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ABSTRACT

Product Labelling, Quality and International Trade*

This Paper analyses the reasons why countries may pursue different labelling policies in autarky and how this affects countries' welfare in the context of international trade. In an asymmetric information environment where producers know the quality of the goods they are selling and consumers are not able to distinguish between them, the quality governments choose to protect with a label depends on consumer preferences for and production costs of different qualities. Countries with different distributions of tastes and/or different production functions will thus decide to label differently. When they trade, welfare effects will be different on the country as a whole and on different types of consumers within each country, depending on whether countries choose to mutually recognize each others' labelling policy or to harmonize their policies. In particular it will be the case that a country with weak preferences for high quality will oppose the introduction of an international, harmonized label as it is better off under a regime of mutual recognition. When countries only differ in their costs of producing quality instead, none of the trading partners will lose from a move towards trade under an international, harmonized label.

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1. Introduction

This paper wants to contribute to the ongoing discussion on the role of labeling in international trade. It concentrates on the analysis of markets characterized by informational asymmetries, in the sense that producers know the quality of their products, but consumers do not.

In particular we focus on products, the quality of which, consumers only recognize after a rather long time span. The type of goods we have in mind are for instance food or medicaments that may have negative effects on health, effects that will only appear a very long time after the use of the product or that may never be known by the consumer.[3] This implies that consumers are back on the market to buy the products without knowing the quality of the product they previously bought. Think for instance of the consumption of beef and the risk of developing Creutzfeldt-Jakob disease. In order to judge the potential risk to health and thus the quality of the relevant piece of beef, consumers would like to know whether the beef they buy is BSE infected, which will in turn depend on the way the relevant animal has been fed. A consumer cannot observe any of these characteristics directly from the piece of meat he buys, nor may he ever find out, even if he develops Creutzfeldt-Jakob disease.[4] The amount of antibiotics used in the raising of salmon or cattle would be another example of the kind of product and product characteristics we have in mind and so would be the extent to which corn or soybeans are genetically modified.

Another characteristic of the products we focus on is that consumers value them differently. To be precise, we assume that consumers agree on the ranking of the relevant characteristic, but that they may have different subjective evaluations (or willingness to pay). Consumers will in general agree that it is safer to eat beef of a cow that has not been fed with animal flour than the opposite. But they may not agree on just how risky it is to consume the latter type of beef. Consumers may also not attach the same importance to their own health. As a consequence of BSE fears beef consumption fell in Germany by about 50 per cent. This implies that many consumers decided to stop buying beef because of the potential health risk its consumption may represent. Yet not all consumers shared this idea. Consumer opinions

[3] A product representing a higher risk for consumer health would thus be considered to be a product of lower quality.

[4] There is some discussion within the scientific community on whether the consumption of BSE infected beef may lead to the development of Creutzfeldt - Jakob disease in the humans or not. Of course, we have no pretensions to participate in this discussion. As economists, we mainly care about what consumers perceive as the potential consequences of the consumption of these goods, even if they are not correct.

may not only differ within countries, but also across countries. According to a MORI survey published in 1997, 78% of Swedes, 77% of French, 65% of Italians and Dutch, 63% of Danes and 53% of British said they would prefer not to eat genetically engineered food.[5] In this paper we will indeed allow for different distributions of consumers tastes across countries.

We will further assume that the product characteristic consumers are interested in affects production costs. In particular we assume that production costs increase with product quality. This assumption would hold for the examples given so far. Indeed the examples even refer to cases where the relevant characteristic is closely linked to production techniques that are aimed at reducing production costs. For instance, the costs of raising salmon decline the more salmons are raised in a given quantity of water. Yet salmons in overcrowded ponds are more likely to suffer from infectious diseases. In order to lower these risks antibiotics are administered to them, which in turn affect the characteristics of the product the final consumer buys.

We will show in this paper that in the absence of government intervention, higher quality products will tend to disappear from markets corresponding to the above-mentioned characteristics. As consumers cannot recognize the quality of the product they are buying they are only willing to pay a price corresponding to the average product quality they expect to be in the market. Any producer therefore takes the price he can receive for his product as given, which leads to a moral hazard effect in each individual firm's choice of quality. With production costs increasing in quality and prices being independent of individual product quality, a producer maximizes profits by producing the lowest quality. As a result high quality products will be driven out of the market and in equilibrium only low quality products will be provided. This "driving out" effect is typical of models with asymmetric information, like those presented in Akerlof (1970) and Leland (1979).[6] In our particular set-up this effect will drive all qualities but the lowest out of the market. Yet, given that consumers are heterogeneous, consumers will not be affected equally by this result. While consumers who prefer higher qualities will suffer, low quality consumers will not mind that high quality products disappear from the market.

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[5] As reported at http://www.centerforfoodsafety.org/facts&issues/polls.html

[6] An important difference between our set-up and the one used in Akerlof (1970) and Leland (1979) is that the supply of quality is endogenous in our paper, whereas it is exogenous in the two mentioned papers. Besides those papers assume that the price consumers are willing to pay is based on quality and quantity of products bought. We instead assume that each consumer only buys one product and production function is CRS in quantities making price depending only on product quality. In this sense our set-up is closer to those in Rosen (1974), Shapiro (1983) and Falvey (1989).

Government interventions that assure the provision of higher quality products can be welfare improving in our set-up. Said in another way: measures of consumer protection may be desirable. As we are restricting our analysis to goods the characteristics of which will only be noticed after a very long time-span (or never), private markets are unlikely to provide for mechanisms that avoid quality deterioration. In particular producers will not have the option to signal high quality or to build the reputation of being a high quality producer, like in the framework presented by Shapiro (1983) and Falvey (1989) or in the models of Bagwell and Staiger (1989) and Grossman and Horn (1988). Those papers assume that consumers know the quality of a good after consuming it once. Besides they assume that consumers can identify different producers when returning to the market and that they know which quality each of them produces.[7] In our set-up instead quality is only recognized a long time after consumption and consumers will return to the market to buy the product without knowing the quality of the product they bought previously.

Existing literature has analyzed the effect of imposed minimum quality standards on the equilibrium in set-ups of asymmetric information.[8] By enforcing a quality standard higher than the quality level prevailing without intervention the provision of higher quality products is obviously ensured through the introduction of a minimum standard. Though high quality consumers take advantage of this, low quality consumers would in our set-up lose from such an intervention. Policies that do not rule out the provision of low quality products thus seem to represent an attractive alternative. This would for instance be the case of mandatory labeling, i.e. the government obliges producers to provide on product labels the information that consumers would need in order to judge the quality of the product. Ideally there would be a different label for every product quality supplied in the market. The original market failure would be completely corrected, as consumers would have the same information producers have with regards to product quality. In practice and depending on the product concerned, this may however be a rather impracticable solution. Consumers may not gain much from labels that indicate exactly how many antibiotics and which type of them have been used to raise a particular salmon. Allowing for a high variety of labels may also turn out to be very costly, as governments, that guarantee the authenticity of labels, would have to develop mechanisms to control that the information indicated on labels is true.

[7] In Shapiro (1983) and Falvey (1989) producers can in every period change the quality they produce, but they do not have an incentive to do so in equilibrium. In Bagwell and Staiger (1989) and Grossman and Horn (1988) instead producers cannot change the quality they produce after the first period.
[8] See for instance Falvey (1989) and Donnenfeld et al. (1985).

In practice the term "label" is used for two different tools that are meant to provide consumers with information. Governments may oblige producers to provide their products with a label giving information on certain aspects of the product. One may for instance want to think of labels on food indicating the main components of the foods and the calorie-content. This type of labeling in fact goes in the direction of "perfect labeling", as the information indicated on the label differs according to the characteristics of each product. "Labels" are however also used to guarantee a certain minimum quality of the product. This would for instance be the case for an "eco-label" or a label indicating that a product is "GMO free". It is the latter type of label we have in mind in this paper.

In particular we will assume that only one label is introduced for the relevant product. Such a label has the characteristic that it divides the market for the relevant product into two categories, i.e. into labeled and unlabeled products. Note that this is what distinguishes a label from a minimum standard in our type of set-up. When a minimum standard is introduced the supply of products having a lower quality than this standard is ruled out. The introduction of a label instead guarantees that products carrying the label have at least the quality corresponding to the standard defined under the label. Lower quality products can be supplied in the market, but they are not allowed to carry the label.

It is realistic to assume that only one label (guaranteeing one minimum quality) is introduced, rather than two or a range of labels. When deciding to protect ecological production methods the German Ministry of Consumer Protection, Food and Agriculture, for instance, decided to introduce *one* eco-label that would protect *one* previously defined production standard. In order to define this standard different interested actors in the economy were asked to sit together and to find an agreement as to which standard to use. The difficulty to reach an agreement represents probably one of the arguments why policy makers do not try to define more than one label. Another argument is reflected in one of the criteria according to which the standard was supposed to be chosen, i.e. the standard should allow for an "easy and non-bureaucratic certification process".[9]

Our analysis can also be applied to the use of generic names in certain cases. In the European Union it has for instance been discussed whether chocolate containing vegetable fat instead of

[9] When it comes to eco-labeling there are even calls to harmonize labels across countries, in order to "avoid undue layers of technical requirements" and to avoid the dangers that are created by a "proliferation of different schemes for the same products based on conflicting criteria". (Abdel Motaal, 1999).

cocoa butter would be allowed to carry the name "chocolate" or not.[10] After a debate that lasted more than two decades it was decided that chocolate producers are allowed to incorporate up to five percent of vegetable fat in their product. Similar discussions took place concerning Tequilas and Margaritas. In 2000 it was proposed to lower the minimum level of agave (a cactus like plant) in tequila from the established minimum 51 percent to a level of 20 percent. At the same time there were petitions to define the contents of the so-called margarita, a lime cocktail being traditionally mixed with tequila, but increasingly being mixed with other, lower priced liquors. In both the chocolate and the tequila case, the generic name indicates a certain quality of the product, in these cases the maximum percentage of vegetable fat used and the minimum percentage of agave used. The petition to define the contents of a margarita would correspond to determining a minimum percentage of tequila to be used in the lime mix. In these cases, generic names thus have a function similar to the one of a label.

It is up to the government to decide which is the threshold amount guaranteed by the label. In other words, the government chooses the product quality protected by the label. This paper will analyze the government's decision and it will show that consumer preferences and production costs for/of different product qualities will play a crucial role in this decision. It will be shown that the informational asymmetry will lead to the survival of only two products after introduction of a product label: the lowest product quality and the quality corresponding to the minimum quality guaranteed by the label. The paper will also analyze how changes in the choice of label affect well-being of different types of consumers.

It has been mentioned before that it is not unrealistic to assume that consumer preferences differ across countries. Also production costs may differ across countries. According to the above arguments countries that differ in one or both aspects would choose a different quality label as being the optimal one under autarky. The next aspect analyzed in this paper will be the one of trade between countries with different labeling policies. In particular we will study two different approaches to trade liberalization. In the first case we assume that countries chose to accept each other's labels, which would be a situation of mutual recognition. In the second case we assume that the labeling policy is harmonized across the two countries. In particular we assume that an external body, like an international organization, sets an international standard such that the aggregate welfare of the two trading countries is maximized.

