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Chapter 1. Introduction

Standards are increasingly important in the global market system. Standards address a large variety of issues in consumption and production such as nutritional (e.g. low fat, vitamin-rich), safety (e.g. pesticide residues, small toy parts), quality (e.g. minimum size requirements, life span guarantees), environmental (e.g. low carbon dioxide emissions, waste management), and social concerns (e.g. no child labor, fair trade).

There exists an extensive theoretical literature on the economics of regulation and standards. Initially, the main focus of this literature was on the competition and welfare effects of minimum quality standards. Examples are Leland (1979), Bockstael (1984), Ronnen (1991), Crampes and Hollander (1995), Valletti (2000), and Winfree and McCluskey (2005). In more recent theoretical work on standards the focus has shifted to the analysis of the relation between trade and standards, see for example Sykes (1995), Thilmany and Barrett (1997), Fischer and Serra (2000), Barrett and Yang (2001), Anderson *et al*. (2004), Sturm (2006), and Baltzer (2010). While minimum quality standards were previously the predominant subject of analysis, other types of standards such as labeling standards (e.g. Fulton and Giannakas 2004; Roe and Sheldon 2007) or environmental standards (e.g. Schleich 1999) became apparent.

Although this literature deals with the welfare and trade effects of standards, little of this literature is concerned with how standards are set by governments. However this is an important question that merits serious analysis. The general literature on minimum quality standards shows that welfare may increase or decrease with the implementation of a minimum quality standard, and that different groups in society, e.g., consumers, low quality producers and high quality producers, may be affected differently. A political economy perspective which allows for interest groups to influence the government's standard-setting behavior is therefore essential to understanding the determinants of standards. It also has important implications for the welfare effects of standards, whether they are suboptimal or not, and for the potential trade-protectionist nature of standards.

The goal of this dissertation is therefore to formally analyze both the economics and politics of standards. The political economy of regulation has a long tradition, starting with the seminal work of George Stigler who analyzed the demand for regulation by economic interest groups and their potential use of public resources and power to improve their economic status (Stigler 1971). Extensive research has been done on the subject of lobbying, for example by Becker (1983) and Bhagwati (1982). Krueger (1974) developed a model of competitive rent-seeking and focused on the negative welfare implications of rent-seeking, as applied to trade policy. Much of the applied work on political economy and lobbying is in the domain of trade policy regulation. In important contributions from Magee *et al*. (1989) and Hillman and Ursprung (1988), competing political parties promise to implement trade polices if elected, and lobby groups contribute resources to the political party that promises them the highest welfare for the purpose of increasing the probability that their favorite party is elected (see Hillman (1989) for a review of the literature). In another approach, an incumbent government seeks to maximize its political support which consists of lobby contributions (welfare) from certain interest groups and the (deadweight loss of) welfare in society, see e.g. Hillman (1982) and Grossman and Helpman (1994; 1995). This dissertation follows the latter approach to analyze the political economy of standards.

The remainder of this introductory chapter is organized as follows. Section 1.1 introduces the concept of 'standards' by explaining their underlying economic intuition and justification, and how our objectives and approach fit within a broader literature. Section 1.2 provides an overview of how standards can be modeled theoretically, how we model standards in the various chapters of this dissertation, and how our modeling approaches relate to the literature. Section 1.3 summarizes the focus and objectives of the different chapters in this volume.

1.1. The Economic Rationale behind Standards

1.1.1. Information Asymmetries

Income growth is fueling consumers' demands for products with characteristics that are meeting increasingly stricter safety, quality, environmental and social requirements (Roberts *et al*. 1999). In general, product characteristics can be divided into three categories: 'search', 'experience', and 'credence' characteristics (Nelson 1970; Darby and Karni 1973). Search attributes can be ascertained in the search process prior to purchase (e.g. the color of an apple), while experience characteristics can only be discovered after purchasing and using the product (e.g. the apple's taste), and credence qualities cannot be evaluated in normal use (e.g. the amount of pesticide residues on the apple). Many of the aforementioned newly-demanded product attributes are experience or credence characteristics – they are not directly observable to consumers (Roe and Sheldon 2007). Due to this incompleteness or lack of information on the side of consumers, both categories of attributes may cause problems related to information asymmetries (Darby and Karni 1973).

