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European Union Environmental Policies and Imports of Agricultural Products from the United States

by

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1. INTRODUCTION

Environmental policies in the European Union used to control pollution and manage landscapes can alter production possibilities and incentives in agricultural markets.[2] Such changes--if significant–could in turn alter some components of EU exports and imports in general and with the U.S. in particular.

The EU is the third largest regional export market for US agricultural products (USDA, FAS, BICO reports), with imports of $6.4 billion 2001, down from about $9 billion in 1996. Of this 2001 total, the U.S. has a fairly diverse structure of exports to the EU. Bulk commodities used as inputs in related agricultural, food, and textile industries accounted for about $2.4 billion, other inputs agricultural producers and food-processing industries accounted for $1.8 billion, and final consumer-oriented food products accounted for $2.1 billion. Soybeans and tobacco have been the two largest bulk imports from the US to the EU in recent years. Soybean exports fell from about $2.3 billion in 1996 to about $1.16 billion in 2001, with tobacco remaining fairly steady from $657 million in 1996 to $634 million in 2001.

Regarding other inputs, feeds and fodder exports fell from about $900 million in 1996 to $539 million in 1999, planting seeds were at a record high of $296 million in 1999 but were 173 million in 2001. Live animal exports were about $219 million in 2001, and vegetable and

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[2] Throughout this paper, the term environmental policy is used to denote all types of policies designed to influence the use of natural resources (land, water, etc.) and the generation of pollution discharged directly or indirectly into the environment.

soybean oils accounted for another $110.

Among consumer-oriented foods products, the EU imported about $500 million of tree nuts, $356 million of processed fruits and vegetables, and $314 million of wine and beer, and another $179 million of fruit and vegetable juices. For reference, the US exports more tree nuts to the EU than wheat and coarse grains combined. The above figures do not include additional exports of manufactured agricultural inputs such as fertilizers, pesticides, and machinery, which total about $300 million in 1999, as well as another $1 billion of forest products and $500 million of seafood items.

There is now a large literature focused on the impact of environmental regulations on international trade, competitiveness, and location of production (see, e.g., Jaffe, et al 1995; Dean, 1992; Kalt, 1988; Ratnayake, 1998; U.S.O.T.A., 1992; Van Beers and Van Den Bergh, 1996). Much of this literature follows from the common concern that additional costs on producers, processors, and exporters due to more stringent (and costly) domestic environmental regulations will reduce domestic supplies, reduce exports, and increase imports. While such concerns are common, the basic empirical evidence from multi-country studies using aggregate time-series data do not generally support such fears (e.g., Dean, 1992; OECD, 1993; Jaffe et al. 1995).[3] More recent works, however, such as Esty and Geradin (1998) and Van Beers and Van Den Bergh (1997), have begun to challenge this conventional wisdom through more detailed

[3]Distinct from the above empirical literature, there is an almost completely separate theoretical literature evaluating the impacts of environmental policies on international competitiveness and trade. This theoretical literature focuses directly on imperfectly competitive markets (see, e.g., Conrad 1993; Markusen 1997; Kennedy 1994; Ulph 1998, 216-34; Van Beers and Van den Bergh 1996, 154-57), and the possibilities that environmental regulations will be used indirectly to promote comparative advantage. This strand of game-theoretic literature includes no direct empirical analysis.

definitions of environmental regulatory "strictness" and a better understanding of specific sectors of the economy.

The aggregate nature of this empirical literature limits its usefulness for the evaluation of specific environmental regulations on U.S. agricultural trade. Outside of the environmental arena, for example, the EU ban on US beef imports has had an obvious impact on beef exports to the EU even though such changes were not substantial relative to total US exports, total US agricultural exports, and total US agricultural exports just to the EU. The fact that aggregate exports did not change substantially does not imply that this is a minor issue.[4] Thus, to address adequately such topics, sector and industry-specific modeling approaches are needed.

The purpose of this paper is to develop a range of models that can be used to analyze the impacts of EU environmental policies on agricultural imports from the U.S. The single and multi-market equilibrium modeling approach developed in Larson (2000) is adapted and extended here. In short, such an approach provides theoretically consistent and empirically relevant sectoral models that can be used to estimate the impact of environmental regulations on EU imports of US agricultural products.

The paper is organized as follows. Section 2 reviews how EU environmental policies may directly and indirectly affect EU demand for US agricultural imports. Section 3 develops a range of empirically tractable, sector-specific models that can be use to simulate the impacts of EU environmental policies on imports from the US. Section 4 concludes.

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[4] In the agricultural and food sectors at least, many recent trade disputes have revolved around fairly detailed sub-sectors and industries of the economy (e.g. tuna, bananas, meat, potatoes). There is a closely related literature investigating the impacts of sanitary, phytosanitary, and technical barriers to trade (see, e.g., Roberts, Josling, and Orden, 1999; and Beghin and Bureau, 2001).

2. EUROPEAN UNION ENVIRONMENTAL AND NATURE PROTECTION POLICIES AFFECTING AGRICULTURE

The indirect or spillover affects of EU environmental policies on US agriculture exports to the EU should depend on the *policy target*, the *stringency of the policy*, and *market structures*. Any analysis of EU environmental policies on US agricultural exports needs to consider carefully each of these issues.

Environmental polices can target ***processes*** used to create the product and/or specific ***attributes*** of the product. EU process-oriented policies that only target EU producers, but do not directly impinge on US producers, are one standard type of environmental policy. Such policies, by altering production possibilities in the EU, may have spill over effects on EU import demands. The Nitrate Directive is a good example of a process-targeted policy designed to control the amount of nitrogen applied on farm lands mainly affects livestock operations and certain crop producers in some member countries (Frederiksen, 1994). Similarly, other process-targeted polices focus on full-cost water pricing for irrigation, water effluent control in food and meat processing, and air pollution policies affecting energy prices.

On the other hand, EU polices that target product attributes directly affect EU producers and may also directly affect US producers. Within the WTO, product attribute regulations for valid purposes are allowable as long as domestic and foreign products are treated equally. The Packaging Directive is a good example of a product-targeted policy designed to control the amount of solid waste generated in the EU. All products sold in the EU, whether domestically produced or imported, need to meet the basic requirements of the directive.

Process regulations targeted to EU and foreign producers that are not related to product attributes are generally inconsistent with WTO principles. Attempts at process regulations have often been considered non-tariff trade barriers and have been discussed regularly in relation to child labor and sweatshop labor issues, sea turtles, and tropical forestry. Of course product attribute regulations almost always involves process changes to meet the new product standards, and governments do not always agree on what's a process and what's a product attribute policy.[5]

While most EU environmental policies are designed to target either processes or product attributes, which essentially act to shift supply schedules, some newer types of policies are also targeted to consumers, with the hope of shifting consumer demands. For example, eco-label programs that provide additional information to consumers on *credence* attributes of products are designed explicitly to shift consumer demands towards labeled products.

In sum, some process regulations on EU producers shift just EU supplies, some process regulations might shift EU and US supplies, and product regulations can shift supplies from both the EU and US as well as consumer demands in the EU. The eventual market impacts of such policies, and the resulting impacts on EU imports in general and US agricultural imports in particular, will depend on the stringency with which such policies are defined, implemented, and enforced. Policies must actually alter production and/or consumption incentives for trade spillovers to occur.