[10] It has in particular been suggested to use names like "industrial chocolate", "vegetable fat milk chocolate" or "vegelate" for "chocolate-like" products that do not contain a sufficiently high percentage

If countries only differ in the distribution of consumer preferences, the country where consumers attach relatively more importance to quality (home) will in autarky choose a labeling policy that guarantees a higher product quality than the other country (foreign). The labeled quality supplied at home in autarky is thus higher than the one supplied abroad. Trade liberalization with mutual recognition will then lead to a process of adverse selection resulting in the disappearance of the home label. Trade liberalization would thus in a sense lead to a "devaluation" of the home label. This reduces the welfare in the home country, as the product supply in the home country will end up corresponding to the distribution of preferences in the foreign country. Yet not everybody is worse off as a consequence of trade. Low quality consumers won't be affected at all as the lowest, non-label product quality continues to be supplied after trade. Those consumers who particularly like the product quality guaranteed by the foreign label will gain from trade. But high quality consumers will lose out as trade lowers the quality of the product protected by the label and, as a consequence, the labeled product supplied corresponds even less to their preferences after trade than before. If a policy of harmonization is pursued instead, the international label will end up protecting some quality level in between the ones protected under autarky in each of the countries. The home country will be better off than under a policy of mutual recognition, but the foreign country will lose from harmonization.

The analysis turns more complex if production costs are allowed to differ across countries. In particular we assume that one country (home) has a comparative advantage in the production of high quality goods, while the opposite is the case for the other country (foreign). It is now not clear a priori, which country will in autarky protect the higher product quality with its labeling policy, as this will depend among others on the assumptions on consumer preferences. It will however still be the case that trade liberalization under mutual recognition will evoke a process of adverse selection and "devaluate" the label in the country with the higher quality label in autarky. Even so, this country may gain from trade in this situation. Again the change in product quality supplied as a consequence of trade may have a negative effect on consumer welfare. Yet on the other hand there will be traditional gains from trade in the form of lower prices of imported products. The combination of the two effects will determine the country's total welfare gains from trade.

The rest of the paper is organized as follows. In section two we present an asymmetric information model in autarky on which the rest of the paper is based. In section three, labeling is introduced and its welfare effects on the country as a whole and on different types of

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of chocolate butter.

consumers are analyzed. In section four we look at the case of international trade, when countries are characterized by different distributions of consumer preferences or by different production costs. In this section we compare two different policy options: trade under a regime of mutual recognition of labels and trade under a harmonized label, set by an international agency that acts as a "world planner". Section 5 extends the model to two alternative policy options: trade when foreign labels are not recognized and trade under mutual recognition of labels when governments have the option to behave strategically, i.e. when governments can adapt their domestic labeling policy unilaterally once their country opens up to trade.

2. Autarky equilibrium without government intervention

Consumers

Our basic set-up is related to the one presented by Rosen (1974)[11]. We work in a partial equilibrium setup, and focus on a single good the quality of which may vary within the range $Q = [q_l, q_h]$. Each consumer can buy either zero or one unit of the good. We assume that consumers differ in their taste for quality (willingness to pay for the product), denoted by θ. There is a continuum of consumers indexed by θ, on the interval $\Theta = [\theta_l, \theta_h]$. The benefit to a consumer θ from purchasing one unit of quality q is θq, the cost is the price of the good, i.e., p(q). Therefore, the net benefit to a consumer of type θ of consuming one unit of good with quality q selling at price p(q) is

$$U(\theta, q) = \theta q - p(q), \tag{1}$$

if the consumer buys one unit of good with quality q, and

$$U(\theta, q) = 0, \tag{2}$$

otherwise. A consumer of type θ will find the quality level $q \in Q$ that maximizes his net benefits and then he will buy a unit of good of that quality if the net benefits he obtains from its consumption are positive. We assume consumers always have enough money to buy one unit of the good if it is optimal to do so. Besides we assume that when a consumer is indifferent between buying and not buying, he buys. The aggregate demand is generated by a distribution of consumers in Θ space, say $F(\theta)$.

Producers

In what concerns producers, we assume a perfectly competitive environment where producers can choose quality. We assume each firm produces a single unit. The cost of producing one unit is positive, increasing and convex in quality, i.e., $C(q) > 0$, $C'(q) > 0$, $C''(q) > 0$, for all $q \in Q$. As in the standard theory of the firm, the objective of each firm is to maximize profits. There is free entry.

Asymmetric information

We introduce asymmetric information into the above set-up, i.e. we assume that producers know the quality of their product, but consumers don't. In particular we assume that consumers can also not learn about the quality of a product for instance through repeated purchasing. One may for instance think of the long-term health effects of certain types of food or medicaments. Because of our assumption producers will not have the possibilities to build up a reputation as a high quality producer, like in the model presented by Shapiro (1983). In Shapiro's set-up high quality producers will sell their products below costs when they first enter the market, because consumers do not know the good's quality and are only willing to pay the price of low quality goods they know to be in the market. Once they have consumed the product, however, they know its quality and will be able to recognize its supplier when buying the good again. They will now be willing to pay a higher price, corresponding to the quality level they are aware off. In equilibrium high quality items will sell at a premium above their costs, with the premium serving as a compensation for the losses producers made in the first period of sales. One important outcome of the assumption of reputation building is that a significant range of the qualities that can be produced will actually be sold in the market.

In our set-up consumers cannot learn about the quality of a producer's goods. In this sense our model is closer to the ones by Akerlof (1970) and Leland (1979). In those models, consumers cannot recognize the quality of the product they are buying and consumers are therefore only willing to pay a price corresponding to the average product quality they expect to be in the market. As this price is lower than the production costs of high quality products, the latter will not be supplied anymore. High quality products will therefore be driven out of the market. As a result markets will end up underproviding quality relative to what would be socially optimal and in particular cases markets for certain products may even disappear completely. Our set-

[11] To be precise it is related to the long run version of the hedonic pricing model when goods have only one characteristic: section III.B of Rosen's paper (1974).

up, however, differs from the ones presented in Akerlof (1970) and Leland (1979) in that supply of quality is endogenous in our model and that consumers are assumed to buy only one unit of the differentiated good, i.e. only quality of goods matters to them, not quantity.

Equilibrium with asymmetric information

Concerning consumer expectations we make the following assumptions. Consumers have an *a priori* distribution of quality, say G(q), in their minds. We assume that this *a priori* distribution is the same for all consumers. As consumers cannot distinguish between qualities, each consumer will be willing to pay a single price, independent of the true quality of the product. Therefore, we can think of consumer θ as having a von-Neuman Morgenstern utility function and buying one unit of the good as long as

$$\theta \int_{ql}^{qh} q dG(q) \geq P \tag{3}$$

Qualities are undistinguishable and consumers therefore pay the same price for any quality. The price a producer receives for the quality he supplies will thus depend on the quality supplied by other producers in the market. Any producer therefore takes the price he can receive as given. This leads to a moral hazard effect in an individual firm's choice of quality. With production costs increasing in quality ($C'(q) > 0$), and price given and independent on individual product quality, a producer maximizes profits by producing the lowest quality. As a result only low quality goods will be provided in the market. Free entry drives profits of low quality producers to zero. As a result $P = P(q_l) = C(q_l)$. Note that for any price exceeding the production costs of the lowest quality, there is an incentive for new firms to enter and sell goods of qualities below any quality higher than the lowest one. This process will only come to a rest when the market price corresponds to the production costs of the lowest quality.[12]

We assume that consumers are rational and are aware of the incentive producers face to lower quality. So when they make their decision they know that the distribution of quality is degenerated in the low quality good, i.e., $G(q_l) = 1$.[13] So a consumer of type θ will buy the good if and only if

[12] See Donnenfeld et al. (1985) for a similar set-up.

[13] Note that our argumentation runs parallel to the one Shapiro (1983) presents when arguing that new entrants in the market will only receive a price equal to the cost of producing the lowest quality good. As Shapiro (1983) points out himself, in his set-up consumers' expectations about new products are not fully rational, because in the equilibrium entrants' qualities will on average be higher than the lowest one. In our set-up instead consumers' expectations are fully rational. As producers have no possibility to build up reputation and they have no incentive to enter the market with a quality higher than the q_l.

$$\theta q_l - P \geq 0 . \quad (4)$$

which implies

$$\theta q_l - C(q_l) \geq 0 . \quad (5)$$

It is easy to see that the market for the good does not disappear. It is only the market for the higher qualities that disappears, but the lowest quality will still be traded.

For the rest of the paper we will make the following assumptions:

$$\theta_l q_l - C(q_l) \geq 0 \quad (6)$$

$$\theta_l \geq C'(q_l) \quad (7)$$

$$\theta_h < C'(q_h) \quad (8)$$

Equations (6) and (7) imply that in equilibrium consumers θ_l will at least consume the lowest quality available in the market, that is, they will always be better off by consuming one unit of the lowest quality good than by not consuming at all. Equation (8) is imposed for technical reasons and it does not change the nature of our results; it tells us that in perfect information equilibrium there would be (high) qualities that would not be traded.

3. Labeling in autarky

In our model the introduction of a label would imply that any product having a quality higher or equal to $\hat{q}$ is allowed to carry the label. The product market is thus divided in two categories: all qualities $[q_l, \hat{q})$ belong to the category of products not carrying a label and qualities $[\hat{q}, q_h]$ belong to the category of products carrying a label. For simplicity we will assume that labeling is costless.[14] When choosing the "cut-off level" $\hat{q}$, i.e. the minimal quality a product must have to deserve a label, the government behaves like a benevolent planner. We thus assume that the government has the knowledge and the ability to choose the cut off level in such a way that consumers' welfare is maximized.

The lowest quality will thus be the only one being offered in equilibrium, which corresponds to consumers' expectations.

[14] Adding labeling costs would not have any significant effects on our analysis. Cases in which our results would change if labeling costs existed will be indicated in the paper.

First, let's take the cut off level $\hat{q}$ as given, looking at the consumer's problem. Consumer θ cannot distinguish between the qualities within the same class and so she will be willing to pay the same price for each type of good within one of the ranges, respectively P_1 and P_2. Hence, the decision of consumer θ will be

$$\max\{\theta\int_{q_l}^{\hat{q}} q\frac{dG(q)}{G(\hat{q})} - P_1, \theta\int_{\hat{q}}^{q_h} q\frac{dG(q)}{1-G(\hat{q})} - P_2\}. \quad (9)$$

Within each range of products the moral hazard effect discussed before will be at work and producers will have an incentive to produce the lower qualities of each range. Because of free entry the equilibrium price within each category will equal the unit production costs of the lowest quality that can be supplied within that category: i.e., $P_1 = C(q_l)$ and $P_2 = C(\hat{q})$. Consumers are aware of producers incentive to supply the lowest quality possible within each category. Therefore, the consumer θ problem reduces to:

$$\max\{\theta q_l - C(q_l), \theta\hat{q} - C(\hat{q})\}. \quad (10)$$

Consequently, consumers will be segmented, with all consumers in the range $[\theta_l, \hat{\theta}(\hat{q}))$ choosing to consume the lowest quality good and all the consumers in the range $[\hat{\theta}(\hat{q}), \theta_h]$ choosing to consume $\hat{q}$, where $\hat{\theta}(\hat{q}) = \frac{C(\hat{q})-C(q_l)}{\hat{q}-q_l}$.[15] As long as $\hat{\theta}(\hat{q}) > \theta_l$, $F(\hat{\theta})$*100% of the consumers will buy q_l and the remaining proportion of the population will buy $\hat{q}$.