As Akerlof (1970) has shown in his seminal 'lemons' article, information asymmetries may lead to the underprovision of these product characteristics, and market failure. Consider the example of batteries. Producers know their batteries' expected lifespan – which may vary considerably among different producers – while consumers can only discover this experience characteristic after consumption. All producers must therefore set the same price which reflects the average battery's lifespan. As a consequence, if providing batteries with a longer lifespan is more costly, producers who provide an above-average lifespan are not willing to remain in the market (or will deliver a shorter lifespan) since the price they receive only reflects the average lifespan. Their exit from the market (or shift to a shorter lifespan) depresses the average lifespan further, such that prices also decrease and additional producers quit or reduce their batteries' lifespan. In the end, this may result in the underprovision of batteries with a sufficiently long lifespan, although such batteries are preferred by consumers.

Several mechanisms may reduce or eliminate these information asymmetries and related market failures. First, producers may provide additional product information by labeling their products, thus transforming experience or credence attributes into search characteristics (Leland 1979). This mechanism is conditional on the presence of independent verification of producers' claims, for example by the government in case of a mandatory label or by a third party in case of voluntary labels (Baltzer 2010). The impact of product labeling on market efficiency and welfare has been extensively analyzed, amongst others for genetically modified (GM) products and products with geographical indications (GI), as for example by Fulton and Giannakas (2004), Lapan and Moschini (2004), Roe and Sheldon (2007), Lapan and Moschini (2007), Veyssiere (2007), Giannakas and Yiannaka (2008), and Moschini *et al*. (2008).

Second, consumers' repeated purchases may induce reputation effects and provide producers with incentives to deliver products with consumers' preferred characteristics (Shapiro 1983; Gardner 2003). The reputation effect of repeated purchases is only effective if consumers are able to observe the product's characteristics after consumption, i.e. for experience qualities. In the case of credence characteristics – where the product's attributes remain hidden even after consumption – reputation mechanisms do not provide a solution to the 'lemons' problem (Baltzer 2010). Moreover, reputation incentives are conditional upon products being traceable to the individual producer. For example, Winfree and McCluskey (2005) show that in the case of experience goods without firm traceability, individual firms have an incentive to provide quality levels that are suboptimal.

A third device that may lessen quality deterioration is to make producers liable for the final characteristics of their products, i.e. 'caveat vendor' instead of 'caveat emptor'. However, for experience qualities which have a long-delayed effect or for credence characteristics, vendor liability has limited or no impact on producers' incentives to provide sufficient levels of these characteristics (Leland 1979).

Fourth, Gardner (2003) argues that in a business-to-business setting quality-linked private contracting and vertical integration may lead to a better provision of quality characteristics (see also Dries and Swinnen 2004; Minten *et al*. 2009; Maertens and Swinnen 2009).

Fifth, standards set by governments, i.e. 'public standards', may reduce or resolve market failures caused by asymmetric information (Thilmany and Barrett 1997; Gardner 2003). By imposing and enforcing public standards, governments specify requirements with which (characteristics of) the production process ('process standards'), the final product ('product standards'), or the packaging of the product ('packaging standards') must comply (Roberts *et al*. 1999). Standards thus allow governments to impose and guarantee the presence of positive, or absence of negative, experience and credence features. Therefore, public standards may improve upon the unregulated market equilibrium. 'Private standards' – set by private entities – may serve the same purposes as public standards. However, as with private labeling, private standards are not credible if independent third-party verification is absent.

From this overview, it is clear that various mechanisms exist to overcome market failures caused by asymmetric information. In this dissertation we only focus on standards – and mainly on public standards – as tools to guarantee the presence or absence of experience and credence characteristics and to reduce or solve information asymmetries. We do not explicitly investigate the other mechanisms.

