Food quality standards in equilibrium models: a discussion of current modeling approaches

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Abstract:

Throughout recent year food quality standards have become a ubiquitous phenomenon that nationally and globally influences agri-food markets. With equilibrium models commonly used in the quantitative analysis of market and trade effects, we review possible approaches to modeling standards existent in the literature, elaborate the reasoning behind them and discuss their suitability to reflect "real world" situations. While the modeling approaches identified may respectively depict a specific situation, they may not be appropriate in others. That is they capture certain effects of standards only. With increasing ability to account for the various effects of standards, the modeling approaches become more complex and the data requirements increase.

JEL classification: F1, C6, Q18

Keywords: food quality, standards, modeling approaches, equilibrium models

1. Introduction

Throughout recent years food quality that not only refers to food safety but also includes aspects of animal welfare and environmental protection has become increasingly important in high-income countries such as the European Union (EU). However, due to the specific characteristics of food quality, information asymmetries prevail in the food market and hence market failure occurs. That leads to an inadequate provision of high quality products as Akerlof (1970) describes in his famous article about the "lemon problem". In order to ensure a satisfactory level of food quality, governments of high-income countries have implemented more and tighter standards for agri-food products. At the same time, producers in the agri-food sector have also established their own systems of quality standards so as to differentiate their products from those of competitors and hence to secure their position in the agri-food market.

In a globalized world, where agri-food markets are further liberalized, agri-food trade between countries increases and consumers more and more demand food products of high quality, agri-food standards can be considered to play an increasingly prominent role. In fact, standards have become a ubiquitous phenomenon that nationally and globally influences agri-food markets (Josling et al., 2003). With equilibrium models commonly used to quantitatively analyze market and trade effects, the question of how to appropriately depict standards arises. However, there are only few attempts to incorporate standards into equilibrium models. This may be due to the considerable difficulty in modeling standards appropriately as well as in obtaining the necessary data.

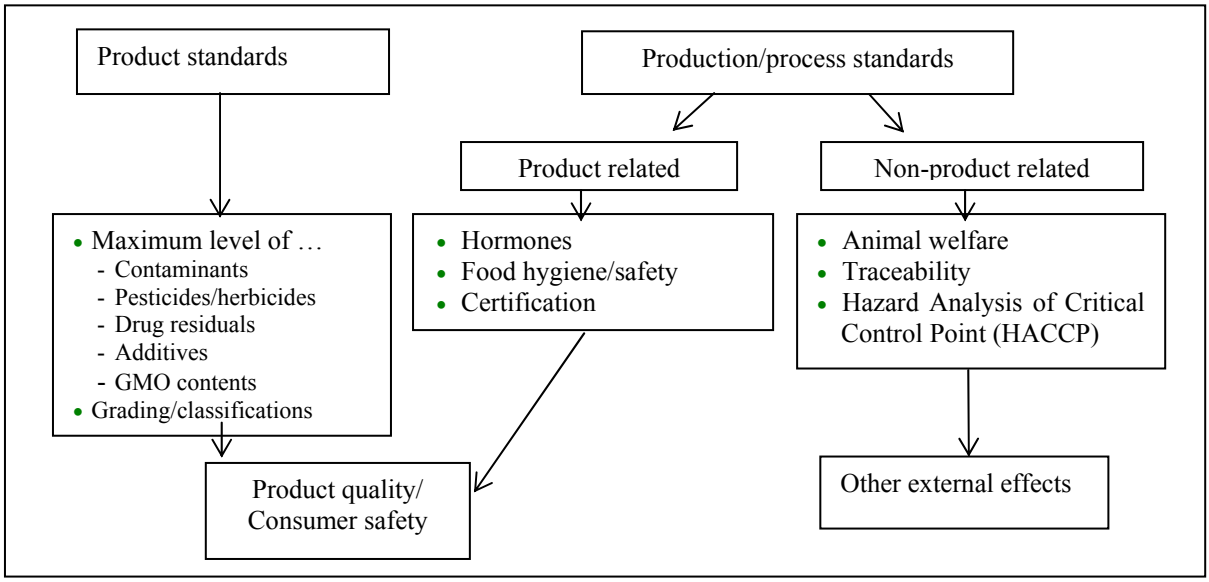
In this paper, we examine approaches of modeling standards already existent in the literature so as to contribute to a better understanding of how to adequately incorporate standards in equilibrium models. To start with, we define standards in general and give examples of the different categories of standards - especially with regard to the EU agri-food sector. With this background information, we then present four possible approaches to model

standards in equilibrium models, elaborate the reasoning behind them and discuss their suitability to reflect "real world" situations. The last chapter summarizes our findings and draws some conclusions.