As the following graph shows, the choice of the label will affect the utility of different consumers differently. The two bold lines reflect consumers' utility when consuming quality q_l and $\hat{q}_n$ respectively. Assume that a government decides that only products of the quality $\hat{q}_n$ or above are allowed to carry the label. It follows from the above that in that case all the qualities between $\hat{q}_n$ and q_l will disappear from the market and consumers will only have the choice between those two qualities. The product carrying the label is obviously of higher quality, but it is also more expensive. Whether or not it is optimal for a consumer to buy it will depend on how much she values quality, i.e. on her level of θ. The level of θ at the

[15] Whenever there it does not lead to confusion we will replace $\hat{\theta}(\hat{q})$ by $\hat{\theta}$

crossing point of the two bold lines, $\hat{\theta}_n$,[16] indicates the type of consumer that is indifferent between buying the good of the high or the low quality. All the consumers with a higher or equal θ will buy $\hat{q}_n$ and those with a lower θ will buy q_l. The graph shows what happens to consumers if the conditions for obtaining the label are changed and a quality of $\hat{q}_m < \hat{q}_n$ is sufficient to obtain the quality label. Quality $\hat{q}_n$ will then disappear from the market and only $\hat{q}_m$ and q_l will continue to be sold. The line between the two bold lines shows the utility different types of consumers obtain from consuming $\hat{q}_m$. As the graph shows, fewer people will now buy q_l, as the type of consumer indifferent between buying q_l or $\hat{q}_m$ is now given by $\hat{\theta}_m < \hat{\theta}_n$.[17] Consumers characterized by a θ higher than $\hat{\theta}_m$ but close to it will be better off with this new label. They have a relatively high preference for quality, but $\hat{q}_n$ was too expensive for them and they therefore ended up buying low quality under the previous label. With the new label instead they can afford buying the higher quality of the two available ones. Consumers with a very strong preference for quality instead (those with the highest θs) lose. Even though they prefer to buy $\hat{q}_m$ to buying q_l, they are worse off: they were willing to pay the high price for $\hat{q}_n$ and lose from the fact that $\hat{q}_n$ is not available anymore.

Result 1*: If the criteria for granting a label are lowered consumers with very strong preferences for quality will tend to be worse off. Consumers with very weak preferences for quality will be indifferent, as they choose to consume the unlabeled product in any case. A group of consumers with intermediate preferences for quality will however gain from the change, as they will be able to afford consuming the new label, whereas they could not afford the labeled product when the labeling criteria were stricter and labeled products were more expensive as a consequence.*

[INSERT GRAPH 1]

As we said before, we assume government's objective function to be social welfare, where social welfare is defined as the sum of the net benefits over consumers. The government's problem in setting the "optimal label" is then:

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[16] Where $\hat{\theta}_n$ corresponds to $\hat{\theta}(\hat{q}_n)$.

[17] Where $\hat{\theta}_m$ corresponds to $\hat{\theta}(\hat{q}_m)$.

$$\max_{\hat{q}\in Q} W = \int_{\theta_l}^{\hat{\theta}(\hat{q})} [\theta q_l - C(q_l)] dF(\theta) + \int_{\hat{\theta}(\hat{q})}^{\theta_h} [\theta \hat{q} - C(\hat{q})] dF(\theta) \tag{11}$$

From now we restrict our analysis to the set of distribution functions that have densities, so that we can write the government's optimization problem as:

$$\max_{\hat{q}\in Q} W = \int_{\theta_l}^{\hat{\theta}(\hat{q})} [\theta q_l - C(q_l)] f(\theta) d\theta + \int_{\hat{\theta}(\hat{q})}^{\theta_h} [\theta \hat{q} - C(\hat{q})] f(\theta) d\theta \tag{12}$$

The first order condition[18] is then given by

$$\int_{\hat{\theta}}^{\theta_h} \theta f(\theta) d\theta - [1 - F(\hat{\theta})] C'(\hat{q}) - \tfrac{\partial \hat{\theta}}{\partial \hat{q}} f(\hat{\theta}) [\hat{\theta}(\hat{q} - q_l) - (C(\hat{q}) - C(q_l))] = 0 \tag{13}$$

but as $\hat{\theta} = \hat{\theta}(\hat{q}) = \frac{C(\hat{q}) - C(q_l)}{\hat{q} - q_l}$,

$$- \tfrac{\partial \hat{\theta}}{\partial \hat{q}} f(\hat{\theta}) [\hat{\theta}(\hat{q} - q_l) - (C(\hat{q}) - C(q_l))] = 0 \tag{14}$$

The first order condition can therefore be reduced to:

$$\int_{\hat{\theta}}^{\theta_h} \theta f(\theta) d\theta - [1 - F(\hat{\theta})] C'(\hat{q}) = 0 \tag{15}$$

which can be rewritten as

$$[1 - F(\hat{\theta})].[E(\theta / \theta > \hat{\theta}) - C'(\hat{q})] = 0 . \tag{16}$$

The optimal label $\hat{q}^*$ is thus determined by:

$$E(\theta / \theta > \hat{\theta}(\hat{q}^*)) - C'(\hat{q}^*) = 0 \Leftrightarrow E[\theta / \theta > \hat{\theta}(\hat{q}^*)] = C'(\hat{q}^*) . \tag{17}$$

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[18] By Weierstrass's Theorem, we know that a solution to the problem (12) exists. The assumption of continuous distribution functions together with assumptions (7) and (8) guarantee the existence of a positive mass of agents preferring qualities in the range (q_l,q_h). This ensures us that an interior solution to this problem exists.

From here it is clear that $\hat{q}^*$ depends both on the distribution of consumer preferences F(.) and on the prevailing production costs for quality C(.). In order for $\hat{q}^*$ to be a maximum the following second order condition must be satisfied:

$$\frac{\partial}{\partial q} E(\theta / \theta > \hat{\theta}(\hat{q}^*)) < C''(\hat{q}^*). \qquad (18)$$

For the time being we assume that a solution to (17) and (18) exists and that it is unique[19].

4. Labeling and International Trade

We now start analyzing different situations that may lead to international trade. In our model different production costs will lead to different product prices in autarky and are thus likely to create an incentive to trade. As we saw in equation (17) a country's production costs will also affect the country's optimal label. The same is the case for the country's distribution of tastes for quality. If consumers in different countries differ in their preference for quality, each country will set a different label in autarky and we shall see that this can also create incentives to trade. In the following we will consider each case, differences in cost functions and differences in tastes, separately. Because it is easier to analyze we will treat the case of differences in consumer tastes first.[20]

When countries start trading domestic governments will need to decide how to treat foreign labels. We will in this section compare two different policy options: mutual recognition of labels and the introduction of an international label. Under the first scenario, each country accepts the trading partner's labeling policy and guarantees equal treatment between labeled imported products and labeled domestic products, even though each country has set its label according to different criteria. We will see in this section that a policy of mutual recognition will tend to lead to adverse selection, resulting in the disappearance of products carrying the label chosen according to stricter criteria, i.e. the label guaranteeing the higher of the two standards. The second scenario refers to the harmonization of labels across countries, i.e. countries decide to use the same criteria for the labeling of products. We assume that these criteria are chosen such as to maximize world welfare. One may assume the existence of an international labeling agency that takes the welfare of both countries into account when

[19] In the appendix we show some class of distribution and cost functions for which this is true.
[20] From what we saw in the previous section it follows that we will not be able to capture scale effects with this set-up; this happens because the function C(q, T)= C(q)T is linear in the quantity (T). The average cost for a given quality is thus constant and does not depend on the quantities produced.

defining the criteria of the international label. We will in this section compare which of the two policy options is preferable from the point of view of world welfare and from the point of view of each country's domestic welfare. From there we can make conclusions as to which policy option the different countries will prefer. A third policy option that is applied in practice is the one where countries simply do not accept each other's labels. Products carrying a foreign label will then be treated as unlabeled products in the domestic market. This policy option will be analyzed in the extensions to the model presented in section 5.

In order to analyze trade under a scheme of mutual recognition we need to make two further assumptions. First we assume that consumers cannot distinguish between a foreign label and a domestic label.[21] In particular we will assume that consumers cannot recognize a product's origin. They are informed about the foreign country's labeling requirements, but once the imported good is on the domestic market they cannot distinguish it from a good produced domestically.

An alternative and maybe more realistic assumption would be that consumers may be able to recognize a product's origin, but do not know the foreign country's labeling policy and assume that it corresponds to the labeling policy of the domestic government. Taking the example of eco-labels it may not be unrealistic to assume that a German consumer considers a Swiss or Swedish eco-label to guarantee a similar standard as the German eco-label. Along the same lines, a Dutch consumer may expect English chocolate to correspond to similar standards as the Dutch chocolate. When it comes to the qualities sold and the prices prevailing in equilibrium, this alternative assumption would lead to the same outcomes as the assumption made in the previous paragraph. The welfare effects would however be slightly more complicated, as under this alternative assumption consumers are in fact mistaken in their believes and take "wrong" decisions.[22] In order to keep the analysis as simple as possible we therefore stick to the assumption in the previous paragraph.

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[21] From a welfare point of view the situation where consumers can differentiate labels will lead to better outcomes than the opposite case, simply because the possibility to differentiate implies that consumers hold more information when deciding which quality to buy. In particular, the possibility to differentiate will rule out the adverse selection processes that will be discussed later on in this section.

[22] More consumers buy the labeled product than would do so, if they knew that the foreign label protects a lower quality. This can be seen from the following expression:

$\hat{\theta}(E(\hat{q}), q_l) = \frac{C(\hat{q}^{*R}) - C(q_l)}{E(\hat{q}) - q_l} = \frac{C(\hat{q}^{*R}) - C(q_l)}{\hat{q}^{*} - q_l} < \hat{\theta}(\hat{q}^{*R}, q_l) = \frac{C(\hat{q}^{*R}) - C(q_l)}{\hat{q}^{*R} - q_l}$, where the superscript "R" refers to country R .

The second assumption we make is that governments do not change their labeling policy once their country has opened up to trade. We will see that in certain cases, governments will have an incentive to behave strategically and to change the domestic label once they allow for the entry of foreign products. This case will also be treated in section 5.