1.1.2. Externalities

Additional to market failures stemming from information asymmetries, standards may solve market failures related to production and consumption externalities as well (Roberts *et al*. 1999; Schleich 1999; van Tongeren *et al*. 2009). Externalities arise when one economic agent's actions have indirect effects on other economic agents, i.e. effects that are not accounted for in the market's price system. For example, an upstream firm's river pollution imposes a negative externality on downstream firms who use the river's water as input, and who may therefore need to install a costly purification plant which is not compensated for by the upstream firm. This type of externality could be reduced by, for example, imposing a minimum abatement standard on the upstream firm.

Standards may also address market failures due to network externalities. In industrial sectors such as communications and consumer electronics, compatibility between different products and firms is an important issue. Compatibility standards that improve the interoperability between various products and firms may have considerable effects on competition and welfare (see e.g. Katz and Shapiro 1985; Farrell and Saloner 1985; Jeanneret and Verdier 1996).

In this dissertation, we do not consider the implementation of standards as mechanisms to correct market failures due to externalities – we focus on standards that reduce or solve information asymmetries.

1.2. Modeling Standards

A key issue is obviously how to model standards. This choice is in the first place determined by the cause of market failure which the standard intends to remedy: information asymmetries or externalities. Standards that address market failures due to information asymmetries guarantee certain experience or credence characteristics which are often vertically aligned (Roe and Sheldon 2007). Therefore, in the literature on standards focusing on information asymmetries, it is common to use a vertical differentiation approach. This type of consumer utility framework assumes that all consumers value the experience or credence characteristic (i.e. the standard), but that they differ in their willingness to pay for this attribute. In other words, if products with and without the standard would be offered at the same price, all consumers would buy the product with the standard, i.e. with guaranteed experience or credence characteristics. This vertical differentiation framework was introduced in the economic literature by Spence (1975), Mussa and Rosen (1978), and Tirole (1988), and has been applied by, amongst others, Ronnen (1991), Motta (1993), Boom (1995), Crampes and Hollander (1995), Jeanneret and Verdier (1996), Maxwell (1998), Valletti (2000), Fulton and Giannakas (2004), Lapan and Moschini (2007), Veyssiere (2007), Roe and Sheldon (2007), Moschini *et al*. (2008), Giannakas and Yiannaka (2008), and Baltzer (2010). We adopt this vertical differentiation framework in Chapters 3, 4, and 6 of this dissertation.

Yet, others have modeled standards that remedy information asymmetries differently, for example by including a preference parameter in the consumer's utility function without specifying a particular functional form. Examples are Leland (1979), Anderson *et al*. (2004), Lapan and Moschini (2004), Winfree and McCluskey (2005), and Swinnen and Vandemoortele (2008). We use a similar approach in Chapters 2 and 5.

Standards that aim at remedying consumption or production externalities are typically modeled by inserting an externality component in the consumer's utility function, the producer's profit function, or the social welfare function, depending on the type of externality under analysis (see e.g. Schleich 1999; Fischer and Serra 2000; Tian 2003; Sturm 2006; van Tongeren *et al*. 2009; Marette and Beghin 2010). Although we do not explicitly consider standards that address externalities, our analyses can be easily extended to account for a standard's impact on production or consumption externalities (see e.g. Swinnen and Vandemoortele 2009). In contrast, analyzing compatibility standards which address network externalities would require a substantially different modeling approach.