2. Background

In general, standards can be classified in various ways. Josling et al. (2003) for example base their classification on four dimensions (goals, attribute focus, breadth, scope) that probably shape the impact of standards. Although this classification is certainly useful, our definition of standards focuses on the distinction between product and production standards. While product standards directly relate to the physical characteristics of products, production standards specify the method of producing/processing food products. Production standards can be further differentiated by product related and non-product related production standards. Product related production standards prescribe specific production processes that influence product characteristics, whereas non-product related standards do not affect the product characteristics per se. Figure 1 gives an overview of the different categories of standards in the agri-food sector.

Figure 1: Standards in the agri-food sector



Source: based on Balkhausen (2003).

Public standards concerning minimum requirements of food quality are typically mandatory for domestic producers. As long as they comprise product standards, they are usually obligatory for importers of agri-food products, too. However, the World Trade Organization (WTO), limits the imposition of food safety and other standards on imports by the Agreement on Sanitary and Phytosanitary Standards (SPS) and on Technical Barriers to Trade (TBT)[1] so as to prevent protectionist measures implemented "in the disguise" of standards.

Within the EU agri-food sector, public product standards are, for example, standards on the maximum level of pesticide residues, veterinary drugs and other contaminants in food products.[2] In contrast, the prohibition of hormones in EU beef production exhibits a product related production standard and minimum standards for the protection of animals are non-product related production standards.[3] In addition to mandatory public standards, there also exist voluntary public standards often combined with certain governmental labels such as the EU's labels of protected designation of origin (PDO), of protected geographical indication (PGI) and of traditional specialty guaranteed (TSG).[4] While these are usually non-product related there are also product related production standards such as some standards on organic production.[5]

Furthermore, the private sector increasingly sets its own product and production standards, which commonly exceed the quality level required by public standards. These private standards are voluntary by nature but can become quasi-mandatory if at certain stages

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[1] See WTO Uruguay Round Agreements Annex 1A.
[2] Directive 86/362/EEC on maximum levels of pesticides for cereals (OJ L221), Directive 86/363/EEC for foodstuffs of animal origin (OJ L211), Directive 90/642/EEC for certain products of plant origin (OJ L350) and Directive 76/895/EEC for fruit and vegetables (OJ L340), Regulation (EEC) 2377/90 on residues of veterinary drug in foodstuffs of animal origin (OJ L224) and Regulation (EEC) 315/93 on residues of contaminants in foodstuffs (OJ L37).
[3] Directive 96/22/EC prohibiting certain hormones in livestock farming (OJ L125), Directive 99/74/EC on the protection of laying hens (OJ L203), Directive 91/630/EEC on the protection of pigs (OJ L340), Directive 91/629/EEC on the protection of calves (OJ L340).
4 Regulation (EEC) 2081/92 on PGI and PDO and (EEC) 2082/92 on TSG (OJ L208).
[5] Regulation (EEC) 2092/91 on organic production (OJ L198).

of the value chain a large share of actors demands compliance with their private standards (Henson and Reardon, 2005).[6] The most prominent example for private standards are the standards by EurepGAP (Euro-Retailer Produce Working Group/Good Agricultural Practices). If the compliance with voluntary standards, no matter whether public or private, is communicated by labels, consumers can distinguish between compliant and non-compliant products and the producers can obtain premium prices for their compliant products. That is voluntary standards can be considered as an attempt to overcome the "lemon problem" of information asymmetry.