4.1. Different distributions of preferences

We assume there are two countries, Home (H) and Rest of The World (R). We assume that H has a "stronger" bias in favor of quality.[23] This simply means that

$$E(\theta / \theta > \hat{\theta}) > E^R(\theta / \theta > \hat{\theta}),\ \forall \hat{\theta} \tag{19}$$

Taking into account equation (7) and the fact that $E(\theta) > \theta_l$, it must be true that $E(\theta) > C'(q_l)$. The solution for the optimal label in the two countries can therefore be represented as in the following graph:[24]

[INSERT GRAPH 2]

The graph shows that in autarky the product quality guaranteed by the label will be higher in H than in R: $\hat{q}^* > \hat{q}^{*R}$.

Mutual recognition of labels

What happens if countries open to trade? If consumers are not able to distinguish between $\hat{q}^{*R}$ and $\hat{q}^*$, i.e., they are denominated in the same way in both countries (e.g. "antibiotics-free" or "GMO-free"), then it happens that $\hat{q}^{*R}$ will crowd out $\hat{q}^*$ of the market. Consumers know that there are potentially two types of labeled products in the market, one of a lower quality than the other. They will not be willing to pay a price of $P = C(\hat{q}^*)$ for the labeled product, because they know that they may be buying a product of quality $\hat{q}^{*R}$, for which they would be paying too high a price. $P = C(\hat{q}^*)$ can therefore not be an equilibrium price, as consumers know that the average quality they buy would be lower than $\hat{q}^*$. What will happen instead is that foreign producers will start supplying labeled products at a lower

[23] Variables referring to country R will in the following be indicated with the superscript "R"

[24] The graph depicts the situation of a uniform distribution of tastes and a quadratic cost function (see appendix). Differences in tastes across countries could in this case be reflected in different upper bounds of the distribution function.

price. As to consumers all the labeled products look the same, they will buy those offered at a lower price. Domestic producers make losses at any price lower than $P = C(\hat{q}^*)$ and will cease production. As domestic producers are unable to signal the superior quality of their products, adverse selection leads to the disappearance of domestic producers and "low quality" drives "high quality" out of the market. The new equilibrium price is $P = C(\hat{q}^{*R})$. At this price producers do not make profits and consumers know that they are not deceived and that they are buying a product of quality $\hat{q}^{*R}$.

Result 2*: If countries only differ in preferences for quality a regime of mutual recognition will evoke a process of adverse selection that will result in the disappearance of the label set by the country with stronger preferences for high quality.*

In the new equilibrium the qualities available to consumers in both countries will be q_l and $\hat{q}^{*R}$. Trade thus leaves consumers in R unaffected, but country H loses from trade, because the new label is suboptimal from the point of view of country H. Country H will thus be worse off with trade than without and overall trade will be welfare reducing for the world in this set-up. Of course, we must take into account that this is a partial equilibrium analysis, so it may not be robust to a multi-good analysis. But above all, the result is in fact not surprising when considering that in the case treated here, there will be no production gains from trade, as both countries have the same cost functions. Trade with "mutual recognition" will then only lead to the undermining of the label in one of the two countries. Implicitly this means that instead of having two policy instruments, each of which corrects the existing informational market failure in the best possible way in one of the two countries, trade leads to the existence of only one label that has to do the job for both countries.[25] It is therefore not surprising that trade leads to welfare losses for the world as a whole in this case. Not everybody loses in country H though. As we know from the discussion of graph 1 some of the consumers who stop buying q_l and replace it by the newly available $\hat{q}^{*R}$ will be better off, whereas consumers having a strong preference for high quality will lose from trade, because $\hat{q}^*$ is not available anymore.

[25] This argument represents in a certain sense the "disadvantage of harmonization" when countries differ. Note besides that the assumption that labeling is costless is important for this result. If there were a cost for each label, two labels would be more costly than one and it would not be clear a priori, whether the disappearance of one label is welfare reducing.

Result 3*: If countries differ only in their distribution of tastes, the country with stronger preferences for high quality will lose from trade under a regime of mutual recognition of labels. The country with stronger preferences for low quality will be indifferent to trade.*

International label (harmonization)

What would happen if instead an international agency were responsible for deciding upon the label to be used in trading countries? It follows from the above argumentation that the world as a whole will again lose from trade, as two labels are better than one. But losses are smaller and above all distributed in a different way. When setting the criteria relevant for the label such an agency would aim at maximizing world welfare, i.e. the sum of the welfare of the trading countries.[26] Then we have $\hat{q}^{*W}$ as being the solution to $E^W(\theta/\theta > \hat{\theta}(\hat{q}^{*W})) = C'[(\hat{q}^{*W})]$, where $E^W(.)$ is the expectation under the distribution $F^W = \frac{L}{L+L^R}F + \frac{L^R}{L+L^R}F^R$, with L and L^R being, respectively, population at Home and the Rest of the World. In our example $\hat{q}^{*W}$ would be somewhere between $\hat{q}^{*R}$ and $\hat{q}^{*}$. As a consequence country R would now also lose from trade, whereas country H loses less in the presence of an international agency than in its absence. Why is this the case? Under mutual recognition it is as if there was a world planner who puts all the weight on the country with strong preferences for low quality; when we introduce the international agency, the home country will never be worse off, because now the world planner takes its welfare into account.

How much a country loses with the optimal international label as compared to a situation of autarky, will to a large extent depend on the country's distribution of tastes and on how close the international label is to its originally optimal label. Here countries' sizes will play a role. The bigger a country compared to the trading partner, the heavier the weight of home country preferences in the welfare function that the international agency maximizes. In the case for instance of the US trading with the Fiji islands, it is realistic to expect that the optimal international label will be close to the one that the US would chose in autarky.

Result 4*: From the point of view of world welfare and if countries only differ in their distribution of tastes, trade under a labeling policy set by an international entity is welfare superior to trade under a regime of mutual recognition. The country with stronger preferences for high quality will prefer labels to be set by an international entity, whereas the country with stronger preferences for lower qualities will prefer trade under a regime of mutual recognition.*

4.2. Different cost-functions

Assume now that countries do not differ in the distribution of their preference for quality, but differ in the cost functions producers face. In particular we assume that the marginal cost functions in the two countries correspond to the ones depicted in the following graph:

[INSERT GRAPH 3]

Analytically: the cost functions at home *C(q)* and abroad $C^R(q)$ are such that:

$C^R{}''(q) > C''(q)$, $C^R{}'(q_l) < C'(q_l)$ and $C^R{}'(q\_) = C'(q\_)$ with $q_l < q\_ < q_h$

In autarky the optimal label, $\hat{q}^*$, must satisfy in the home country:

$$E(\theta / \theta > \hat{\theta}(\hat{q}^*)) - C'(\hat{q}^*) = 0 \Leftrightarrow E[\theta / \theta > \hat{\theta}(\hat{q}^*)] = C'(\hat{q}^*) \qquad (20)$$

where $\hat{\theta}(\hat{q}^*) = \frac{C(\hat{q}^*) - C(q_l)}{\hat{q}^* - q_l}$

and in the rest of the world the optimal label $\hat{q}^{*R}$ is given by:

$$E(\theta / \theta > \hat{\theta}(\hat{q}^{*R})) - C^R{}'(\hat{q}^{*R}) = 0 \Leftrightarrow E[\theta / \theta > \hat{\theta}(\hat{q}^{*R})] = C^R{}'(\hat{q}^{*R}) \qquad (21)$$

where $\hat{\theta}(\hat{q}^{*R}) = \frac{C^R(\hat{q}^{*R}) - C^R(q_l)}{\hat{q}^{*R} - q_l}$

Note that the left hand sides of equations (20) and (21) differ even though the distribution of tastes f(θ) is the same in both countries. This difference stems from the fact that a country's cost function is taken into account in the determination of the indifferent consumer $\hat{\theta}$ and cost functions do differ across countries.

We assume the cost and distribution functions satisfy conditions previously mentioned in section 3.[27] Besides we have to make assumptions concerning the unit cost functions in the two countries, in order to analyze what happens when the countries start trading. In particular we make two further assumptions that will simplify the analysis of trade patterns. We assume that $C^R(q_l) < C(q_l)$ and that $C^R(q_t) = C(q_t)$ for $q_t < q_h$. This would imply that country R has a

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[26] We will use the subscript "W" (world) for variables referring to the international agency.

[27] Besides we assume that equations (6)-(8) are satisfied in each country with respect to the cost function of the other country.

comparative advantage in the production of lower qualities, whereas country H has a comparative advantage in the production of high qualities. From the analysis in the previous section we know that with trade only two types of products will remain in the market, one of which is q_l. Country R will thus always produce and export q_l, whereas depending on the parameters of the model any of the two countries may export the higher quality good. We will in the following assume that q_<q_t, which would for instance be the case when cost functions are quadratic. [28]

Depending on the parameters of the model, the following situations can then occur as to the optimal label in each country: [29]

i) In autarky equilibrium: $\hat{q}^{*R} < \hat{q}^* < q_t$

Preferences and cost functions are such that in autarky the foreign label protects a lower quality than the domestic label. For both labels it is however the case that the foreign country has a cost advantage in producing the corresponding protected quality.

ii a) In autarky equilibrium: $\hat{q}^* < \hat{q}^{*R} < q_t$, and $C(\hat{q}^*) < C^R(\hat{q}^{*R})$

ii b) In autarky equilibrium: $\hat{q}^* < \hat{q}^{*R} < q_t$ and $C(\hat{q}^*) \geq C^R(\hat{q}^{*R})$

In both cases iia) and iib) the domestic label protects a lower quality in autarky than the foreign label. This situation can for instance occur if there is a significant difference between the marginal costs at home and abroad in the low quality range. For the determination of trade patterns it is besides important to distinguish between the case where autarkic prices are lower for labeled products at home than abroad (iia) and the opposite case (iib).[30]

iii) In autarky equilibrium: $\hat{q}^{*R} < q_t < \hat{q}^*$

Like in case i), the foreign label protects a lower quality than the domestic label. Yet in this case the home country has a cost advantage in the production of the higher quality, domestic label. This situation is more likely the stronger consumer preferences for high quality.

iva) In autarky equilibrium: $q_t < \hat{q}^{*R} < \hat{q}^*$, and $C(\hat{q}^*) \leq C^R(\hat{q}^{*R})$

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[28] This is the case treated in the appendix.

[29] The cases $q_t < \hat{q}^* < \hat{q}^{*R}$ and $\hat{q}^* < q_t < \hat{q}^{*R}$ are not dealt with explicitly in this paper, but it is straightforward to deduce their treatment from the four cases that are presented.

[30] Note that we do not treat in detail the possible, but less interesting case of $\hat{q}^{*R} = \hat{q}^*$.

ivb) In autarky equilibrium: $q_t < \hat{q}^{*R} < \hat{q}^*$ and $C(\hat{q}^*) > C^R(\hat{q}^{*R})$

Again the foreign label protects a lower quality than the domestic label, but now the home country has a cost advantage in the production of both qualities. This situation is more likely to occur the stronger the preferences for high quality in both countries. Besides, also in this case, we need to differentiate between the case where autarkic prices are lower for labeled products at home than abroad (iva) and the opposite case (ivb).