Second, one needs to decide how to model the impact of standards on producers. It is generally assumed that standards involve some compliance costs for producers. The idea behind this assumption is that all standards can be defined as the prohibition to use a cheaper technology. Examples are the prohibition of an existing technology (e.g. child labor) or of a technology that has not yet been used but that could potentially lower costs (e.g. GM technology). Also traceability requirements can be interpreted as a prohibition of cheaper production systems which do not allow tracing the production. Some authors have assumed that standards involve fixed implementation costs, e.g. Leland (1979), Ronnen (1991), Motta (1993), Boom (1995), Maxwell (1998), Fischer and Serra (2000), Valletti (2000), Tian (2003), Amacher *et al*. (2004), Roe and Sheldon (2007), and Moschini *et al*. (2008). Others assume that standards increase variable production costs, e.g. Motta (1993), Crampes and Hollander (1995), Fischer and Serra (2000), Tian (2003), Anderson *et al*. (2004), Fulton and Giannakas (2004), Lapan and Moschini (2004), Winfree and McCluskey (2005), Sturm (2006), Lapan and Moschini (2007), Veyssiere (2007), Giannakas and Yiannaka (2008), Moschini *et al*. (2008), Swinnen and Vandemoortele (2008), van Tongeren *et al*. (2009), Baltzer (2010), and Marette and Beghin (2010). In all chapters of this dissertation, we follow the latter approach and assume that standards increase producers' variable production costs. Additionally, in line with Amacher *et al*. (2004), Chapter 4 assumes there is a fixed cost of switching between different levels of a standard.

Third, both continuous and binary variables can be used to represent standards. Both approaches are common and the choice mainly depends on the underlying product characteristics that are guaranteed by the standard. Standards that regulate the amount of an ingredient are usually modeled with a continuous variable. We use continuous variables to represent standards in Chapters 2, 3, and 5. Other examples in the literature that use a continuous variable are Leland (1979), Ronnen (1991), Motta (1993), Boom (1995), Crampes and Hollander (1995), Fischer and Serra (2000), Valletti (2000), Tian (2003), Anderson *et al*. (2004), Winfree and McCluskey (2005), Sturm (2006), Roe and Sheldon (2007), and Marette and Beghin (2010).

Standards are best represented by a binary variable when they determine whether an ingredient or a technology is allowed or not. Using a binary variable to model standards is common when analyzing producers' or governments' choices between different production technologies, and/or the labeling of that choice, such as GM technology and GI products labeling (see e.g. Jeanneret and Verdier 1996; Fulton and Giannakas 2004; Lapan and Moschini 2004; Lapan and Moschini 2007; Veyssiere 2007; Moschini *et al*. 2008; Giannakas and Yiannaka 2008). We apply binary variables to model standards in Chapters 4 and 6 since Chapter 4 analyzes governments' strategic technology choices through their implementation of public standards, and Chapter 6 analyzes developing countries' endogenous introduction of high quality products (e.g. subject to a standard) as compared to low quality products (e.g. not subject to a standard).

Fourth, there is the choice between modeling public standards set by governments, and private standards set by private firms. In Chapters 2, 3, and 4, we assume that only governments may impose (public) standards, and that firms are not allowed or able to set private standards. In Chapter 5 we explicitly address the possibility that firms (retailers in our case) may impose private standards at higher levels than public standards. Since Chapters 3, 4, and 5 analyze governments' decision-making on public standards, we adopt a political-economic approach in each of these chapters, based on the seminal 'protection for sale' framework of Grossman and Helpman (1994). Since Chapter 6 does not consider the standard-setting behavior of either governments or firms, it does not distinguish between public and private standards. Chapter 6 assumes that there are two quality levels in the market, high and low, where the high quality could be mandated by a public or private standard exogenous to the model.

1.3. Dissertation Outline

Chapter 2 starts this dissertation off by presenting a simple conceptual framework on the efficiency and equity issues of public standards and demonstrates that public standards may have different (positive or negative) impacts on consumers, (different types of) producers, and social welfare. These potentially diverse welfare implications for different market players motivate the political economy lens that we adopt in the rest of this dissertation on the politics and economics of standards. If public standards affect market players differently, it is not unconceivable that certain (groups of) market players form into interest groups that lobby the government to influence its standard-setting behavior.

In Chapter 3 we present a political economy model of public standards in an open economy model. We use the model to derive the politically optimal public standard and to analyze different factors that have an influence on this political equilibrium. The chapter discusses how the level of development influences the political equilibrium. We also analyze the relation between trade and the political equilibrium and compare this political outcome with the social optimum to identify under which cases 'under-standardization' or 'over-standardization' results, and which public standards can be labeled as (producer-)protectionist measures.