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[5]The distinction between process and product targets is not always clear. Bans on certain inputs, such as certain pesticides, could be considered both product- and process-targeted policies. Input bans act as product regulations in factor markets, which in turn have process implications in agricultural production. Agreeing on the distinction between a product and process regulation is also not always easy. The EU ban on US meat imports due to the use of hormones in the livestock sector is considered an unfair process regulation by the US, but a reasonable product regulation by the EU to satisfy EU food safety objectives.

Banning pesticides that are not used, or for which good substitutes exist, have little impact on production possibilities and costs. Enforcing stringent water effluent policies through effluent taxes is different than strict enforcement with large subsidies for pollution control investments. Historical data from manufacturing industries consistently suggest that pollution control expenses are less than 2% of total costs for high polluting industries (manufacturing) facing strict regulatory environments, while such expenses are less that 0.5% of total costs for less polluting industries.

The interpretation of such cost information is difficult to interpret in the context of agriculture, and there is a dearth of information on the basic cost implications of complying with various environmental regulations in agricultural sectors in the EU. For example, irrigated water expenses could account for 10% of production costs of certain crops in the southern regions of the EU. A move toward full-cost water pricing that incorporates both delivery and scarcity value to such water could easily double costs for certain crops in certain parts of the EU. In such situations, the cost of just one stricter environmental policy could increase total costs by 10% without further adjustments in inputs, outputs, and water efficiencies in the production process.

Besides regulatory targets and stringency discussed above, the final issue noted here is market structure. Trade in bulk and fairly homogeneous commodities, such as soybeans, may differ from trade in intermediate inputs and consumer-oriented products. EU demands for soybeans are derived demands from industries, while EU demands for snack foods are more closely tied to EU consumer demands for ready-to-eat food products. Given basic grading standards, there is easy substitution in production processes between soybeans from the EU, the US, Brazil, and elsewhere. It seems likely that trade in such markets is relatively competitive and products are relatively homogeneous.[6] In consumer-oriented products and at least some intermediate products, product differentiation is probably more important. Given that EU imports from the US are roughly split in value in terms of bulk, intermediate, and consumer-oriented products, market characteristics and structures should play a role in the transmission of EU environmental policies to EU imports from the US.

3. MODELING THE IMPACTS OF EU POLICIES ON IMPORTS

The impacts of EU environmental policies on imports from the US can be discussed in general using basic demand and supply graphs (see, e.g., Krutilla 1991, Anderson 1992, Smith and Espinosa 1996, and Larson 2000). To calculate numerically the changes implied in graphical analyses for specific components of agricultural trade, Larson (2000) uses some basic microeconomic foundations to decompose supply and demand shifts into separate components that may be easier to understand, estimate, and discuss.

The models developed in this section adapt the Larson (2000) analysis to address the impacts of EU environmental regulations on imports from the US. Since US exports to the EU include inputs (i.e. commodities such as soybeans and tobacco and processed inputs such as feeds, planting seeds, soybean oils, fertilizers, pesticides, machinery), and consumer-oriented food products (e.g., tree nuts, wine and beer, and processed fruits and vegetables, fresh fruit, and snack foods), models are developed to be relevant for markets with homogeneous products and markets where product differentiation is important.

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[6]Biotechnology has perhaps begun to change this conclusion to some degree.

For markets with homogeneous products, three general cases are presented. Case 1 focuses on process regulations affecting only EU producers assuming that import prices are fixed. Case 2 extends Case 1 to allow for the case where import prices may also adjust. Case 3 focuses on product attribute regulations that affect both EU and US producers, and it is noted here that Case 3 is also applicable to EU regulations that attempt to regulate production processes for domestic and foreign producers that are not directly related to product characteristics.[7]

For markets with differentiated products, three cases are also provided. Case 4 considers the impacts of process regulations that just affect EU producers when import prices are fixed. Case 5 extends Case 4 to allow for import price effects. Case 6 focuses on product attribute regulations that affect both EU and US producers. Case 6 includes the possibility that the product regulation on EU producers also shifts EU consumers demands, as for example is the hope of EU eco-label programs. The following sections outline the modeling approach. For each case, a graphical overview is provided and then the detailed conceptual results are provided that allow the impacts to be estimated and simulated.

Case 1. Process Regulations Targeted to EU Producers (Homogeneous Products, Import Prices Fixed)

As a starting point, a simple homogeneous market situation is outlined in Figure 1, where Figure 1.a shows the EU domestic demand and supply situation and Figure 1.b shows the related EU import demand and import supply situation. In the domestic market, Y^0 is an initial EU

[7] While not addressed directly here, Larson (2000) shows how to include the possibility of efficiency improvement induced by the policy into the analysis. The basic idea is that efficiency improvements tend to offset some of the initial cost increases of the policy.

supply schedule for the item, p^w is a constant world price for the commodity (in domestic currency units), B represents domestic derived demand for the bulk item in some processing industry, and $I^0 = B^0 - Y^0$ is the initial level of EU imports. Given this situation in Figure 1.a, the initial import demand schedule is I^0, and the fixed price at p^w represents world import supply to the EU.

Any policy change that targets production processes in the EU, and therefore imposes costs on EU producers, shifts the domestic market supply from the original level Y^0 to a new level Y^1. Given a fixed world price at p^w, production falls from Y^0 to Y^1 and imports increase from $B^0 - Y^0$ to $B^0 - Y^1$. Figure 1.b shows that these types of domestic EU process regulations act to shift out the EU import demand schedule and, in the end, increase imports.

To estimate/calculate these impacts identified in Figure 1. a and 1.b, the basic process outline in Larson (2000) is followed here. For notation, let Y represent EU supply; let p represent the EU market price, let B represent total EU consumption; and let I = B - Y represent EU import demand. In the soybean market, for example, B is the derived demand for bulk soybeans in the EU, Y is EU supply of soybeans, and I represents EU import demand for soybeans. On the EU production side, let X represent some regulated input or inputs that may be the target of the environmental policy with initial prices w, let K represent other variable inputs with prices r, and let F represent fixed costs. EU production costs are C = wX+rK, and let Y= f(X,K) represent a decreasing returns to scale production technology.

Two types of regulatory impacts are analyzed, depending on whether the environmental policy affects a specific input (denoted X above) or leads to overall average cost increases. As the base case, given an initial regulatory situation denoted as R', the input price is w' = w(R') for the regulated input. If policies change from R' to R", then the new price is w" = w(R"). As a result, the regulatory change from R' to R" implies a price change dw = w" - w', which in percentage terms can be written as dw/w' = (w"-w')/w'.[8]

On the other hand, it is possible that environmental regulations affect average production costs by some amount 'm' (e.g. $8 per unit of output). In this case, for example, let M(R') = 0 be the initial situation and let M(R") = m represent the regulatory cost increase. As a result, dM = m, and m/C is the percentage increase in production costs due to the environmental policy.