For ease of exposition, we will in this section treat the situation of a harmonized, international label before the case of mutual recognition.

International label (harmonization)

Before dealing in detail with the different cases mentioned before, we want to point out one fundamental difference between trade when countries differ in cost functions and trade when countries differ in tastes. In the former case, countries have different labels in autarky because cost functions differ across countries. Trade allows countries in this case to take advantage of the other country's cost function if this is more advantageous than its own cost function, as it makes it possible to import goods at lower prices in these cases. This leads to a traditional type of gains from trade. In our set-up trade would thus ideally allow for production of each quality always to take place in the country where its production costs are lowest. This will indeed be the outcome attained in an equilibrium with an international label. Production costs would then in fact be the same across countries thanks to trade. As a result the optimal "world label" would also be optimal from the point of view of each single country. Contrary to the case treated in section 4.1 trade will therefore not per definition be inferior to a situation of no trade if only one label survives. This can also be seen from the welfare function (22). Welfare will always be increased by lowering the costs of production for q_l and/or $\hat{q}$. As f(θ) is the same in both countries, this is true for the welfare in each country and also for world welfare.

$$\max_{\hat{q}\in Q} W^W = \int_{\theta_l}^{\hat{\theta}(\hat{q})} [\theta q_l - C^R(q_l)] f(\theta) d\theta + \int_{\hat{\theta}(\hat{q})}^{\theta_h} [\theta \hat{q} - C^?(\hat{q})] f(\theta) d\theta \qquad (22)$$

Let the above equation represent world welfare. A world planner would then plot the lowest cost function into each of the two terms. For the first term this is per definition the foreign cost function, as we assumed that this country produces q_l at lower costs than the home country. It depends on the parameters of the model , which cost function is used in the second term. Graph 3 allows us to visualize part of the planners optimization problem. Choosing the

lowest unit cost function implies in this graph that the planner's first order condition will only reflect the bold sections of the marginal cost functions. As a result, C^R'(q) will apply for any $q \leq q_t$, whereas C'(q) applies for $q > q_t$.[31] In order to represent the whole optimization problem $E(\theta / \theta > \hat{\theta})$ needs to be plotted into the graph. This is done in graph 4i, for case i).

[insert graph 4i]

Graph 4i reflects that in the planner's problem $E(\theta / \theta > \hat{\theta}(\hat{q}^{*R}))$ is only taken into account for $q \leq q_t$, whereas $E(\theta / \theta > \hat{\theta}(\hat{q}^{*}))$ is valid for $q > q_t$. It is clear from the graph that the planner's problem has only one optimal solution, which is $\hat{q}^{*R}$.[32] The international label chosen by the world planner will thus be the foreign label. With this label trade increases welfare in the home country, as the country can now import both products, i.e. the labeled and the unlabeled product, at a lower price. Welfare in the foreign country remains unchanged. The outcome will be similar in cases iia) and iib), as is visible in graph 4ii). Again the optimal label from the world planner's point of view is $\hat{q}^{*R}$. The home country will in this trade equilibrium end up with a higher label than under autarky and with a higher welfare level. Welfare in the foreign country remains unchanged.

[Insert graph 4ii]

Case iv) represents a mirror image of case ii) with the difference that this time both autarkic optima lie above q_t. This implies that the home country's cost function is valid for the planner in this case. As a consequence $\hat{q}^{*}$ is the optimal international label. In this situation both countries gain from trade. The home country gains because it can import q_l at a lower price. The foreign country gains, because it also has quite a strong preference for high quality and can now import $\hat{q}^{*}$ at a lower price than the one corresponding to its domestic cost function. Case iii) is more complex and is therefore again exposed in a graph. Graph 4iii) shows that in this case valid functions cross both in the bold areas to the left of q_t and to the right of q_t, which implies that the planner's maximization problem has two local optima. Depending on the parameter values of the model, either $\hat{q}^{*}$ or $\hat{q}^{*R}$ leads to the highest of

[31] Represented by the bold sections in graph 3.
[32] Given by the point where a bold marginal cost function intersects with a bold function reflecting the truncated expected value of θ.

these two optima and the planner will chose the international label accordingly. The resulting welfare effects are represented in Table 1, and so are the other results presented so far in this subsection.

[Insert graph 4iii]

Table 1: international, harmonized label

Situation in autarky	Qualities supplied in both countries when countries trade under a regime of a harmonized, international label	Welfare W_{IL} in home country in trade equilibrium (autarkic welfare level: W_A)	Welfare W_{IL}^R in foreign country in trade equilibrium (autarkic welfare level W_A^R).
i) $\hat{q}^{*R} < \hat{q}^* < q_t$	$q_l, \hat{q}^{*R}$	$W_{IL} > W_A$	$W_{IL}^R = W_A^R$
iia) $\hat{q}^* < \hat{q}^{*R} < q_t$, $C(\hat{q}^*) < C^*(\hat{q}^{*R})$	$q_l, \hat{q}^{*R}$	$W_{IL} > W_A$	$W_{IL}^R = W_A^R$
iib) $\hat{q}^* < \hat{q}^{*R} < q_t$, $C(\hat{q}^*) \geq C^*(\hat{q}^{*R})$	$q_l, \hat{q}^{*R}$	$W_{IL} > W_A$	$W_{IL}^R = W_A^R$
iii) $\hat{q}^{*R} < q_t < \hat{q}^*$	a) $q_l, \hat{q}^{*R}$ b) $q_l, \hat{q}^*$	a) $W_{IL} > W_A$ b) $W_{IL} > W_A$	a) $W_{IL}^R = W_A^R$ b) $W_{IL}^R > W_A^R$
iva) $q_t < \hat{q}^{*R} < \hat{q}^*$, $C(\hat{q}^*) \leq C^R(\hat{q}^{*R})$	$q_l, \hat{q}^*$	$W_{IL} > W_A$	$W_{IL}^R > W_A^R$
ivb) $q_t < \hat{q}^{*R} < \hat{q}^*$, $C(\hat{q}^*) > C^R(\hat{q}^{*R})$	$q_l, \hat{q}^*$	$W_{IL} > W_A$	$W_{IL}^R > W_A^R$

Mutual Recognition

Given that the production of the lowest quality good is cheaper in the foreign country than at home, the foreign country will supply this quality when countries start trading under a system of mutual recognition. As for the labeled product, it will again be the case that a process of adverse selection will lead to the disappearance of one label, i.e. the label that is supplied at the higher price in the market. When looking at the left column in table 2, one can conclude that in all but the cases iia) and iva) the adverse selection process will lead to the disappearance of the home label from the international market, as the foreign labeled product

will be supplied at a lower price once countries allow for trade. Welfare will therefore be unchanged in the foreign country with or without trade, as both qualities will be supplied by this country in the trade equilibrium and they will be supplied at the same price as under autarky. When comparing this outcome with the one in a regime of an international label, we see that in case i), iib) and iiia) the foreign country is equally well off under both regimes. In case iiib) and ivb) however it would have been better if the home label had survived instead of the foreign label. This is true from the point of view of world welfare and the point of view of the foreign country's welfare.

Table 2: mutual recognition

Situation in autarky	Qualities supplied in both countries when countries trade under a regime of mutual recognition	Welfare W_{MR} in home country in trade equilibrium (autarkic welfare level: W_A)	Welfare in country R W_{MR}^R in trade equilibrium (autarkic welfare level W_A^R).
i) $\hat{q}^{*R} < \hat{q}^* < q_t$	$q_l, \hat{q}^{*R}$	$W_{IL} = W_{MR} > W_A$	$W_{IL}^R = W_{MR}^R = W_A^R$
iia) $\hat{q}^* < \hat{q}^{*R} < q_t$, $C(\hat{q}^*) < C^*(\hat{q}^{*R})$	$q_l, \hat{q}^*$	$W_{IL} > W_{MR} > W_A$	$W_{IL}^R = W_A^R > W_{MR}^R$
iib) $\hat{q}^* < \hat{q}^{*R} < q_t$, $C(\hat{q}^*) \geq C^*(\hat{q}^{*R})$	$q_l, \hat{q}^{*R}$	$W_{IL} = W_{MR} > W_A$	$W_{IL}^R = W_{MR}^R = W_A^R$
iii) $\hat{q}^{*R} < q_t < \hat{q}^*$	$q_l, \hat{q}^{*R}$	a) $W_{IL} = W_{MR} > W_A$ b) $W_{IL} > W_{MR} >< ? W_A$	a) $W_{IL}^R = W_{MR}^R = W_A^R$ b) $W_{IL}^R > W_{MR}^R = W_A^R$
iva) $q_t < \hat{q}^{*R} < \hat{q}^*$, $C(\hat{q}^*) \leq C^R(\hat{q}^{*R})$	$q_l, \hat{q}^*$	$W_{IL} = W_{MR} > W_A$	$W_{IL}^R = W_{MR}^R > W_A^R$
ivb) $q_t < \hat{q}^{*R} < \hat{q}^*$, $C(\hat{q}^*) > C^R(\hat{q}^{*R})$	$q_l, \hat{q}^{*R}$	$W_{IL} > W_{MR} >< ? W_A$	$W_{IL}^R > W_{MR}^R = W_A^R$

The welfare effects in the home country are more complex. The possibility to import q_l at a lower price will in all the cases lead to welfare gains from a move towards trade. In the cases i), iib) and iiia) the level of welfare under a regime of mutual recognition is therefore welfare superior to no trade and leads to the same level of welfare as a regime with an international label. In cases iiib) and ivb) instead the home country suffers at the same time losses because the home label actually guarantees a higher welfare level in the home country than the foreign label. This follows from the discussion in the paragraphs on the international label. Welfare under a regime of mutual recognition is therefore lower in these cases than under a regime of an international label. The change in welfare with respect to autarky is instead ambiguous.

Of the two remaining cases, case iia) is the most interesting one. In this case the home label survives when countries start trading, because its price is lower than the foreign labeled product. The foreign country would be able to produce this good more cheaply, but it is not allowed to as according to the foreign country's rules goods produced locally do not obtain a label if their quality is below $\hat{q}^{*R}$. The foreign country thus loses out for two reasons: the labeled product is supplied at too high a price and the optimal label to survive would in any case have been the foreign label. As a result the foreign country is worse off than in autarky. With respect to the autarkic situation, the home country instead gains from trade, because it can import q_l at a lower price.

Result 5: *If countries only differ in their production costs, trade under a regime of mutual recognition will evoke a process of adverse selection that will result in the disappearance of one of the two labels. The label of which country disappears depends on the parameters of the model.*

Result 6: *If countries only differ in their production costs, trade under a regime of mutual recognition can have perverse effects on the allocation of production, in the sense that goods may be produced in countries and exported by countries that have a comparative cost disadvantage in the production of these goods.*

In the remaining case, case iva) the home label survives, which is optimal from the home country's and the world planner's point of view. Also the foreign country gains from importing the higher quality good with the home label, that is besides supplied at a lower price than would be the case if the same quality was produced in the foreign country.