In Chapter 4 we develop a formal and dynamic model of government decision-making on technology regulation and public standards based on the model developed in Chapter 3. We show that minor differences in consumer preferences can lead to important and persistent regulatory differences, and that temporary shocks to preferences can have long-lasting effects. This hysteresis in regulatory differences is shown to be caused by producer-protectionist motives. We argue that our model may contribute to explaining the difference between EU and US biotechnology regulation.

Chapter 5 develops a political economy model that contributes to explaining the stylized fact that private standards are frequently more stringent than their public counterparts. We show that if producers are able to exercise their political power to induce the government to set a lower public standard, retailers may apply their market power to set a private standard at a higher level than the public one, depending on a multiplicity of factors.

Chapter 6 leaves the political-economic track and develops a formal theory of the endogenous process of the introduction of high quality products in developing countries. Initial differences in income and in capital and transaction costs are shown to affect the emergence and size of the high quality economy. Additionally, we demonstrate that initial differences in the production structure and the nature of transaction costs – as well as the possibility of contracting between producers and processors – determine which producers are included in the high quality economy, and which are not.

Chapter 7 provides some general conclusions by summarizing the main results and policy implications of the different chapters.

Chapter 2. Equity and Efficiency Issues of Public Standards

We start this dissertation off by developing a simple conceptual framework to analyze the efficiency and equity effects of public standards. We consider the market for a good with a certain experience or credence characteristic which may be guaranteed by a public standard. We assume that producers are not able set private standards. Define the inverse demand and supply functions as

$$p = D(q,s); \qquad (2.1)$$

$$p = S(q,s); \qquad (2.2)$$

where p is the market price of the good, q is the quantity produced and sold, and s is the public standard. A higher s refers to a more stringent standard. The inverse demand and supply functions are normally behaving, i.e.

$$D_q(q,s) < 0; \qquad (2.3)$$

$$S_q(q,s) > 0; \qquad (2.4)$$

where the subscripts denote partial derivatives.

A standard which guarantees certain experience or credence features of the product affects consumer utility as it reduces or solves information asymmetries. Therefore a standard induces consumers to consume more of the product through an increased willingness to pay, ceteris paribus. For example consumers who perceive health problems with certain (potential) ingredients or production processes may increase consumption if they are guaranteed the absence of these elements. Therefore demand is increasing in the standard, i.e.

$$D_s(q,s) > 0. \tag{2.5}$$

We assume that the standard imposes some production constraints or obligations which increase production costs. This implies that

$$S_s(q,s) > 0. \tag{2.6}$$

At the market equilibrium, demand equals supply and

$$p^* = D(q^*,s) = S(q^*,s); \tag{2.7}$$

where q^* and p^* denote the market equilibrium. In equilibrium, aggregate consumer and producer surplus are respectively

$$\Pi^c = \int_0^{q^*} D(q,s)\,dq - p^* \cdot q^*; \tag{2.8}$$

and

$$\Pi^p = p^* \cdot q^* - \int_0^{q^*} S(q,s)\,dq. \tag{2.9}$$

Aggregate welfare is defined as the sum of aggregate consumer and producer surplus and equals

$$W = \int_0^{q^*} \left[D(q,s) - S(q,s) \right] dq. \tag{2.10}$$

This definition of aggregate welfare is not necessarily restricted to domestic welfare, since producers are not necessarily domestic to the country that imposes the standard.

We analyze the impact of a change in the public standard on aggregate consumer surplus, producer surplus, and welfare, for three different cases. In the first case, there are no implementation costs related to the standard. The second case introduces these implementation costs and the third case analyzes the effects when implementation costs are different between different types of producers.