3. Modeling approaches

In applied economics, both partial (PE) and general equilibrium (GE) models are commonly used to quantitatively analyze the market impact of regulatory regimes such as standards. Although the modeling approaches of standards presented in the following can be applied in both kinds of equilibrium models, each framework has advantages and drawbacks in its application to modeling standards. Since meeting standards can result in different factor requirements, a GE framework may be preferable to a PE framework that usually excludes factor markets. However, due to their flexibility PE models allow for quite detailed specifications of markets and policy measures. This may be advantageous when modeling standards that are often formulated rather specifically. Both PE and GE models can be either static or dynamic. While a static modeling framework assumes immediate adjustments of consumption and production[7], a dynamic modeling framework accounts for lags in adjustment over one or more periods. The latter may be of particular interest when complying with standards involves considerable investments for domestic producers or importers.

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[6] For instance, the British Retail Consortium (BRC, 2005) states that "The majority of UK and Scandinavian retailers will only consider business with suppliers who have gained certification to the appropriate BRC global standard".

[7] Note that lags in adjustment are implicitly accounted for in many static models, as the time horizon of the projection is known and behavioral parameters of supply and demand functions are specified such that they take into account the projection period.

In the following, we present four possible methods of incorporating standards into equilibrium models, point out their major advantages and disadvantages and discuss the situations for which they seem reasonably applicable.

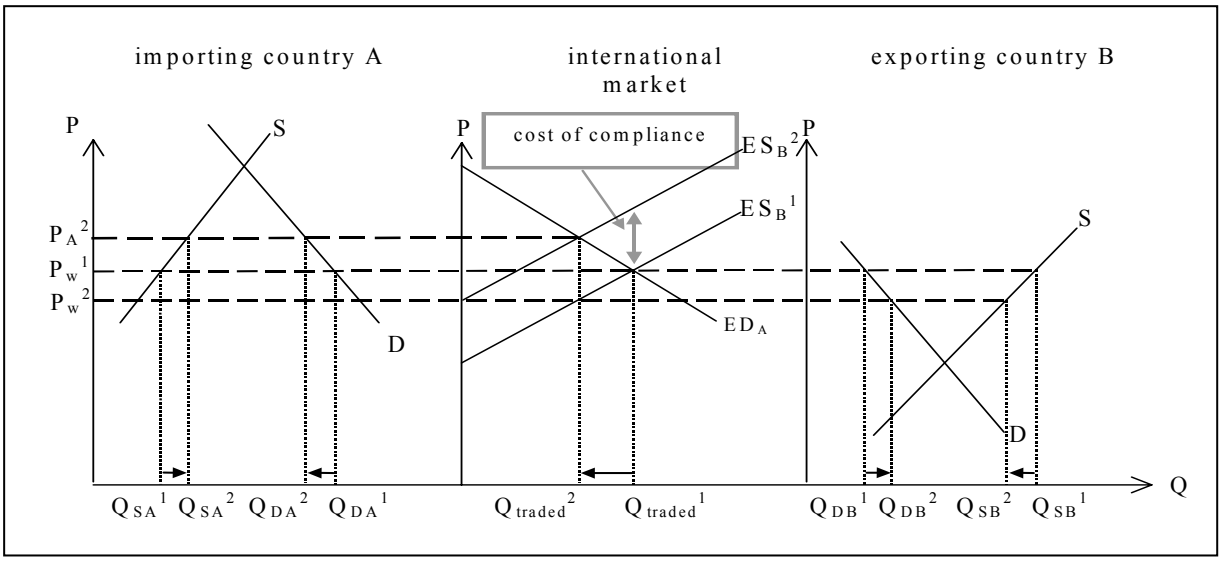
3.1. Modeling standards as tariff equivalents

A first possibility of modeling standards refers to standards as functioning like non-tariff barriers to trade (NTBs). To be eligible for being imported into a country, products have to be compliant with the standards of the importing country. Just like tariffs, complying with such import standards creates additional costs for exporters. On this basis, the compliance costs of standards are depicted by introducing estimates of tariff equivalents in models.[8]