The above discussions leads to the following result:

Result 7: *From the point of view of world welfare and if countries only differ in their production costs, trade under a labeling policy set by an international entity is welfare superior to a situation without trade and to trade under a regime of mutual recognition. Besides, none of the trading countries will lose from a move towards trade under a labeling policy set by an international entity, independent of whether the starting-point is autarky or trade with mutual recognition.*

5. Extensions

5.1 When governments do not recognize foreign labels

Instead of recognizing each others' labels or trying to agree on a harmonized label, countries may decide simply not to recognize labels that are not domestic. In this case, products carrying a foreign label will simply be treated like non-labeled products in the market of the importing country and as a consequence consumers will consider all imported products to be products of the lowest quality.

Different distribution of preferences

When consumers consider all imported products to be products of the lowest quality no country will export its labeled products as it will not be able to sell it at an acceptable price. There may be trade in q_l, but the prices of this good have not changed with respect to autarky. As a consequence trade will under this regime lead to the same outcome as in autarky, if countries only differ in the distribution of their preferences.

Different cost-functions

The home country will end up importing products of the lowest quality q_l as they are produced more cheaply abroad than at home. The product carrying the home label will continue to be supplied in the home country and at the same price. As a consequence the home country is better off in a situation of trade without recognition of foreign labels than in a situation of autarky. In the cases iiib) and iv) this outcome corresponds besides to the country's welfare maximizing solution in the case of trade, i.e. the outcome when an international label is used. In all the other cases, non recognition of labels is welfare inferior at home to the implementation of an international label. When comparing the outcome to the one under mutual recognition of labels, we see that non recognition of labels leads to the same level of welfare as mutual recognition in cases iia) and iva) and to higher welfare in cases iiib) and ivb). Contrary to the case of mutual recognition, no recognition leads to the survival of the wrong qualities in the cases i), iib) and iiia). In the first two cases the surviving quality is besides supplied at the least advantageous cost function and is thus more expensive than necessary. In all three cases no recognition is therefore welfare inferior to trade under a regime of mutual recognition.

In the foreign country no recognition of labels leads exactly to the same outcome as autarky: q_l and $\hat{q}^{*R}$ will be the qualities supplied in the market and they will both be produced at home. This leads us to the following main result of this section:

Result 8*: Trade without recognition of foreign labels will in no country be welfare inferior to the situation of no trade, independent of whether countries differ in preferences for quality or in production costs.*

5.2 When governments behave strategically.

So far we assumed that governments set domestic labels in autarky and either keep domestic labels at the same level when they open up for trade or agree with the trading partner on an international label. One could alternatively imagine the situation in which a government unilaterally adapts the domestic labeling policy once the country opened up for trade. This would allow the government to take the possibility of trade into account when maximizing domestic welfare. In the following we will continue to assume that consumers cannot differentiate between domestic and foreign labels, but that both governments can behave strategically when opening up for trade. We will ask the question whether Nash equilibria exist leading to welfare superior outcomes than the option of trade under mutual recognition and without strategic behavior.

Different distribution of preferences

When countries only differ in the distribution of their preferences, the foreign country has no incentive to change its domestic label as long as the home country sets a label that protects a quality equal or higher than $\hat{q}^{*R}$, as $\hat{q}^{*R}$ would be the label to survive in the case of trade and this is the label that maximizes the foreign country's welfare. What about the home country? If the home country lowers the domestic label to $\hat{q}^{*R}$, this would allow domestic firms to survive and sell labeled products. But given that firms don't make profits in our set-up this would not lead to any welfare increases. It is not in the interest of the home country to set the domestic label below $\hat{q}^{*R}$, as this would only lead to further reductions in domestic welfare.

Result 9: *When countries only differ in preferences the country with the stronger preferences for high quality will not be able to avoid the welfare losses caused by trade under mutual recognition even if it has the option to adapt its labeling policy.*

Different cost functions

The outcome is quite different when countries only differ in their production costs. Remember that in this case both countries pursue the same interest: guarantee the survival of the label that allows them to use both countries' cost functions in the most advantageous way, i.e. guarantee the survival of the label that a world planner would set. As this label is the one that maximizes each single country's welfare when trade is possible, it is in the interest of each country to adapt its domestic label to this level in order to make sure that this label survives and that consumers are informed about the quality that is protected by it. In other words strategic behavior by domestic governments will be able to replicate the outcome that would be obtained by a world planner. In particular, this will imply that the home country lowers its label to $\hat{q}^{*R}$ in the cases i), iiia) and iva) and that it increases its label to $\hat{q}^{*R}$ in cases iia) and iib). The foreign country will instead adapt its policy in the remaining cases and increase its label to $\hat{q}^{*}$ in cases iiib) and ivb).

Result 10: *When countries only differ in production costs and when allowing for strategic behavior of governments, each country will set its domestic labeling policy such that the world planner's optimal solution is reached. The outcome will thus be the same as the one reached under a harmonized, international label.*

6. Conclusions

We presented a model of asymmetric information, where producers know the quality of the goods they are selling, while consumers do not know the quality and also cannot learn about it through repeated purchase of the product. Because production costs increase with product quality, low quality products will in our framework drive high quality products out of the market. As a result only the lowest product quality will be supplied in equilibrium. A product label introduced by the government and that is given to products satisfying a certain minimum quality will be welfare improving in our model, as the label allows for the supply of an additional quality in equilibrium: the quality certified by the label. The definition of the optimal label, i.e. of the label that maximizes consumer welfare, will depend on the

distribution of consumer preferences and on production costs. Countries differing in one (or both) of the two aspects will thus pursue different labeling strategies in autarky.

In our set-up the welfare effects of trade will depend on whether countries differ in their preferences for quality or in their production costs. We analyze the two situations separately. We also distinguish between two different regimes of trade: trade under mutual recognition of labels and trade under a harmonized label, set by an international agency that acts as a "world planner". We find that a regime of mutual recognition will evoke a process of adverse selection that will result in the disappearance of one of the two labels. If countries only differ in the distribution of tastes the label that disappears will be the one set by the country with the stronger preferences for high quality. As a consequence this country loses from trade, whereas the other country is indifferent to trade. World welfare can be increased if an international label is introduced by a world planner who takes into account the preferences for quality of both countries. While the country with stronger preferences for high quality gains from a move towards this policy, the country with the weaker preferences for high quality loses (compared to the situation of both autarky and trade under mutual recognition) and will thus oppose the introduction of a harmonized label.

If countries only differ in their production costs, it depends on the parameters of the model the label of which country will disappear if countries trade under a regime of mutual recognition. It also depends on the parameters of the model which country loses or gains from trade under mutual recognition. In certain situations trade under mutual recognition can have perverse effects on the allocation of production, in the sense that goods may be produced in countries and exported by countries having a comparative cost-disadvantage in the production of the relevant goods. From the point of view of world welfare trade under a labeling policy set by an international entity is welfare superior to a situation without trade and to trade under a regime of mutual recognition. Besides, none of the trading countries will lose from a move towards trade under a labeling policy set by an international entity, independent of whether the starting-point is autarky or trade with mutual recognition. Yet the outcome reached by a harmonized international label will also be reached if governments behave strategically, i.e. if they adapt their labeling policy unilaterally when opening up to trade.

Independent of whether a policy of mutual recognition or an international label is chosen, trade will create winners and losers within each country whenever trade leads to a change in the definition of the label that is supplied in the market. If, for instance, the criteria for granting a label are lowered, consumers with very strong preferences for quality will tend to be worse off. Consumers with very weak preferences for quality will be indifferent, because

they will in any case consume the unlabeled product. A group of consumers with intermediate preferences for quality will however gain from the change, as they will be able to afford consuming the new label, whereas they could not afford the labeled product when the labeling criteria were stricter and labeled products were as a consequence more expensive. Welfare gains or losses are thus not distributed equally within each country and as a consequence internal opposition against a move towards trade cannot be excluded.

7. References

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A. Appendix

Model with uniform distribution of tastes and quadratic cost function

Consider a uniform distribution defined in the range $[\theta_l, \theta_h]$:

$$f(\theta) = \frac{1}{\theta_h - \theta_l}$$

$$F(\theta) = \frac{\theta - \theta_L}{\theta_h - \theta_l}$$

The expected value of the truncated distribution at threshold value $\hat{\theta} \in (\theta_l, \theta_h)$ is

$$E[\theta / \theta > \hat{\theta}] = \frac{1}{1 - F(\hat{\theta})} \int_{\hat{\theta}}^{\theta_h} \frac{\theta}{\theta_h - \theta_l} d\theta = \frac{\theta_h - \theta_l}{\theta_h - \hat{\theta}} \int_{\hat{\theta}}^{\theta_h} \frac{\theta}{\theta_h - \theta_l} d\theta = \frac{\theta_h + \hat{\theta}}{2}$$

and its first and second derivatives are respectively:

$$\frac{\partial}{\partial \hat{\theta}} E[\theta / \theta > \hat{\theta}] = \frac{1}{2},$$

$$\frac{\partial^2}{\partial \hat{\theta}^2} E[\theta / \theta > \hat{\theta}] = 0.$$

Therefore, it is obvious that the expected value of the truncated distribution as a function of the threshold level is a straight line with slope $\frac{1}{2}$.

A.1 One country case

Consider the following quadratic cost function:
$C(q) = a+bq+cq^2$, with a>0, b>0, c>0.

Conditions (9)-(10) imply that

(9') $\theta_l \geq b + 2cq_l$

(10') $\theta_h < b + 2cq_h$

The first order condition in our model is:

$$\int_{\hat{\theta}}^{\theta_h} \theta f(\theta) d\theta - [1 - F(\hat{\theta})] C'(\hat{q}^*) = 0,$$

which under the assumptions imply:

$$\int_{\hat{\theta}}^{\theta_h} \frac{\theta}{\theta_h - \theta_l} d\theta - \left[\frac{\theta_h - \hat{\theta}}{\theta_h - \theta_l} \right] \cdot (b + 2c\hat{q}^*) = 0,$$

which is equivalent to:

$$\left(\frac{\theta_h - \hat{\theta}}{\theta_h - \theta_l} \right) \left[\frac{1}{2} \left(\theta_h + \hat{\theta} \right) - b - 2c\hat{q}^* \right] = 0.$$

We saw in the paper that the threshold level must be

$$\hat{\theta} = \frac{c\left[(\hat{q}^*)^2 - (q_l)^2 \right] + b(\hat{q}^* - q_l)}{\hat{q}^* - q_l} = b + c\left(\hat{q}^* + q_l \right),$$

so the first order condition thus can be simplified to:

$$\frac{1}{2}\left(\theta_h + b + c\hat{q}^* + cq_l \right) - b - 2c\hat{q}^* = 0$$

or

$$\theta_h + cq_l - b = 3c\hat{q}^* \Leftrightarrow \hat{q}^* = \frac{\theta_h + cq_l - b}{3c}.$$

A solution for this equation exists under the assumptions made to our model.

