -0.005 High s: -0.005	Low s: -0.001 High s: -0.002
$R_4$	Low s: 14.611 High s: 14.497	Low s: -0.802 High s: -0.811
$R_5$	Low s: -0.005 High s: -0.005	Low s: -0.001 High s: -0.002
$R_6$	Low s: -0.847 High s: -0.915	Low s: -0.792 High s: -0.818
$R_7$	Low s: -0.780 High s: -0.733	Low s: -0.798 High s: -0.809



Table IV. Relative change in returns to fixed factors in the case where EU labels relative to the case when neither country labels.

	US returns	EU returns
$R_1$	Low s: 0.000 High s: 0.000	Low s: -0.001 High s: -0.001
$R_2$	Low s: -0.111 High s: -0.124	Low s: 0.464 High s: 0.217
$R_3$	Low s: -0.002 High s: -0.002	Low s: -0.001 High s: -0.0018
$R_4$	Low s: -0.121 High s: -0.134	Low s: 0.281 High s: 0.280
$R_5$	Low s: 0.000 High s: 0.000	Low s: -0.001 High s: -0.001
$R_6$	Low s: -0.124 High s: -0.136	Low s: -0.673 High s: -0.880
$R_7$	Low s: -0.121 High s: -0.134	Low s: 0.350 High s: 1.043

Table V: Relative change in returns to fixed factors in the case where both countries label relative to the case when neither country labels.

	US returns	EU returns
R <sub>1</sub>	Low s: -0.000 High s: -0.000	Low s: -0.001 High s: -0.001
R <sub>2</sub>	Low s: -0.157 High s: -0.389	Low s: 0.322 High s: 0.115
R <sub>3</sub>	Low s: -0.001 High s: -0.001	Low s: -0.001 High s: -0.001
R <sub>4</sub>	Low s: 0.412 High s: 0.497	Low s: 0.157 High s: 0.148
R <sub>5</sub>	Low s: -0.001 High s: -0.001	Low s: -0.001 High s: -0.001
R <sub>6</sub>	Low s: -0.059 High s: -0.263	Low s: -0.559 High s: -0.843
R <sub>7</sub>	Low s: 0.308 High s: 0.289	Low s: 0.816 High s: 1.521

## Appendix 1.

The analytical model describes two economies that trade with each other and the rest of the world. Each country (i) is endowed with a mobile factors, labor ( $v_L^i$ ), and seven fixed sector-specific factors ( $v_j^i$ ). The model's equilibrium solution is based upon the definition of sectoral value-added functions ( $G_j^i(w^i, p_j, v_j^i)$  for  $j=1, 2, 3$  and  $6$  and  $G_j^i(w^i, p_j, p_{mj}^i, v_j^i)$  for  $j=4, 5$  and  $7$  where  $w^i$  is the country-specific wage rate,  $p_{mj}^i$  is the country specific price of the intermediate good used in the production of  $j$ , and  $p_j$  is the world price for final good  $j$ . Since production functions are assumed to be Cobb-Douglas, and thus are nonempty, closed and satisfy the free disposal condition, the sectoral value-added functions have properties identical to traditional GNP functions [24]. The envelope properties of sectoral value-added functions can be used to define sector labor demand ( $v_{Lj}^i(w^i, p_j, v_j^i)$  for  $j=1, \dots, 7$ ), intermediate good supply ( $y_j^i(w^i, p_j, v_j^i)$  for  $j=2, 3$ , and  $6$ ), and intermediate good demand ( $y_{mj}^i(w^i, p_j, p_{mj}^i, v_j^i)$  for  $j=2, 3$ , and  $6$ ) for  $m_j=2, 3$ , and  $6$  where  $p_j$  refers to the price of the final marketed good associated with the  $m_j$  intermediate agricultural good).

In the following description the country specific subscripts are suppressed for ease of notation. Given the definitions for sectoral value added functions in the non-segregated case, sectoral labor demand is defined as

$$v_{Lj}(w, p_j, v_j) = \frac{\partial G_j(w, p_j, v_j)}{\partial w} \quad \text{for } j=1, 2, 3, \text{ and } 6$$

$$v_{Lj}(w, p_j, p_{mj}, v_j) = \frac{\partial G_j(w, p_j, p_{mj}, v_j)}{\partial w} \quad \text{for } j= 4, 5, \text{ and } 7$$

Sectoral supply is defined as

$$y_j(w, p_j, v_j) = \frac{\partial G_j(w, p_j, v_j)}{\partial p_j} \quad \text{for } j=1, 2, 3, \text{ and } 6$$

$$y_j(w, p_j, p_{mj}, v_j) = \frac{\partial G_j(w, p_j, p_{mj}, v_j)}{\partial p_j} \quad \text{for } j=4,5, \text{ and } 7$$

Intermediate good demand from the marketing sectors is defined as

$$y_{mj}(w, p_j, p_{mj}, v_j) = \frac{\partial G_j(w, p_j, p_{mj}, v_j)}{\partial p_{mj}} \quad \text{for } j=5 \text{ and } 7$$

where the subscript "mj" refers to the intermediate good m used in the production of final good j. In addition, in the non-segregated case, the demand for good 2 by sector 4 is defined as

$$y_2(w, p_7, p_2, v_4) = \frac{\partial G_4(w, p_7, p_2, v_4)}{\partial p_2}$$

where  $p_7$  is the world price of the un-segregated final product.

In the segregated case, primary agricultural producers use labor to segregate the traditional from the GM agricultural varieties, where "s" is the elasticity of labour used in segregating the GM from the non-GM intermediate goods. The solution to the producer's joint maximization problem provides a joint sectoral "segregation" GDP function for these two primary sectors:

$$G_{seg} = G_{seg}(w, p_2, p_6, v_2, v_6)$$

which has the same properties as the sectoral GDP functions described above. The sectoral supply equations defined above change accordingly when producers are segregating. Each of these products has a unique price. Specifically,

$$y_j(w, p_2, p_6, v_2, v_6) = \frac{\partial G_{seg}(w, p_2, p_6, v_2, v_6)}{\partial p_j} \quad \text{for } j=2 \text{ and } 6$$

Agricultural marketers purchase segregated inputs and produce a GM and a non-GM final good.

Given Cobb-Douglas production functions, the sectoral value added functions are separable in the fixed factors,  $v_j$ . Hence, sectoral value-added functions can be used to define the returns to fixed factors,  $R_j$  for all sectors  $j=1, \dots, 7$ .

$$R_j = \frac{\partial G_j(w, p_j, v_j)}{\partial v_j} \quad \text{for } j=1,2,3 \text{ and } 6$$

$$R_j = \frac{\partial G_j(w, p_j, p_{mj}, v_j)}{\partial v_j} \quad \text{for } j=4,5, \text{ and } 7$$