This modeling approach is illustrated in figure 2 for a simple two-country model where A is an importing and B is an exporting country. In the base situation (situation 1), free trade between country A and B is assumed and hence producers and consumers in both countries face the world market price (P_w^1). In situation 2, country A introduces a standard imports from country B have to comply with. As shown in the second panel of figure 2, this results in compliance costs that shift the excess supply curve upwards ($ES_B^1 \rightarrow ES_B^2$).[9] The world market price decreases ($P_w^1 \rightarrow P_w^2$) and so do the quantities traded ($Q_{traded}^1 \rightarrow Q_{traded}^2$). In country A, which imposes the standard, the price (P_A^2) lies above the world market level and hence production increases and demand decreases. In country B, where the now lower world market price prevails, the opposite happens: demand goes up and supply goes down.

[8] Many attempts have been made to estimate tariff equivalents of NTBs. For an overview see Ferrantino (2005).
[9] For illustrative purposes the large country assumption is chosen. The small country assumption results in similar effects.

Figure 2: Standards as tariff equivalents



D = demand, S = supply, ED = excess demand, ES = excess supply, Q = quantity, P_A = price in country A, P_w = world market price

Source: own graph.

In the literature, this modeling approach is commonly found in studies on quantifying the impact of SPS as well as TBT measures (e.g. Sumner and Lee, 1999; Calvin and Krissoff, 1998). However, its ability to depict the "real world" seems to be quite limited. That is since it describes a situation, where a standard is only imposed on foreign products - but not on domestic products, as the domestic supply curve remains unchanged. Due to the WTO agreements on SPS and TBT, this scenario is rather implausible.

However, one situation where it could be applicable relates to countries that on the one hand lack the administrative capacity to enforce standards domestically, but on the other hand do control the respective standards at their ports - which is usually much easier. One could also imagine a situation where imports become subject to standards that already apply for domestic production in the base situation. Only in the aforementioned situations, the modeling approach of standards as tariff equivalents is a sound representation of reality.

In both situations, consumers are implied not to prefer compliant products to non-compliant ones, as the demand curve (in both countries) does not change. Furthermore, instead of an explicit increase in production costs in the exporting country, the cost increase

takes place when the compliant product crosses the border.[10] If standards set by an importing country affect neither production costs nor consumers' willingness to pay and if they do not generate any other economic benefits, they would indeed be "disguised" protectionist measures. Only such standards are appropriately represented by tariff equivalents.

In addition to the shortcomings of properly representing reality, another problem exits: When introducing tariff equivalents in models, tariff revenues are generated. Particularly, in a GE framework they have to be distributed in order to keep the social accounting matrix (SAM) consistent. In the case of modeling standards, the incurrence of such revenues and their distribution to one or more economic actors seems to be rather controversial.

3.2. Modeling standards as shifting supply

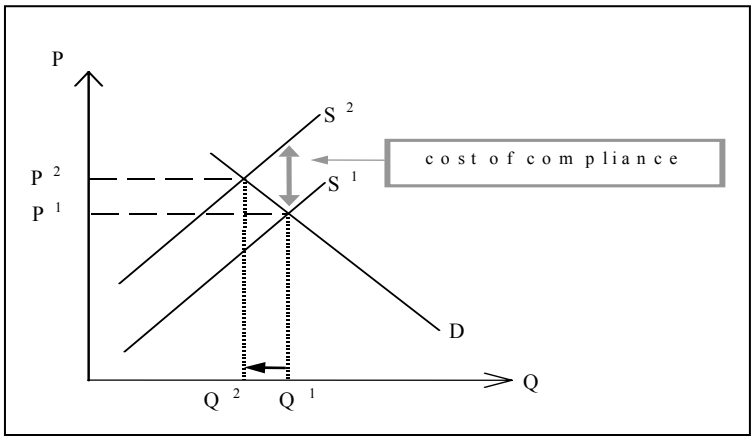
A second possible modeling approach focuses on the reasoning that producing according to standards raises production costs in terms of compliance costs. Like in the "tariff equivalent" approach, determining compliance costs is a rather difficult and tedious task to undertake. Most of the few studies on compliance costs therefore only cover the direct costs of compliance and neglect other cost components such as opportunity costs or costs resulting from uncertainty/risk when complying with standards (Brouwer et al., 2000). Despite this simplification, an appropriate estimation remains challenging. To complicate matters, it can be argued that the implementation of standards may also have positive effects on production costs. Being obliged to fulfill standards, producers may improve the efficiency of production processes for example by upgrading their facilities or by using modern technologies. That is standards may encourage competitiveness and innovation.