The Larson (2000) approach simply assumes that firms maximize profits within the context of competitive markets. As a result, standard duality relationships between a profit function $\pi = \pi(p,w,r)$ and a variable cost function C = C(w,r, Y), the symmetry of the Hessian π, and the envelope theorem (Hotelling's Lemma and Sheppard's Lemma) can be used to show that:

$$\frac{\partial Y}{\partial w} = - \frac{\partial X}{\partial p} = - \frac{\partial X^c}{\partial y} \frac{\partial Y}{\partial p} \qquad \textbf{(1)}$$

where Y=Y(p,w,r) is the profit-maximizing supply function, X = X(p,w,r) is the profit-maximizing input demand function, X^c is the cost-minimizing input demand function, and y is a reference level of output in a cost function.

The result in (1) can be rewritten as:

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8 This approach tying regulatory changes to a key input (or set of inputs) is consistent with the "price-wedge" method discussed in Beghin and Bureau (2001). It is a simple extension to consider policies that affect over all productions costs or to consider policies that affect the productivity of key inputs.

$$\eta_{yw} = \frac{\partial Y}{\partial w}\frac{w}{Y} = -\left[\frac{wX}{C}\right]\left[\frac{C}{pY}\right] * \eta_{yp} * \eta^{c}_{xy}$$

$$\% \Delta Y = \eta_{yw} * \frac{\Delta w}{w} * 100 \qquad \textbf{(2)}$$

$$\% \Delta I = - \% \Delta Y * \frac{(Y/B)}{(I/B)}$$

where $\eta_{yp} = (\partial Y/\partial p)(p/Y)$ is the output own-price elasticity, $\eta^{c}_{xy} = (\partial X^{c}/\partial y)(X/Y)$ is the elasticity of the cost-minimizing input demand with respect to the reference output level, and %ΔY denotes the percentage change in EU production, defined as ΔY/Y, and similarly %ΔI is the percentage change in EU imports.

The relationship in equation (2) shows that the impact of more stringent EU policies on EU production and imports should depends on six specific factors: (1) the regulated input's cost as a share of total costs, wX/C; (2) total costs as a share of total revenues, C/pY (which is essentially an inverse normal profit rate); (3) the EU supply elasticity with respect to output price, η_{yp}; (4) the input demand elasticity (cost-minimizing) with respect to output level, η^{c}_{xy}; (5) the actual regulatory impact on production costs, dw/w' = (w"-w')/w'; and (6) the share of domestic production relative to imports, Y/I. One benefit of the simple decomposition in (2) is that the assumptions and calculations are very transparent and relatively easy for policy makers and industry interest groups to evaluate and discuss.

For reference, wX/C and C/pY are both between zero and one, and $1 \leq \eta^{c}_{xy}$ is likely, recalling that $\eta^{c}_{xy} = 1$ implies constant returns to scale (in which case the profit function is not defined). Table 1 provides a simple breakdown of production cost shares for key inputs for individual countries in the EU. For example, Eurostat data for 1999 suggests that the farm cost shares for fertilizers is about 0.025 in Denmark but 0.09 in the United Kingdom, and pesticides are also a fairly small share of production costs. Animal feed is the largest share of costs for all countries in the EU-15, ranging from a low of 0.27 in the United Kingdom to 0.54 in Denmark and Belgium. Thus, due to differing cost structures, the same policy change (e.g. a $0.10 increase in fuel costs due to additional environmental regulations related to air pollution from fuel plants and transportation), would affect Greek and Swedish agricultural producers more than Belgium and French producers.

In some situations, such as end-of-pipe pollution control technologies for industries, it may be difficult to attribute environmental regulatory changes to specific inputs. In such circumstances, the variable cost function can be written as C = C(w,r,y) + my, where m represents the fixed increase in average variable production costs due to the regulation. In this case, the supply function just shifts from Y = Y(p, w,r) without the regulation to Y(p-m,w,r) with the regulation. The final impact on production and imports can be written as:

$$\%\Delta Y = -\eta_{yp} * \frac{mY}{C} * \frac{C}{pY} * 100$$

(3)

$$\%\Delta I = \%\Delta Y * (Y/I)$$

In this increasing average cost increase case, it is just necessary to know the basic supply elasticity and an estimate of the existing production cost increase (m or mY/C) to evaluate the impact of higher regulatory costs on production and imports.[9]

Case 2. Process Regulations Targeted to EU Producers (Homogeneous Products) with Import Price Effects

Figure 2 extends the analysis from Figure 1 to allow for price effects in import markets. If the EU is large in the import market for such items, any shifts in EU demand could lead to import price adjustments. Figure 2.a and 2.b again represent the EU domestic and EU import markets, as in Figures 1, except that now the import supply function in Figure 2.b is upward sloping (denoted as S^0). In this situation, the shift out in the EU import demand schedule from I^0 to I^1 in Figure 1.b increases the import price from p_w^0 to p_w^1 . As a result, imports fall back to I^2, with EU production increasing from Y^1 to Y^2, domestic EU consumption falling from B^0 to B^2. In sum, the possibility that some of the cost of the EU process regulations are passed along to import prices will tend to mitigate the final effect of such regulations on import quantities.

To allow for import price adjustments, now let S = S(p) represent the import supply function, with B(p) representing domestic demand and Y(p,w,r) representing domestic supply as for Case 1. The import market clears where B(p) - Y(p,w,r) = S(p) at the equilibrium price p = p(w,r). After taking the total differential of the equilibrium condition with respect to p and w, the impacts of higher input costs due to more stringent environmental regulations on the market price p can be written as:

[9] Note that this formulation is slightly different from that outlined in Larson (2000) for the average cost case.

$$\eta_{pw} = \left[\frac{\eta^{p}_{yw}}{-\eta_{yp} + \eta_{Bp}\frac{1}{(Y/B)} - \eta_{Sp}\frac{1}{(Y/S)}} \right] \tag{4}$$

where η_{Sp} is the elasticity of import supply with respect to price, and η_{Bp} is the elasticity of domestic demand with respect to price. Thus, (4) shows how much of the input price increase is passed along to the domestic and import market.

Writing the expanded form of the import demand function as I = B(p(w)) - Y(p(w), w, r), the effects of environmental regulations on domestic and import markets with import price adjustments can be written as:[10]

$$\eta_{yw} = \eta^{p}_{yw} + \eta_{yp} * \eta_{pw} \quad and \quad \%\Delta Y = \frac{\Delta Y}{Y} = \eta_{yw}\frac{dw}{w} \tag{5}$$

for domestic production, where the elasticity η^{p}_{yw} in (5) is the cross price elasticity defined in (2) which holds price p fixed. For domestic consumption,

$$\frac{\Delta B}{B} = \eta_{Bp}\,\eta_{pw}\frac{dw}{w} \tag{6}$$

And for imports,

$$\frac{\Delta I}{I} = \frac{\Delta B}{B}\frac{1}{(I/B)} - \frac{\Delta Y}{Y}\frac{(Y/B)}{(I/B)} \tag{7}$$

where the percentage change in domestic consumption is defined in (6), the percentage change in domestic production is defined in (5), and I/B is simply the import share in total domestic

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[10] It is also possible that environmental regulations on one input, say energy, may also induce adjustments in other inputs, in which case r = r(w) could be considered as well.

consumption and Y/B is the domestic supply share of total domestic consumption. In comparison to Case 1, two additional pieces of information are needed to estimate the effects in Case 2 (the import supply elasticity with respect to price, and the domestic demand elasticity with respect to price).