It is easy to check that the assumptions (9') and (10') ensure that $\hat{q} \in (q_l, q_h)$ (as we imposed when equating the first order condition to zero):

$\hat{q}^* > q_l \Leftrightarrow \theta_h > 2cq_l + b$ and this is ensured by (9') because $\theta_h > \theta_l \geq 2cq_l + b$;

$\hat{q}^* < q_h \Leftrightarrow \theta_h < 3cq_h - cq_l + b$ and this is ensured by (10') because $\theta_h < 2cq_h + b < 3cq_h - cq_l + b$.

As for the second order condition, derivation of the first order condition gives:

$$\frac{1}{2}c - 2c = -\frac{3}{2}c < 0,$$

which is always satisfied (we imposed c>0).

A.2 Trade: two countries case

Call the country we just described H. Consider a different country R.

A.2.1 Different distributions of preferences

Assume both countries face the same cost function. And that assumptions (9') and (10') are verified for both countries.

However, country R has a different distribution of H in the sense that the support of the uniform distribution is different, i.e., $\Theta = [\theta_l, \theta_h]$ and $\Theta^R = [\theta_l, \theta_h^R]$, where $\theta_h^R < \theta_h$. Therefore

$$E^R[\theta / \theta > \hat{\theta}] = \frac{1}{1 - F(\hat{\theta})} \int_{\hat{\theta}}^{\theta_h^R} \frac{\theta}{\theta_h^R - \theta_l} d\theta = \frac{\theta_h^R - \theta_l}{\theta_h^R - \hat{\theta}} \int_{\hat{\theta}}^{\theta_h} \frac{\theta}{\theta_h^R - \theta_l} d\theta = \frac{\theta_h^R + \hat{\theta}}{2},$$

and so the condition (25) in the paper is verified (with the qualification that $\hat{\theta} < \theta_h^R$), i.e.,

$$E[\theta / \theta > \hat{\theta}] = \frac{\theta_h + \hat{\theta}}{2} > E^R[\theta / \theta > \hat{\theta}] = \frac{\theta_h^R + \hat{\theta}}{2}, \forall \hat{\theta} \in \Theta^R.$$

A.2.2 Different cost functions

Assume now that the distribution function is the same, but cost functions differ. The cost function of H is the one specified in 1.1 whereas the cost function of R is given by

$C^R(q) = a^R + b^R q + c^R q^2$, with $a^R > 0$, $b^R > 0$, $c^R > 0$

and the following relation between parameters:

$a > a^R$, $b > b^R$ and $c < c^R$;

$$q_l < \frac{b - b^R}{2(c^R - c)};$$

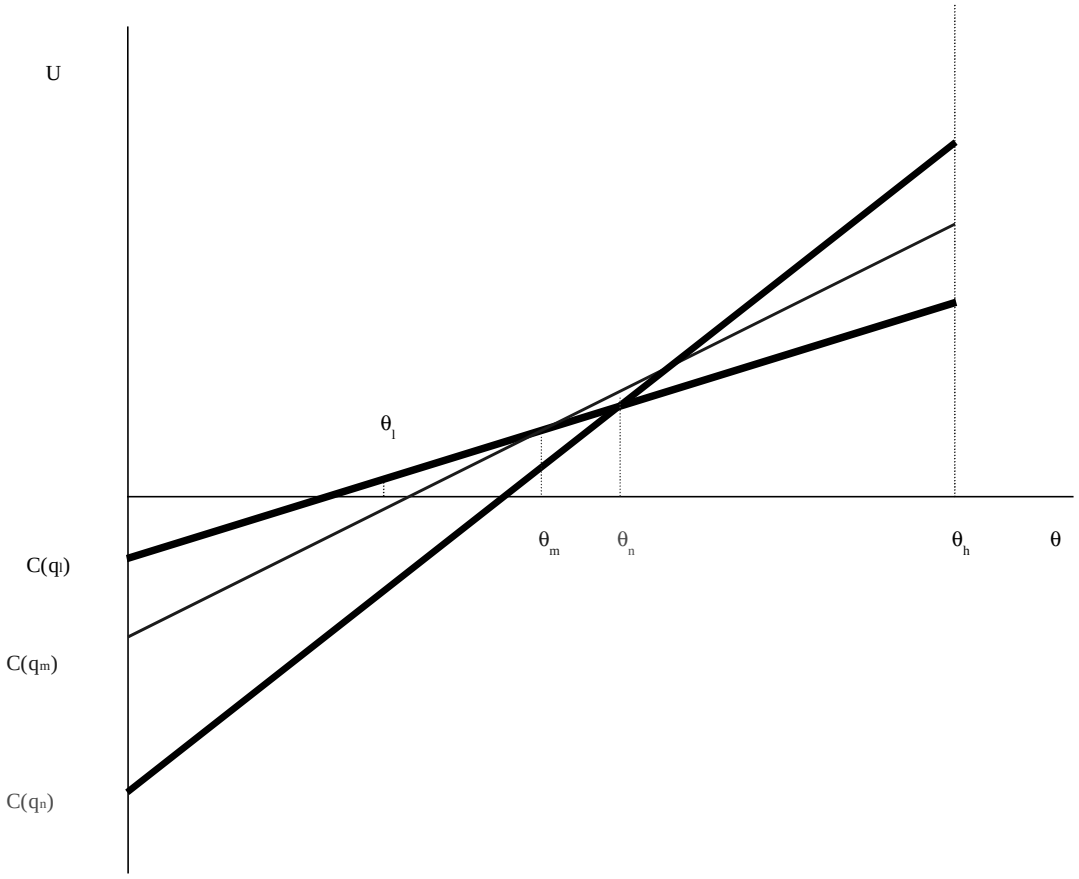
$$q_h > \frac{b - b^R}{2(c^R - c)}.$$

Simple computations show that $q\_ = \frac{b - b^R}{2(c^R - c)}$; and

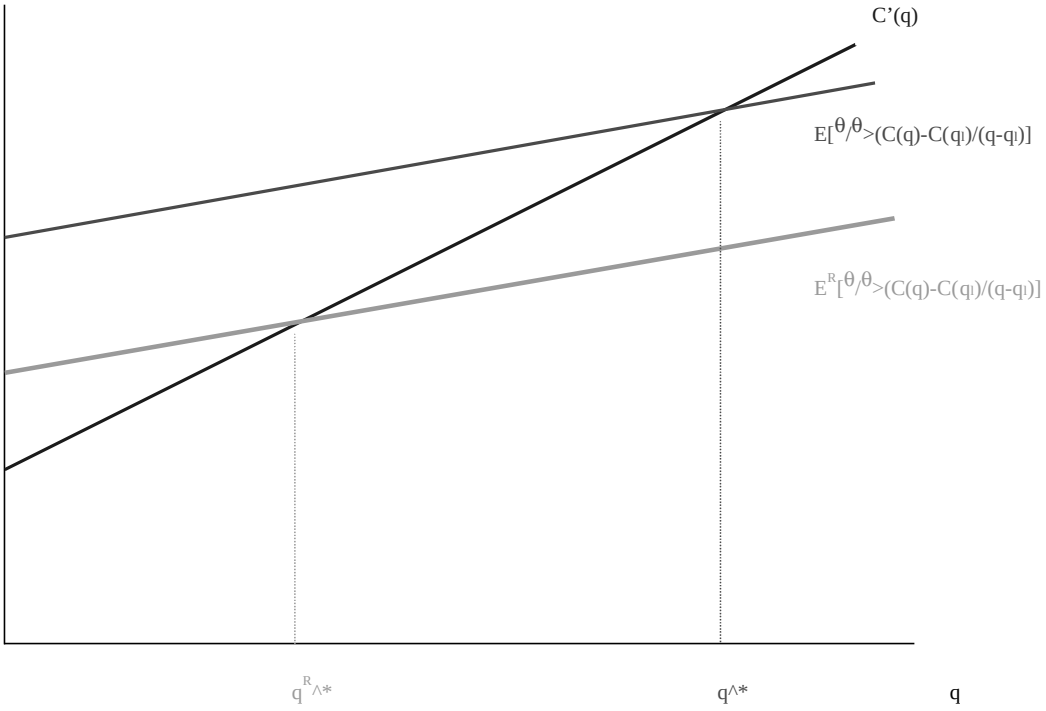
$$q_t = \frac{1}{2}\left(\frac{b - b^R}{c^R - c}\right) + \frac{1}{2}\sqrt{\frac{\left(b - b^R\right)^2}{\left(c^R - c\right)^2} - 4\frac{\left(a^R - a\right)}{\left(c^R - c\right)}} > \frac{\left(b - b^R\right)}{\left(c^R - c\right)}.$$

Therefore the uniform distribution and the quadratic cost function case are a special case of the more general specification given in the text. Given this parameterization a more explicit welfare analysis of the mutual recognition and the international standard agency can be done.