Abstracting from possible pro-competitive and innovative effects, the implementation of standards leads to a cost-increasing supply shift. In figure 3, this is illustrated for a single country in a closed economy. With standards being imposed, the supply curve shifts upwards

[10] If standards that require the adaptation of production processes do not raise production costs, the unlikely case of multiple cost minima for a given quantity of output is implied.

by the compliance costs ($S^1 \rightarrow S^2$). Hence, the price increases ($P^1 \rightarrow P^2$) and the quantity produced and consumed decreases ($Q^1 \rightarrow Q^2$).

Figure 3: Standards as shifting supply, closed economy

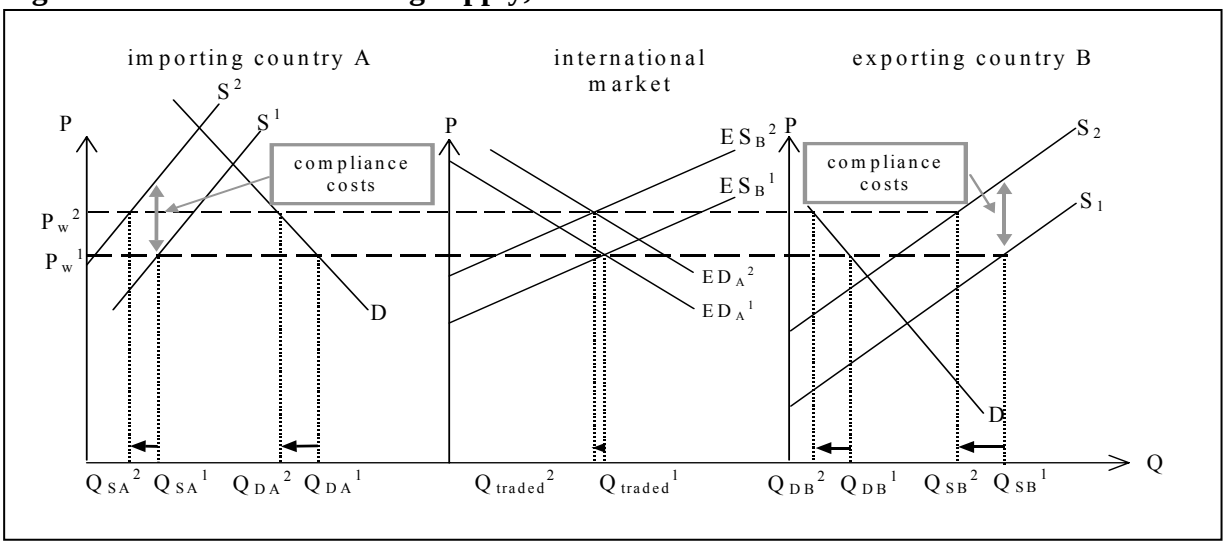


Source: own graph.

Figure 4 illustrates the approach of standards as shifting supply in a world market model. The base situation (situation 1) is identical to the one in figure 2. In situation 2, country A introduces a standard domestic products as well as imports into country A have to comply with. The supply curves in both country A and B shift upwards by the compliance cost.[11] Consequently, A's excess demand curve ($ED_A^1 \rightarrow ED_A^2$) and B's excess supply curve ($ES_B^1 \rightarrow ES_B^2$) shift upward. As the costs of production increase "globally", the (world market) price also increases and hence the quantities demanded in both countries decrease. In figure 4, the quantities supplied in both countries decrease, too. This does not need to be the case. If in one of the two countries the compliance costs were sufficiently smaller than the price increase, this country's production would expand. The same holds for the quantities traded on the international market. In our example the quantities traded decrease. Obviously, the quantity and price changes depend on the shape of the supply and demand curves as well as the relative magnitude of the compliance costs between countries.