Case 3. Product Regulations Targeted to EU and Foreign Producers (Homogeneous Products) with Import Price Effects.

Product regulations affect production costs for both domestic and foreign suppliers, and the same product standard can lead to different cost implications for domestic and foreign supplies. As shown in Figure 3, changes in environmental policies targeted to product attributes shift domestic supply, as discussed for Case 1 and Case 2, and import supply functions. Conceptually, the impact of product regulations can be analyzed in two stages. The first stage in the analysis is exactly the same as for Case 2, with equations (4) - (7) providing the basic results describing the change in imports from I^0 to I^1 , and then I^1 to I^2 in Figure 3.b.

The second stage includes the additional shock to the market from the additional costs of production for the import suppliers that also need to meet the product standard. In Figure 3.b, the effect is represented by the change in import supply from S^0 to S^1 . Due to this import supply shift, the final result shown in Figure 3.b is that imports adjust to I^3, the import price increases to p^0, EU supply adjusts to Y^3 and EU consumption falls to B^3.

To estimate these changes, the analysis for Case 2 above needs to be modified slightly. For notation, now let S = S(p, W) represent the import supply function, where p remains the output price but W represents some input prices that will adjust due to the product standard.

With B(p) representing domestic demand, Y(p,w,r) is domestic supply, the import market clears where B(p) - Y(p,w,r) = S(p, W) at the equilibrium price p = p(w, W, r).

The total differential of the market equilibrium condition with respect to p, w, and W can be written as:

$$\frac{\partial B}{\partial p}dp - \frac{\partial Y}{\partial p}dp - \frac{\partial Y}{\partial w}dw = \frac{\partial S}{\partial p}dp + \frac{\partial S}{\partial W}dW \qquad \textbf{(8)}$$

If dW = dw in (8), it could be argued that the policy leads to the same cost impact on EU and US producers. On the other hand, if dW = θdw, there is a differential impact, with $\theta > 1$ implying that it costs US producers more to comply with the EU product standard than EU producers (and vice versa).

Substituting dW = θdw into (8) and rearranging, the impacts of stricter product standards on the market price p can be written as:

$$\eta_{pw} = \left[\frac{Y\eta^{p}_{yw} + S\eta_{Sw}(\theta w)/W}{\eta_{Bp}B - \eta_{Yp}Y - \eta_{Sp}S} \right] \qquad \textbf{(9)}$$

where η_{Sp} is the elasticity of import supply with respect to price, and η_{Bp} is the elasticity of domestic demand with respect to price. Equation (9), which can be directly compared to (4), includes all price adjusts due to the simultaneous impacts on domestic and foreign production costs due to the product regulations. It is noted here that the cross price elasticity η_{SW} can be computed exactly as in equation (2) above with the appropriate redefinition of variables.

Writing again the import demand function as I = B(p(w)) - Y(p(w), w, r), the effects of environmental regulations on domestic and import markets with import price adjustments can be written as:[11]

$$\eta_{yw} = \eta^{p}_{yw} + \eta_{yp} * \eta_{pw} \quad and \quad \%\Delta Y = \frac{\Delta Y}{Y} = \eta_{yw}\frac{dw}{w} \tag{10}$$

for domestic EU production, where the elasticity η^{p}_{yw} in (5) is the cross price elasticity defined in (2) which holds price p fixed and the price elasticity η_{pw} is now defined in (9). For domestic consumption,

$$\frac{\Delta B}{B} = \eta_{Bp}\,\eta_{pw}\frac{dw}{w} \tag{11}$$

and for imports,

$$\frac{\Delta I}{I} = \frac{\Delta B}{B}\frac{1}{(I/B)} - \frac{\Delta Y}{Y}\frac{(Y/B)}{(I/B)} \tag{12}$$

where the percentage change in domestic consumption is defined in (11), the percentage change in domestic production is defined in (10), and I/B is again the import share in total domestic consumption and Y/B is the domestic supply share of total domestic consumption.

As a final possibility here, environmental policy changes (either product or process policies) could alter product quality as perceived by consumers. If consumers cared about such changes, a final effect is that the derived demand schedules depicted in Figures 1-3 could also shift due to the policy change. For example, in textiles, a standard or label identifying higher quality cotton yarns could shift demand for the product. Similarly, a standard or label identifying sweatshop-free labor could influence demand for the textiles even though other 'product'

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[11] It is also possible that environmental regulations on one input, say energy, may also induce adjustments in other inputs, in which case r = r(w) could be considered as well.

characteristics are unchanged.

To allow for domestic and import supply shifts due to environmental policy changes as well as derived demand shifts, the analysis for Case 3 needs to be modified slightly. Now let B = B(p, A(w)) represent domestic demand with price p and quality attribute A. The notation A = A(w) is used to allow for the possibility that the regulatory change, denoted dw, will also influence a quality attribute in the market that is valued on the demand side. Also let S = S(p,W) continue to represent the import supply function, where p remains the output price and W represents some input prices that will adjust due to the EU product standard. With Y = Y(p,w,r) representing domestic supply, the import market clears where B(p, A(w)) - Y(p,w,r) = S(p, W) at the equilibrium price p = p(w, W, r).

The total differential of the equilibrium condition with respect to p, w, W, and A can be written as:

$$\frac{\partial B}{\partial p}dp + \frac{\partial B}{\partial A}\frac{\partial A}{\partial w}dw - \frac{\partial Y}{\partial p}dp - \frac{\partial Y}{\partial w}dw = \frac{\partial S}{\partial p}dp + \frac{\partial S}{\partial W}dW \qquad \textbf{(13)}$$

As for Case 3, let dW = θdw, where θ > 1 implies that it costs US producers more to comply with the EU product standard than EU producers (and vice versa).

After substituting dW = θdw into (13) and rearranging, the impacts of stricter product standards on the final price p can be written as:

$$\eta_{pw} = \left[\frac{Y\eta_{yw}^{p} + S\eta_{Sw}(\theta w)/W - \eta_{BA}\eta_{Aw}}{\eta_{Bp}B - \eta_{Yp}Y - \eta_{Sp}S} \right] \qquad \textbf{(14)}$$

where η_{Sp} is the elasticity of import supply with respect to price, η_{Bp} is the elasticity of domestic demand with respect to price, η_{BA} is the elasticity of domestic demand with respect to the product attribute A, and η_{Aw} is the elasticity of quality attribute with respect to the policy change. Equation (14) is a straight-forward extension of equations (9) and (4). It is again noted here that the cross price elasticity η_{SW} for import supply can be computed exactly as in equation (2) with the appropriate redefinition of variables.

Writing again the import demand function as I = B(p(w), A(w)) - Y(p(w), w, r), the effects of environmental regulations on domestic and import markets with import price and attribute adjustments can be written as:

$$\eta_{yw} = \eta^{p}_{yw} + \eta_{yp} * \eta_{pw} \quad and \quad \%\Delta Y = \frac{\Delta Y}{Y} = \eta_{yw}\frac{dw}{w} \tag{15}$$

for domestic EU production, where the elasticity η^{p}_{yw} in (15) is the cross price elasticity defined in (2) which holds price p fixed and the price elasticity η_{pw} is now defined in (14). The impact on domestic consumption is now:

$$\frac{dB}{B} = (\eta_{Bp}\,\eta_{pw} + \eta_{BA}\,\eta_{Aw})\frac{dw}{w} \tag{16}$$

and for imports,

$$\frac{\Delta I}{I} = \frac{\Delta B}{B}\frac{1}{(I/B)} - \frac{\Delta Y}{Y}\frac{(Y/B)}{(I/B)} \tag{17}$$

where the percentage change in domestic consumption is defined in (16), the percentage change in domestic production is defined in (17), and I/B is again the import share in total domestic consumption and Y/B is the domestic supply share of total domestic consumption.