2.1. No Implementation Costs

In the first case, producers are not directly affected by the public standard because there are no implementation costs, so the inverse supply function is specified as

$$p = S(q); \tag{2.11}$$

with the market equilibrium at

$$D(q^*, s) = S(q^*). \tag{2.12}$$

Taking the total derivative of Equation (2.12) with respect to the standard results in

$$D_s(q^*, s) + \frac{\partial q^*}{\partial s} D_q(q^*, s) = \frac{\partial q^*}{\partial s} S_q(q^*). \tag{2.13}$$

Rewriting this expression shows that

$$\frac{\partial q^*}{\partial s} = \frac{D_s(q^*, s)}{S_q(q^*) - D_q(q^*, s)}. \tag{2.14}$$

When the inverse supply and demand functions are properly behaving and demand is increasing in the standard, Equation (2.14) demonstrates that $\frac{\partial q^*}{\partial s} > 0$. Logically, the market equilibrium output increases with a more stringent standard if consumers have a willingness to pay for the experience or credence characteristic in the absence of implementation costs.

The marginal impact of an increase in the standard on consumer surplus is

$$\frac{\partial \Pi^c}{\partial s} = \underbrace{\int_0^{q^*} D_s(q,s)\,dq}_{>0} - \underbrace{q^* \left[\frac{-\varepsilon_p^D D_s(q^*,s)}{\varepsilon_p^S - \varepsilon_p^D} \right]}_{>0}; \qquad (2.15)$$

where $\varepsilon_p^S = \frac{1}{S_q(q^*)} \frac{S(q^*)}{q^*}$ is the price-elasticity of supply and $\varepsilon_p^D = \frac{1}{D_q(q^*,s)} \frac{D(q^*,s)}{q^*}$ is the price-elasticity of demand. The first term, $\int_0^{q^*} D_s(q,s)\,dq$, is the (positive) *efficiency gain* of the more stringent standard, i.e. the value that consumers attach to the reduced information asymmetries. The second term, $q^* \left[\frac{-\varepsilon_p^D D_s(q^*,s)}{\varepsilon_p^S - \varepsilon_p^D} \right]$, is the *marginal increase in consumption expenditure*, and is also positive since $\varepsilon_p^D < 0$. The combination of an increase in the equilibrium price (straightforward from the right hand side of Equation (2.13)) and an increase in the equilibrium output leads to an increase in consumption expenditure. The magnitude of this increase in consumption expenditure depends on the supply and demand price elasticities. The more inelastic supply is (ε_p^S low), the larger is the increase in consumption expenditure. Similarly, if demand is more elastic ($\left|\varepsilon_p^D\right|$ high), then the increase in consumption expenditure is larger. Since both terms on the right hand side of Equation (2.15) have opposing effects, the sign of $\frac{\partial \Pi^c}{\partial s}$ is undetermined. Hence an increase in the public standard may either increase or decrease consumer surplus, amongst others depending on the price elasticities of supply and demand.

The marginal impact of a more stringent standard on producer profits, in the absence of implementation costs, equals

$$\frac{\partial \Pi^{p}}{\partial s} = q^{*}\left[\frac{-\varepsilon_{p}^{D} D_{s}\left(q^{*}, s\right)}{\varepsilon_{p}^{S} - \varepsilon_{p}^{D}}\right] > 0\,, \tag{2.16}$$

where the right hand side is the *marginal increase in producer revenue* and is equal to the marginal increase in consumption expenditure. Equation (2.16) shows that the marginal impact on producer surplus is always positive in the absence of implementation costs. The revenue gain for producers is larger when supply is more inelastic (ε_{p}^{S} low) and demand more elastic ($\left|\varepsilon_{p}^{D}\right|$ high). More importantly, Equations (2.15) and (2.16) show that an increase in the standard creates a *rent transfer* from consumers to producers.

The effect of a change in the standard on aggregate welfare is

$$\frac{\partial W}{\partial s} = \int_{0}^{q^{*}} D_{s}\left(q, s\right) dq > 0\,; \tag{2.17}$$

which is equal to the efficiency gain and is unambiguously positive. In summary, this analysis shows that a more stringent standard is welfare-improving thanks to the efficiency gain, $\int_{0}^{q^{*}} D_{s}\left(q, s\right) dq$, but creates at the same time rent-redistribution from consumers to producers equal to the amount $q^{*}\left[\frac{-\varepsilon_{p}^{D} D_{s}\left(q^{*}, s\right)}{\varepsilon_{p}^{S} - \varepsilon_{p}^{D}}\right]$. Hence producers always gain in the absence of implementation costs, and consumers may either gain or lose depending on the size of the efficiency gain and the price sensitivity of supply and demand.