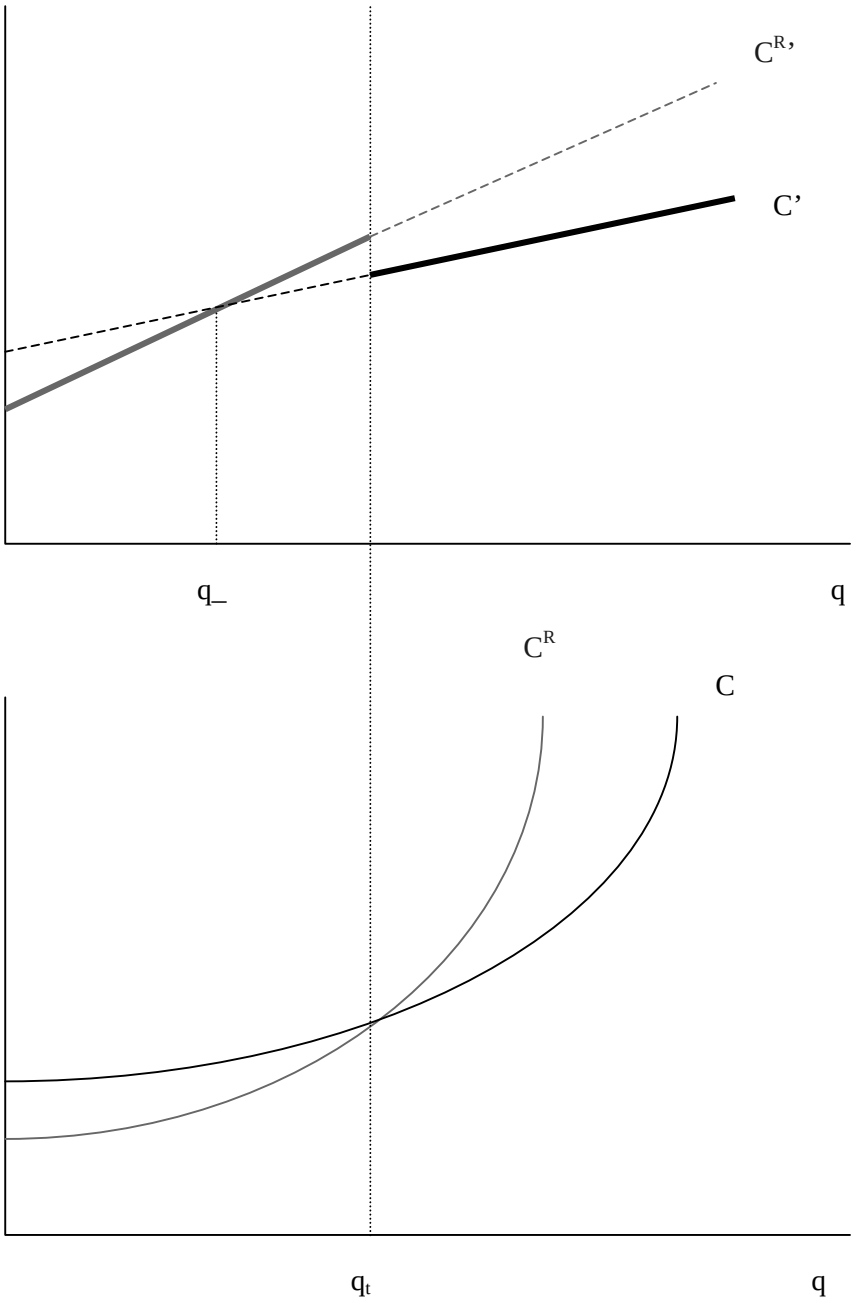
graph 1



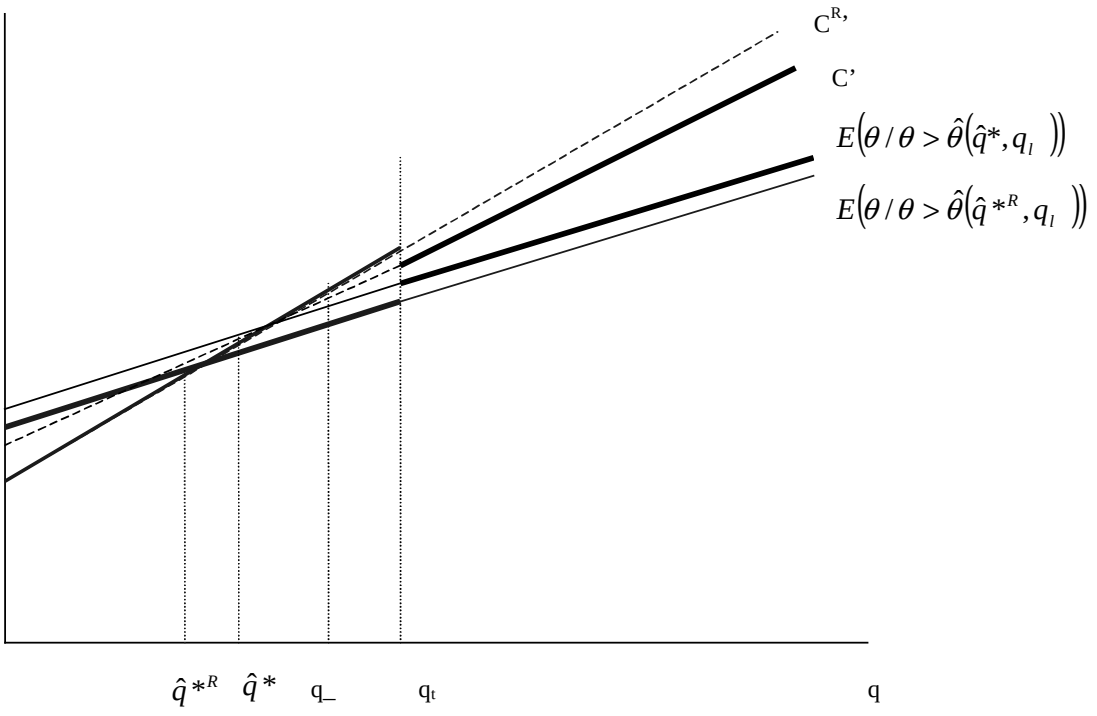
graph 2:



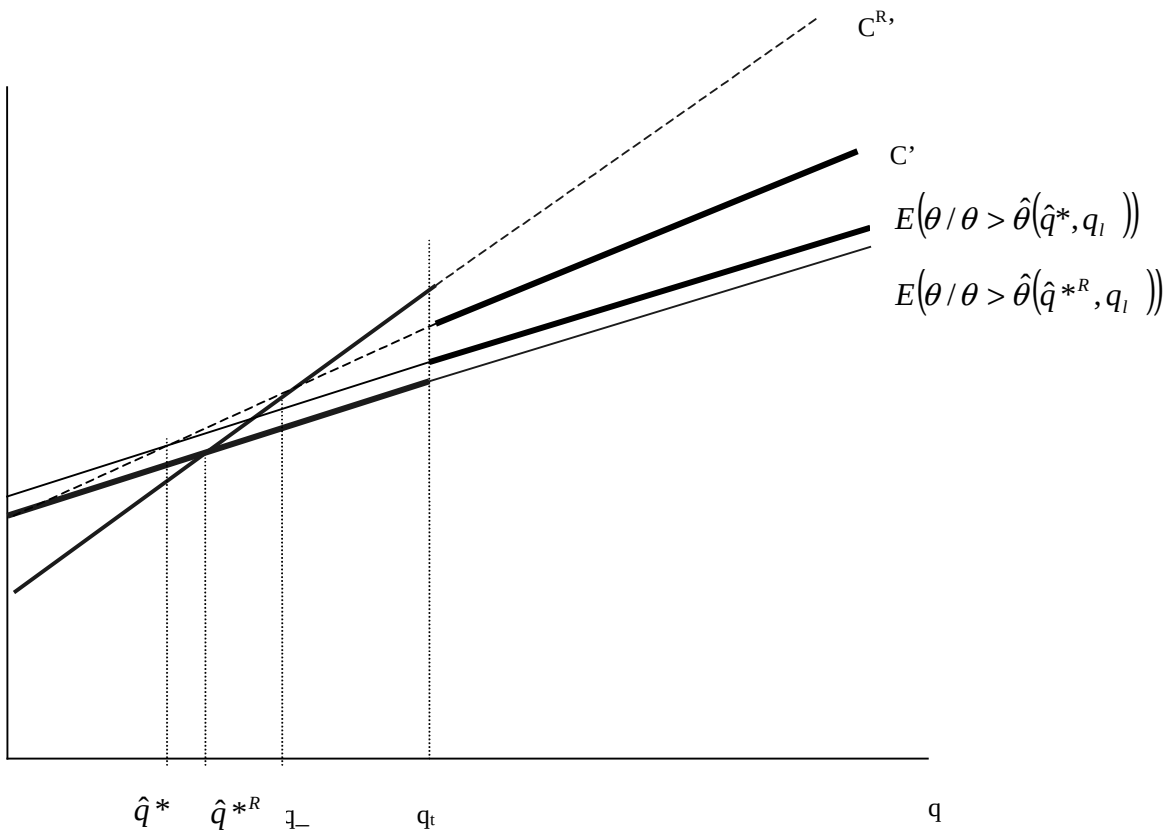
graph 3:



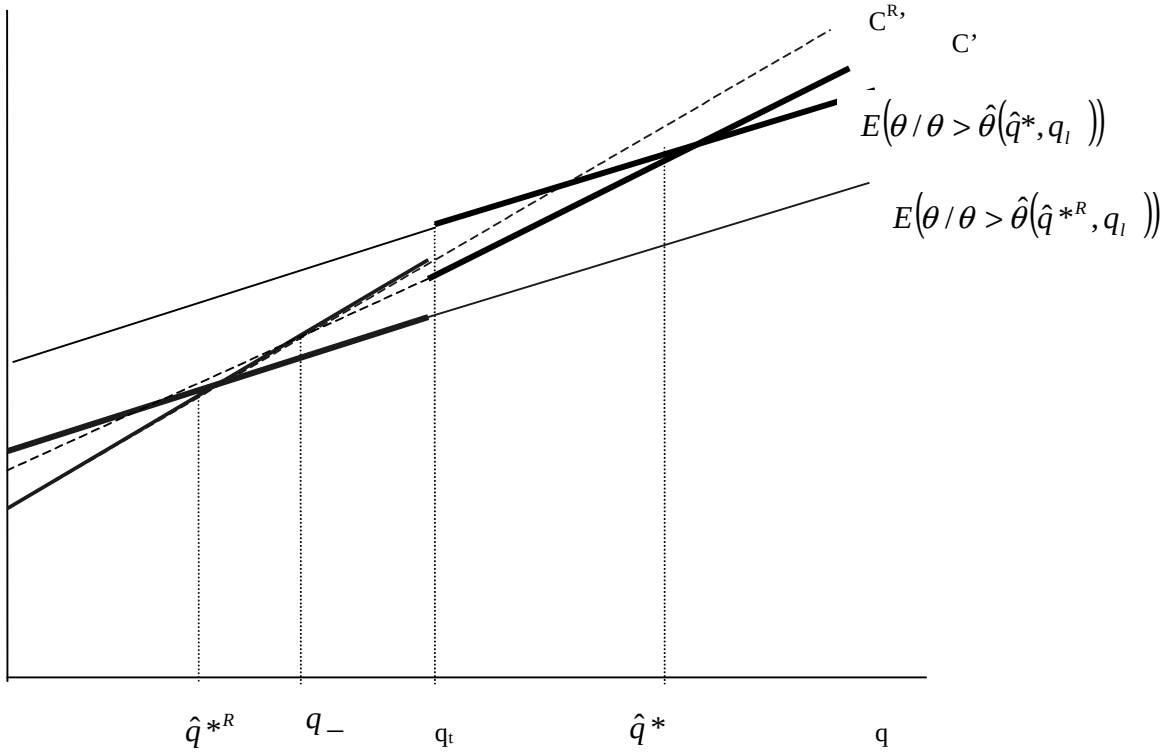
graph 4i)


C^R,
C'
$E\left(\theta / \theta > \hat{\theta}\left(\hat{q}^*, q_l\right)\right)$
$E\left(\theta / \theta > \hat{\theta}\left(\hat{q}^{*R}, q_l\right)\right)$
$\hat{q}^{*R}$
$\hat{q}^*$
q_
qt
q

graph 4 ii)


C^R,
C'
$E(\theta / \theta > \hat{\theta}(\hat{q}^*, q_l))$
$E(\theta / \theta > \hat{\theta}(\hat{q}^{*R}, q_l))$
$\hat{q}^*$
$\hat{q}^{*R}$
q_t
q

graph 4 iii)


C^R,
C'
$E\left(\theta / \theta > \hat{\theta}\left(\hat{q}^*, q_l\right)\right)$
$E\left(\theta / \theta > \hat{\theta}\left(\hat{q}^{*R}, q_l\right)\right)$
$\hat{q}^{*R}$
q_-
q_t
$\hat{q}^*$
q