Case 4. Process Regulations Targeted to EU Producers (Differentiated Products with Fixed Import Prices)

Differentiated product markets exist when consumers consider domestically produced items and imported items to be imperfect substitutes. As outlined in Figures 4.a and 4.b, with differentiated products, there are now two distinct markets: one market for the domestically produced item (Figure 4.a) and one for the imported item (Figure 4.b). To allow for differentiated products, some additional notation is needed. Let Y=Y(p,w,r) continue to represent EU supply, but now let B = B(p,R) represent EU demand for the domestic product, where p continues to represent the price of the EU item and R now represents the price of the imported item. In the import market, let S = S(R) represent the import supply function, and let I = I(R,p) represent EU import demand. The domestic market clears with B(p,R) = Y(p,w,r) and the import market clears with I(R,p) = S(R).

For Case 4, it is assumed that the price of R is fixed. As depicted in Figure 4.a, process regulations that affect production costs in the EU (a shift in supply from Y^0 to Y^1) will increase the domestic price p (an increase from p^0 to p^1). Assuming for now that the two items are substitutes, this increase in the domestic price p will shift EU import demand. With import price fixed at R, imports will increase from I^0 to I^1 .

To calculate these changes numerically, it is necessary to take the total differential of domestic market equilibrium condition B(p,R) = Y(p,w,r) with respect to p and w, and then use the implicit function theorem to solve for dp/dw. In elasticity form, the impact of EU process regulations on the domestic market price p can be written as:

$$\eta_{pw} = \left[\frac{\eta^{p}_{yw}}{-\eta_{yp} + \eta_{Bp}} \right] \tag{18}$$

Similar to Case 2, equation (18) shows how environmental regulatory costs are passed along to retail market prices (assuming for now that the import price R is fixed).

Recalling that the import demand function is I = I(R,p), the effects of EU process regulations on imports, assuming differentiated products, is simply:

$$\frac{\Delta I}{I} = \eta_{Ip}\, \eta_{pw} \frac{\Delta w}{w} \tag{19}$$

where the percentage change in EU imports is simply the product of three terms: the cross price elasticity of import demand with respect to the price of the EU product; the regulatory impact on EU domestic price defined in (18); and the regulatory cost impact.

Case 5. Process Regulations Targeted to EU Producers (Differentiated Products with Fixed Import Prices)

While Case 4 assumed that the import price R remained fixed, Case 5 incorporates the possibility that import prices may also adjust. All notation remains as for Case 4, so that Y=Y(p,w,r) is EU supply, B = B(p,R) is EU demand for the domestic product, where p continues to represent the price of the EU item and R represents the price of the imported item. In the import market, S = S(R) represents the import supply function, and I = I(R,p) represents EU import demand. The domestic market clears with B(p,R) = Y(p,w,r) and the import market clears with I(R,p) = S(R).

For Case 5, it is not assumed that the price of R is fixed. As depicted in Figure 5.a, process regulations that affect production costs in the EU (a shift in supply from Y^0 to Y^1) will increase the domestic price p (an increase from p^0 to p^1). Assuming that the two items are substitutes, this increase in the domestic price p will shift EU import demand. With an upward sloping import supply S = S(R), however, this increase in demand will increase the import price.

To calculate these simultaneous price changes in both markets, it is necessary to take the total differential of both market equilibrium conditions, B(p,R) = Y(p,w,r) and S(R) = I(R,p), with respect to p, R, and w, and then use Cramer's Rule to solve for dp/dw and dR/dw. In elasticity form, after some further manipulation, the impact of EU process regulations on the domestic market price p can be written as:

$$\eta_{pw} = \left[\frac{\eta^{p}_{yw}}{-\eta_{yp} + \eta_{Bp} - \dfrac{\eta_{BR}\,\eta_{Ip}}{\eta_{IR} - \eta_{SR}}} \right] \tag{20}$$

And, in a similar fashion, the impact of EU process regulations on the import price R can be written as:

$$\eta_{Rw} = \left[\frac{\eta^{p}_{yw}}{\eta_{BR} + \dfrac{(\eta_{Bp} - \eta_{Yp})(\eta_{IR} - \eta_{SR})}{\eta_{Ip}}} \right] \tag{21}$$

Equations (20) and (21) shows how prices in the domestic and import markets adjust to more stringent process regulations in the EU market that only affect EU producers directly. The impacts of such regulations spillover on the import market due to import price increases.

Recalling again that the import demand function is I = I(R,p), the effects of EU process regulations on imports when both prices adjust is:

$$\frac{\Delta I}{I} = [\ \eta_{Ip}\,\eta_{pw} + \eta_{IR}\,\eta_{Rw}\ ]\frac{\Delta w}{w} \tag{22}$$

Case 6. Product Regulations Affecting EU and US Producers (Differentiated Products) with Import Price Adjustments and Consumer Eco-Preferences

While Case 5 for process regulations allowed the import price R to adjust, Case 6 for product regulations now includes the additional possibility that product regulations increase costs for both EU producers and foreign producers. Because of the product attribute changes, the possibility is also included that consumers in the EU value these attribute changes.

For notation, Y=Y(p,w,r) is EU supply, B = B(p,R, A(w)) is EU demand for the domestic product, where p continues to represent the price of the EU item and R represents the price of the imported item, and A(w) represents consumers preferences for attributes of the product that will adjust with the product standard. In the import market, S = S(R,W) now represents the import supply function, where as in Case 3 W now represents the prices of some inputs that will need to adjust to meet the product standard. And last, let I = I(R,p, a(w)) represents EU import demand, where a(w) again represents EU consumer preferences for attributes of the imported item that will adjust to meet the product standard.

For case, the domestic and import markets clear at prices p and R so that:

$$B(p, R, A(w)) = Y(p, w, r)$$

$$I(R, p, a(w)) = S(R, W).$$

For Case 6, as depicted in Figure 6.a, product regulations production costs in the EU (a shift in supply from Y^0 to Y^1) and also shift out demand, with both effects putting upward pressure on price. At the same time, the product regulation also increases production costs for importers, so that supply shifts up in Figure 6.b as well, while demand also shifts out due to the increased product quality. Assuming that the two items are substitutes, these simultaneous demand and supply shifts will also have feedback effects on demands in both markets. One possible final equilibrium adjustment is shown in Figures 6.a and 6.b with lower quantities in each market with higher prices. A range of possibilities exist, however, depending on the relative magnitudes of the demand and supply shifts and the various demand and supply elasticities underlying the demand and supply schedules.