2.2. Implementation Costs

In the second case, we assume – more realistically – that there are implementation costs related to the standard. We therefore use the inverse supply function as specified in Equation (2.2). Taking the total derivative of the market equilibrium in Equation (2.7) results in

$$D_s\left(q^*,s\right)+\frac{\partial q^*}{\partial s}D_q\left(q^*,s\right)=S_s\left(q^*,s\right)+\frac{\partial q^*}{\partial s}S_q\left(q^*,s\right); \tag{2.18}$$

and written differently, shows that

$$\frac{\partial q^*}{\partial s}=\frac{D_s\left(q^*,s\right)-S_s\left(q^*,s\right)}{S_q\left(q^*\right)-D_q\left(q^*,s\right)}. \tag{2.19}$$

In contrast to Equation (2.14), the sign of Equation (2.19) is undetermined. The marginal impact of the public standard on the equilibrium output is positive if the marginal efficiency gain $D_s\left(q^*,s\right)$ is larger than the marginal implementation cost $S_s\left(q^*,s\right)$; and vice versa.

The marginal impact of an increase in the standard on consumer surplus is

$$\frac{\partial \Pi^c}{\partial s}=\underbrace{\int_0^{q^*}D_s\left(q,s\right)dq}_{>0}-\underbrace{q^*\left[\frac{\varepsilon_p^S S_s\left(q^*,s\right)-\varepsilon_p^D D_s\left(q^*,s\right)}{\varepsilon_p^S-\varepsilon_p^D}\right]}_{>0}; \tag{2.20}$$

where, as before, ε_p^S and ε_p^D are the price-elasticities of respectively supply and demand. Again, an increase in the standard may either increase or decrease consumer surplus, depending on the price elasticity of both supply and demand. As before, the first term on the right hand side of Equation (2.20) is the (positive) *efficiency gain* of the more stringent standard. Analogously, the second term, $q^*\left[\frac{\varepsilon_p^S S_s\left(q^*,s\right)-\varepsilon_p^D D_s\left(q^*,s\right)}{\varepsilon_p^S-\varepsilon_p^D}\right]$, is the *marginal increase in consumption expenditure* and is also positive since $\varepsilon_p^D<0$. However, if one departs from the same initial equilibrium q^*, this term is larger than in the first case. This is easily inferred from comparing Equations (2.15) and (2.20). The cause for this higher marginal increase in consumption expenditure is the implementation cost of the more stringent standard which must be compensated for by a larger price increase. Hence, consumers gain less (or lose more) from an increase in the standard if the standard involves implementation costs.

The marginal impact of an increase in the standard on producer profits is

$$\frac{\partial \Pi^p}{\partial s}=\underbrace{-\int_0^{q^*} S_s\left(q,s\right)dq}_{<0}+\underbrace{q^*\left[\frac{\varepsilon_p^S S_s\left(q^*,s\right)-\varepsilon_p^D D_s\left(q^*,s\right)}{\varepsilon_p^S-\varepsilon_p^D}\right]}_{>0}. \tag{2.21}$$

The first term on the right hand side of Equation (2.21), $-\int_0^{q^*} S_s\left(q,s\right)dq$, is the *implementation cost* of the standard and is negative. The second term, $q^*\left[\frac{\varepsilon_p^S S_s\left(q^*,s\right)-\varepsilon_p^D D_s\left(q^*,s\right)}{\varepsilon_p^S-\varepsilon_p^D}\right]$ is the *marginal increase in producer revenue* and is positive. This implies that the effect of the marginal price increase on producer revenue is always positive, independent from the marginal impact on output (which could be positive or negative, see Equation (2.19)). Equation (2.21) shows that the impact on producer profits may be either positive or negative, depending on the relative sizes of the price elasticities of supply and demand, and the implementation cost.