[11] In figure 4, the cost of compliance in country A and B are assumed to be the same. This is not necessarily the case, though.

Figure 4: Standards as shifting supply, world market



Source: own graph.

In order to model supply shifts in equilibrium models shift parameters are commonly introduced in supply functions. For example, when depicting the trade effect of technical progress that augments output, the respective supply curves are shifted to the right. Since meeting standards however leads to an output decreasing supply shift as argued above, standards can be modeled by a "negative" technical change. Accounting for the introduction of mandatory quality assurance and labeling regimes in the US meat industry, Lusk and Anderson (2003) for example model a "negative" technical change in a PE framework. Similarly, Ganslandt and Markusen (2001) shift supply curves of a GE model so as to generally analyze the welfare effects of standards.

This "supply shift" approach reflects compliance costs by an increase in production costs rather than by an increase in trade costs as in the "tariff equivalent" approach. This may be appropriate in cases where standards indeed concern production processes and do not primarily serve protectionist purposes. Furthermore, in the application of the "supply shift" approach the problem of distributing a non-existent tariff revenue does not arise. The "supply shift" approach seems to be relatively more flexible since the supply curves in either one or both countries can be shifted. This may, be useful for example when modeling non-product related production standards that only target the domestic production in one of the two

countries. Another example comprises standards addressing external effects that have national consequences only - for instance labor standards. In these cases, only the supply curve of the country introducing the standard shifts upwards. Despite the advantages of the "supply shift" approach, some drawbacks remain and in fact other problems arise. Like in the "tariff equivalent" approach the standard has no effect on the demand curve. As explained, this is not quite realistic. Furthermore, the "supply shift" approach implies that the standard necessarily takes the form of a mandatory national (shifting one supply curve) or global (shifting both curves) standard. The latter is particularly unrealistic because an exporting country usually does not adapt its entire production to the standards of the importing country. It is expected to only adjust the part of production producing for the export market.

3.3. Modeling standards as shifting demand

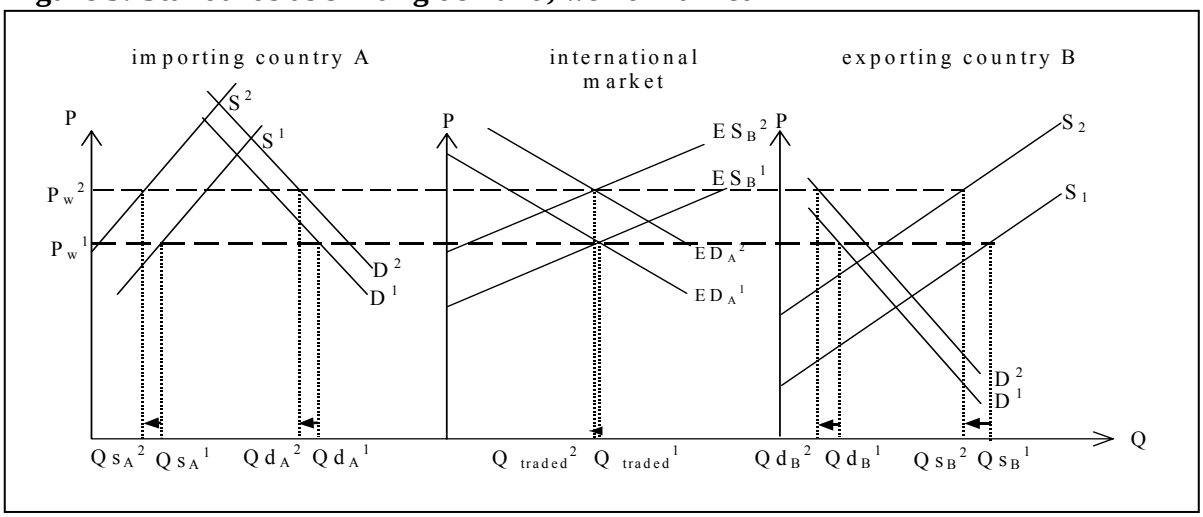
Standards most probably have effects on consumer preferences. Affecting the actual and/or perceived characteristics of products, standards may make consumers less worry about consuming products as well as may alleviate their uncertainty about product quality (Josling et al., 2003).[12] If that is the case, consumers benefit from the implementation and enforcement of standards. If their willingness to pay for a product increases with standards being implemented, the demand curve shifts upwards. However, such demand shifts are difficult to determine since they crucially depend on the marginal utility consumers experience when consuming the compliant product. In the literature, only few studies include the "demand shift" approach to model standard. For example Thilmany and Barrett (1997) model a demand shift to reflect the consumers' benefits from technical regulations in the US dairy sector.