To calculate these simultaneous price changes in both markets due to the product standard, it is first necessary to take the total differential of both market equilibrium conditions, with respect to p, R, w and W, which for reference are:

$$B_p\, dp + B_R\, dR + B_A\, A_w\, dw = Y_w\, dw + Y_p\, dp$$

$$I_R\, dR + I_p\, dp + I_a\, a_w\, dw = S_R\, dR + S_W\, \theta\, dw$$

where subscripts denote partial derivatives, and dW = θ dw is used as discussed above under Case 3, and W = γw will be used in the expressions below.

After using Cramer's Rule to solve for dp/dw and dR/dw, and then manipulating the expressions, the impact of EU product regulations on the domestic market price p can be written as:

$$\eta_{pw} = \frac{(\eta_{Yw} - \eta_{Aw})(\eta_{IR} - \eta_{SR}) - \eta_{BR}(\eta_{SW}(\theta/\gamma) - \eta_{Ia}\,\eta_{aw})}{(\eta_{Bp} - \eta_{Yp})(\eta_{IR} - \eta_{SR}) - \eta_{BR}\,\eta_{Ip}} \quad \textbf{(23)}$$

And, in a similar fashion, the impact of EU process regulations on the import price R can be written as:

$$\eta_{Rw} = \frac{(\eta_{SW}(\theta/\gamma) - \eta_{Ia}\,\eta_{aw}) - \eta_{Ip}(\eta_{Yw} - \eta_{BA}\,\eta_{Aw})}{(\eta_{Bp} - \eta_{Yp})(\eta_{IR} - \eta_{SR}) - \eta_{BR}\,\eta_{Ip}} \quad \textbf{(24)}$$

Equations (23) and (24) show how prices in the domestic and import markets adjust to more stringent product regulations in the EU market, where such product regulations affect EU and foreign producers and EU consumers care about the product quality changes in the domestic and imported item induced by the regulations.

Recalling again that the import demand function is I = I(R,p, a(w)) for Case 6, the effects of EU product regulations on imports, when both prices and quality adjust, is:

$$\frac{\Delta I}{I} = [\,\eta_{Ip}\,\eta_{pw} + \eta_{IR}\,\eta_{Rw} + \eta_{Ia}\,\eta_{aw}\,]\,\frac{\Delta w}{w} \quad \textbf{(25)}$$

4. CONCLUSIONS

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Table 1. Input Cost Shares

	Input Costs (Million Euro's)	Seeds	Fuels	Fertilizers	Pesticides	Veterinary	Animal feed	Machinery (maintanence)	Buildings (maintanence)	Agricultural Services	Other products and services
EU-15	129963										
Belgium	4224	5.9	7.5	5.2	4.5	4.5	54.5	7.7	1.4	1.5	7.3
Denmark	4579	2.5	5	4.8	3.5	2.5	54.2	7.4	2.6	6	11.5
Germany	24549	3.1	8.4	6.2	4.5	2.8	45.8	7.8	2.5	4.9	14.1
Greece	2880	8.9	16.1	10	9.7	2.4	41.1	2.2	1.2	3.1	5.4
Spain	11398	4	7.1	7.8	5.1	3.6	44.9	13.9	2.4	4.3	6.9
France	31591	5.2	7	8.9	8.4	3.2	36.5	7.3	1.5	8	14
Ireland	2973	2.3	11.4	11.5	2.2	3.3	42.9	5.4	2.2	9.2	9.6
Italy	13168	4.1	11	6	5.1	0.2	51.7	2	0.7	3.9	15.2
Luxembourg	129	3.9	7.9	8	2.9	2.2	38.9	13.7	1.4	5.8	15.3
Holland	9997	9.8	10.8	2.3	3.2	2.3	33.3	5.9	1.1	12.8	18.4
Austria	2942	4.9	8.3	3.9	2.7	6.1	37.7	7.9	1.6	16.7	10.2
Portugal	2913	11	6.5	7	5.1	1.2	48	1.9	1.5	0.1	17.8
Finland	2429	2.8	8.4	8.3	2.4	2.4	43.1	5.7	2.4	4.2	20.3
Sweden	2941	5	10.6	6.8	2.3	0.9	40.6	8	3.2	3.4	19.2
UK	13249	3.8	7.1	8.9	7.2	3.1	27.3	7.9	3.7	6.8	24.3

Source Eurostat

Figure 1. The Effects of EU Process Regulations on Imports with a Fixed Import Price (the homogeneous commodity case)

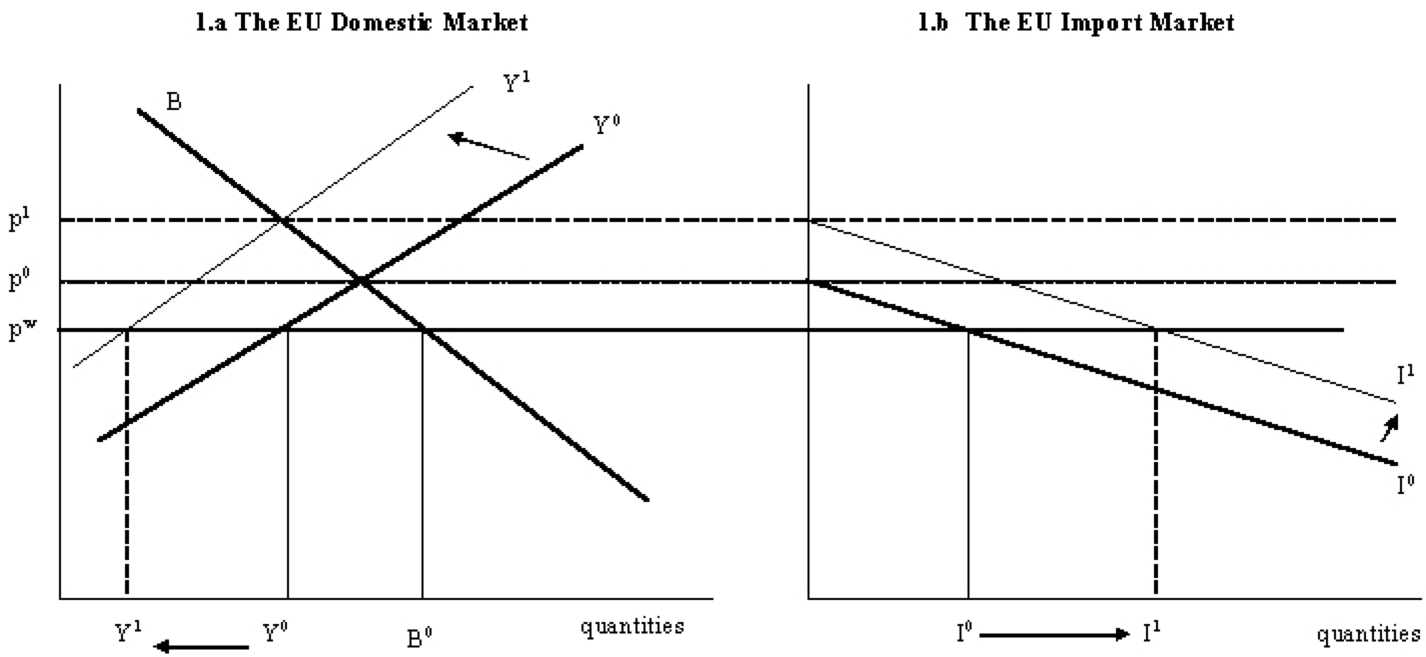

Figure 2. The Effects of EU Process Regulations on Imports with Import Price Effects (the homogeneous commodity case)

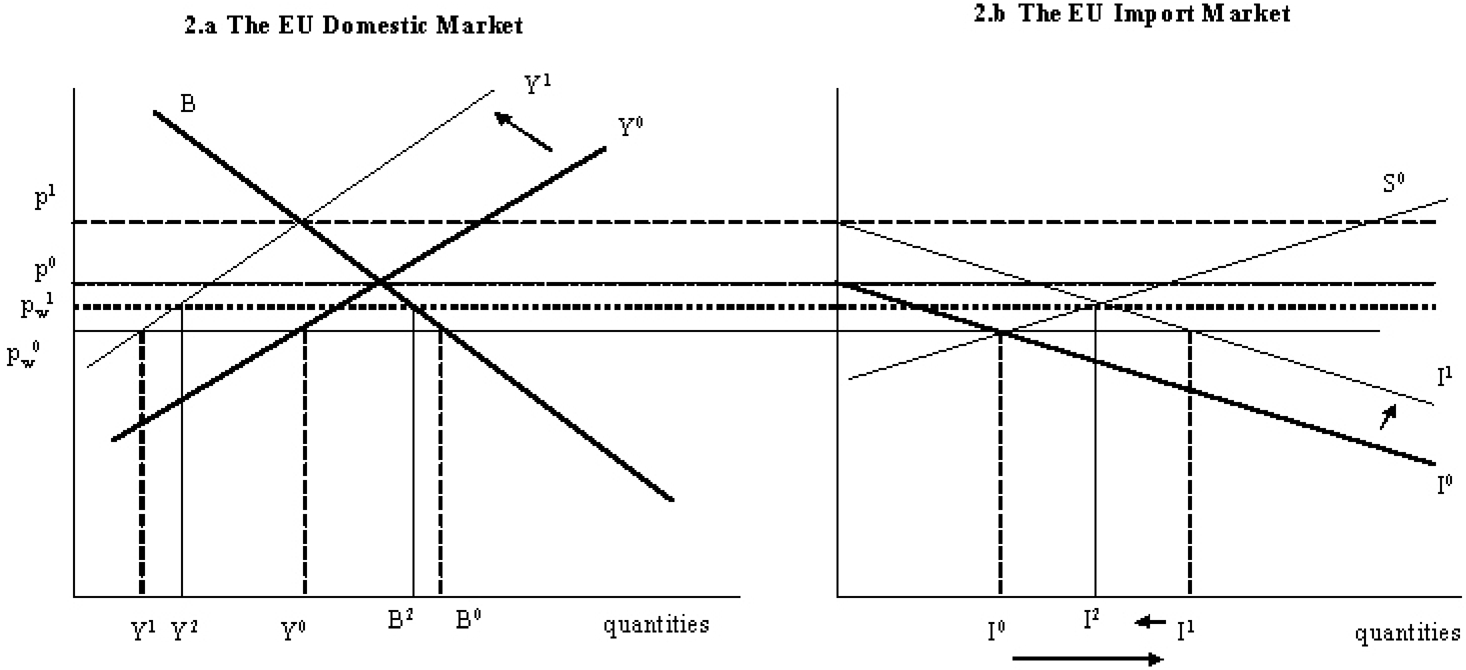

Figure 3. The Effects of EU Product Regulations on Imports with Import Price Effects (the homogeneous commodity case)

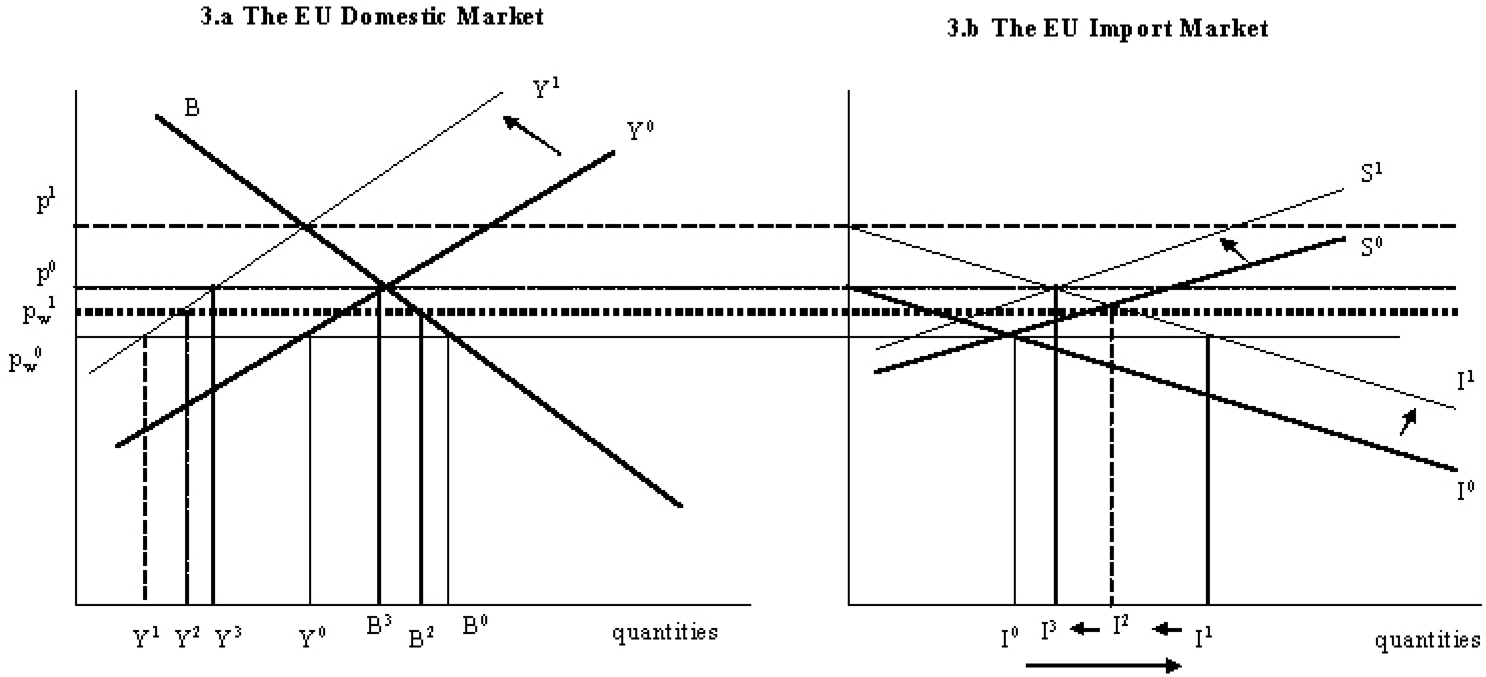

Figure 4. The Effects of EU Process Regulations on Imports with a Fixed Import Price (the differentiated product case)