Figure 5 illustrates the "demand shift" approach in combination with the "supply shift" approach. With the magnitude of the supply shift exceeding the demand shift in our example, the quantities demanded and supplied in both countries decrease relative to the base. The

[12] This is obviously only true if the respective standards are recognized by consumers (possibly via labelling) and if compliance is checked or guaranteed (possibly via certification).

increase in the world market price is ceteris paribus more pronounced than in the situation where only the supply curves are shifted. Obviously larger shifts of the demand curve lead to different results.

Figure 5: Standards as shifting demand, world market



Source: own graph.

So far, changes in welfare resulting from the introduction of standards have not been discussed, as they were necessarily negative without any effects beyond those on supply curves. Taking into account shifts of the demand curves, the net welfare effect is not a priori clear anymore. Although it is negative in the example given here, introducing smaller supply and/or larger demand shifts may result in a positive net welfare effect.

Unlike the modeling approaches discussed above, the approach presented in this section takes into account the effects of standards on consumer behavior. Ignoring these effects seems to be rather unrealistic, especially when modeling standards whose implementation can be considered as predominantly consumer driven. However, the issue of "universally" shifting demand and supply curves remains unsolved. This issue is addressed in the following section.

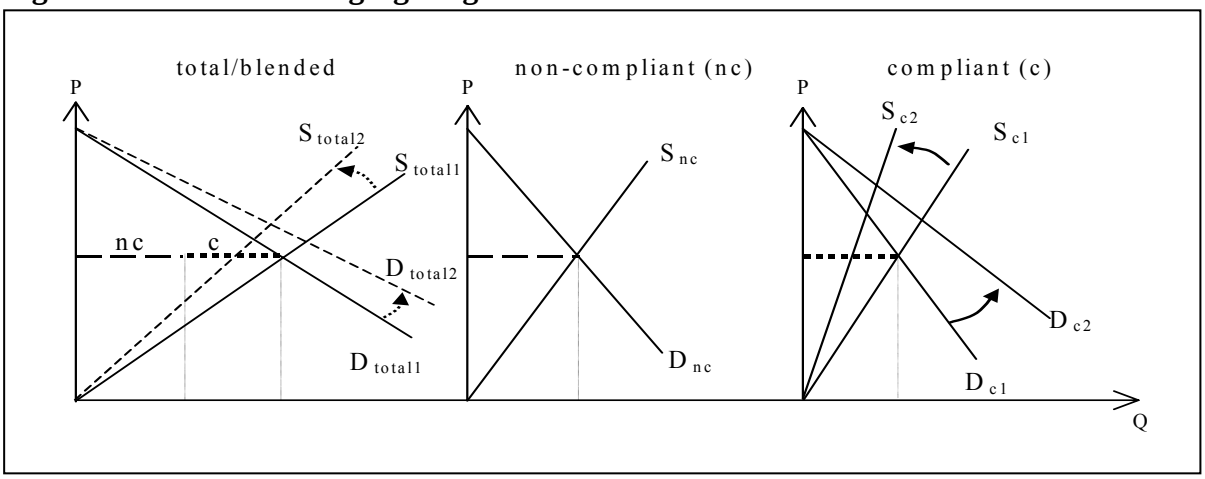
3.4. Modeling standards as segregating markets