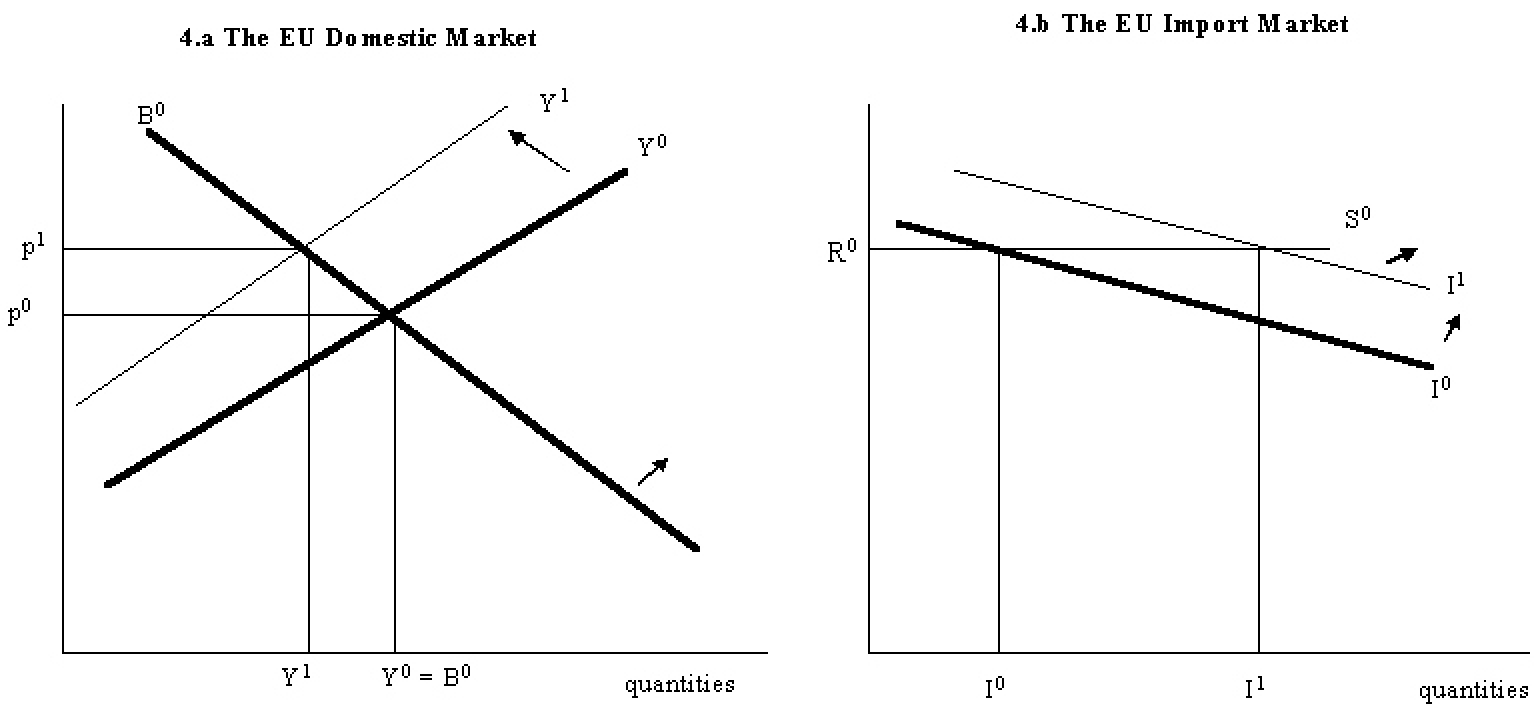

Figure 5. The Effects of EU Process Regulations on Imports with Import Price Effects (the differentiated product case)

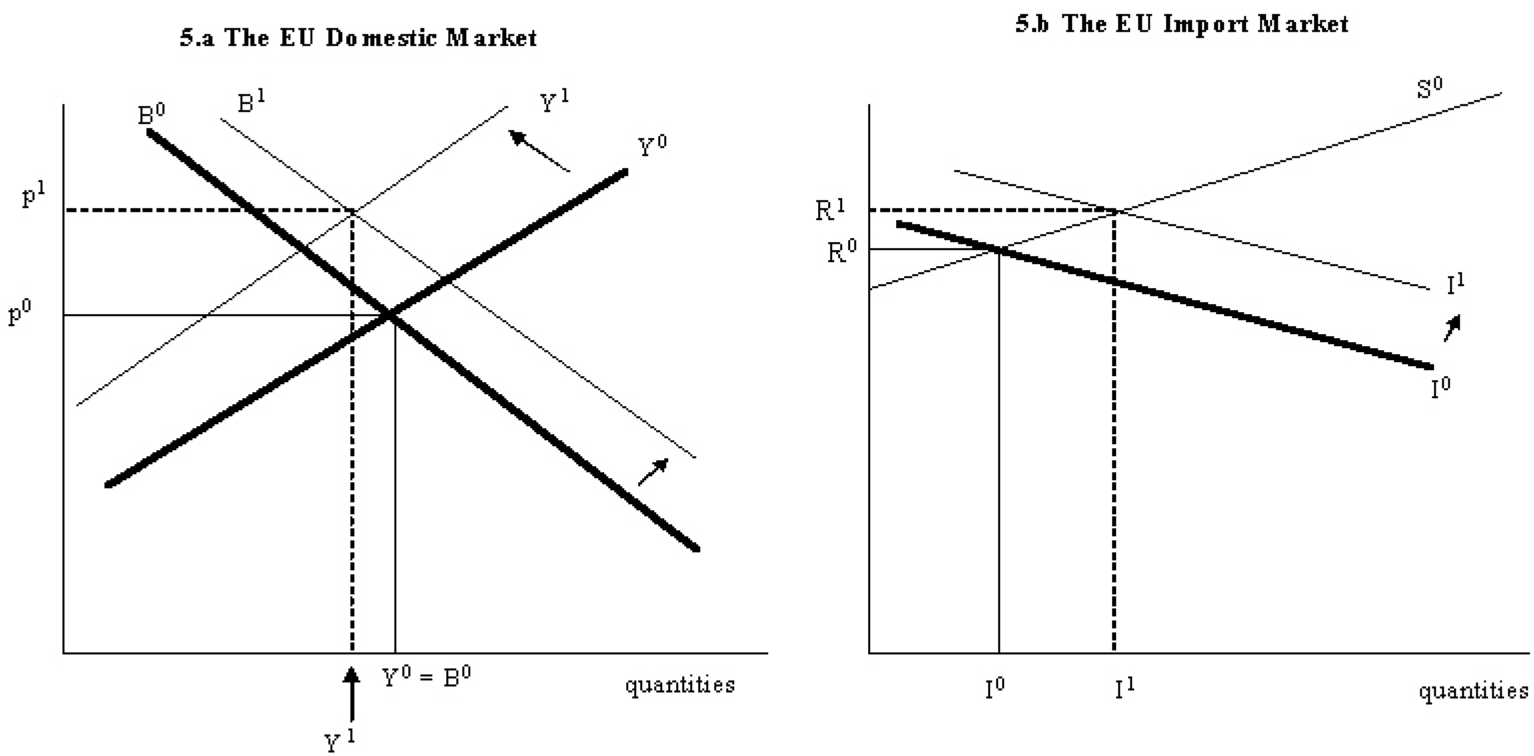

Figure 6. The Effects of EU Product Regulations also on Imports, with Import Price Effects (the differentiated product case)