In many cases, compliant and non-compliant products co-exist in a market. This holds for example for voluntary standards that allow consumers to decide whether to consume the compliant or the non-compliant product and producers to decide whether to meet the respective standards or not. However, co-existence can also occur in the case of mandatory

standards: If an importing country imposes standards on foreign products, producers in the exporting country can decide whether to fulfill them so as to export their compliant products to that market or to produce non-compliant products for other markets.[13]

With standards leading to compliant and non-compliant products coexisting on the market, they can be modeled by market segregation. That is two markets with different supply and demand functions – one for compliant and one for non-compliant products – are constructed. On the supply side, total supply is split into the supply of the compliant and non-compliant product. Along the lines of the "supply shift" modeling approach, an upward shift of the supply curve of the compliant product accounts for the cost increase due to producing according to the respective standard. Similarly, total demand is divided into the demand for the compliant and non-compliant product. In order to account for possible consumer benefits from the implementation of the standard, the demand curve of the compliant product may be shifted upwards like in the "demand shift" modeling approach. Figure 6 illustrates the modeling approach of standards as market segmentation for a single-country model.

Figure 6: Standards as segregating markets



Source: Own graph.

[13] Compliant and non-compliant products may also co-exist in the market in countries lacking the institutional capacities to enforce mandatory standards.

Studies on trade effects caused by the introduction of GMO technologies model segregated market so as to depict the differentiation between GMO and non-GMO products. For an overview of studies modeling GMOs see Nielson et al. (2002). Another strand of literature on equilibrium models that commonly applies market segregation deals with other issues of food quality (e.g. Peterson and Orden, 2004).

The most crucial part of this approach is how to split demand and supply into the two categories of compliant and non-compliant. Conducting market segmentation requires knowledge about how many consumers turn to the compliant product and of how many producers take the risk of changing their production so as to meet the respective standard (or the risk of not changing it) without knowing the chances of their products on the market. At the same token, the question about the degree of substitutability between the compliant and non-compliant product in consumption and production arises. This information cannot be easily obtained prior to the introduction of the standard and hence assumptions must be made.

4. Summary and Conclusions

The modeling approaches of standards reviewed in this paper are most commonly used in the literature of applied economics. They have been ordered such that they become increasingly flexible with regard to their ability to account for the effects of standards on the production and consumption side. Allowing for both the consumers' and producers' choice between consuming and producing compliant and non-compliant products, respectively, the "market segmentation" approach is the most flexible of the approaches reviewed in the paper.

The one fundamental difference between the approaches presented is the inclusion of the demand side effects of standards. The implementation of policy measures such as standards must at least benefit one group in society, otherwise they would not be agreed upon. It can therefore be argued that modeling approaches that do not take into account the utility increase for consumers or any other welfare enhancing effects are surely a misrepresentation of reality. Although modeling approaches ignoring the demand side effects of standards seem

to be unsuitable for comprehensive welfare calculations, they can nevertheless generate useful results on how standards quantitatively influence trade flows or production.

The paper shows that the data requirements or assumptions to be made intensify with the degree of flexibility. These comprise estimates for compliance costs, the consumers' willingness to pay as well as the shares of consumers and producers who turn to the production and consumption of the compliant product, respectively. It has also been shown that the less flexible approaches may be appropriate to simulate the effects of certain types of standards or to cover their major effects only - like for example in the case of ignoring the demand side effects of standards as described above.

Yet, there are issues not covered in this paper that may be of importance when analyzing the effects of standards. One of them concerns external effects standards are designed to create or to alleviate. Although standards addressing external effects may not necessarily affect consumers individually, they might have an impact on the welfare of the society as a whole. These effects on overall societal welfare e.g. due to animal protection standards are, if at all, difficult to capture in equilibrium models. Another issue not covered relates to the fact that consumers may not unambiguously value standards or rather compliant products higher than non-compliant ones. This refers to horizontal product differentiation, as opposed to vertical product differentiation assumed throughout the paper, and involves issues of product variety.

In conclusion, one can state that there is no generally superior modeling approach of standards. Each approach discussed in this paper may appropriately represent standards in certain "real world" situations. The choice of which approach to apply depends on the target of the standards to be modeled, the focus of the analysis as well as on the assumptions about how the behavior of economic actors is affected.

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