Departing from the same initial equilibrium, q^*, it is not sure how Equation (2.21) compares to Equation (2.16). On the one hand, Equation (2.21) is smaller due to the implementation cost; on the other hand, the marginal increase in producer revenue is larger than in Equation (2.16). The latter effect implies that there is a larger rent transfer from consumers to producers in the case with implementation costs. In other words, the implementation cost is not born solely by producers, but also partially conferred on consumers by a larger rent transfer.

The impact on aggregate welfare is now ambiguous, with

$$\frac{\partial W}{\partial s} = \int_0^{q^*} \left[D_s(q,s) - S_s(q,s) \right] dq \,. \tag{2.22}$$

Equation (2.22) shows that the impact on total welfare depends on the relative efficiency gain and implementation cost of the standard. At the same time, the standard involves a rent transfer from consumers to producers which is larger than in the absence of implementation costs.

2.3. Different Implementation Costs for Different Producers

In this third case, we assume N producers, indexed $i \in \{1, \ldots, N\}$, who may have different production costs (both related to quantity and the standard) and hence different supply functions. The market equilibrium is identified by the following $N+1$ equations:

$$D(q^*, s) = S^i(q^{i*}, s) \;\; \forall i \in \{1, \ldots, N\}; \tag{2.23}$$

$$q^* = \sum_{i=1}^{N} q^{i*} \,. \tag{2.24}$$

Taking the total derivative of expressions (2.23) and (2.24) with respect to the standard results in

$$D_s\left(q^*,s\right)+\frac{\partial q^*}{\partial s}D_q\left(q^*,s\right)=S_s^i\left(q^{i*},s\right)+\frac{\partial q^{i*}}{\partial s}S_q^i\left(q^{i*},s\right); \tag{2.25}$$

and

$$\frac{\partial q^*}{\partial s}=\sum_{i=1}^{N}\frac{\partial q^{i*}}{\partial s}. \tag{2.26}$$

The marginal impact on consumer surplus is the same as before, namely

$$\frac{\partial \Pi^c}{\partial s}=\underbrace{\int_0^{q^*}D_s\left(q,s\right)dq}_{>0}-\underbrace{q^*\left[D_s\left(q^*,s\right)+\frac{\partial q^*}{\partial s}D_q\left(q^*,s\right)\right]}_{>0}; \tag{2.27}$$

and can be either positive or negative, depending on the relative sizes of the *efficiency gain*, $\int_0^{q^*}D_s\left(q,s\right)dq$, and the *marginal increase in consumption expenditures*, $q^*\left[D_s\left(q^*,s\right)+\frac{\partial q^*}{\partial s}D_q\left(q^*,s\right)\right]$, i.e. the aggregate rent transfer to producers.

The marginal impact on the individual profits of the different producers is

$$\frac{\partial \Pi^i}{\partial s}=\underbrace{-\int_0^{q^{i*}}S_s^i\left(q^i,s\right)dq^i}_{<0}+\underbrace{q^{i*}\left[S_s^i\left(q^{i*},s\right)+\frac{\partial q^{i*}}{\partial s}S_q^i\left(q^{i*},s\right)\right]}_{>0}. \tag{2.28}$$

Its sign is undetermined and depends on the relative sizes of the *individual implementation cost*, $-\int_0^{q^{i*}}S_s^i\left(q^i,s\right)dq^i$, and the *individual marginal increase in producer revenue*, $q^{i*}\left[S_s^i\left(q^{i*},s\right)+\frac{\partial q^{i*}}{\partial s}S_q^i\left(q^{i*},s\right)\right]$. In aggregate, the marginal impact on producer profits is

$$\frac{\partial \Pi^p}{\partial s} = \underbrace{\sum_{i=1}^{N}\left(-\int_0^{q^{i*}} S_s^i\left(q^i,s\right)dq^i\right)}_{<0} + \underbrace{q^*\left[D_s\left(q^*,s\right)+\frac{\partial q^*}{\partial s}D_q\left(q^*,s\right)\right]}_{>0}. \tag{2.29}$$

The marginal impact on aggregate welfare is found by combining Equations (2.27) and (2.29):

$$\frac{\partial W}{\partial s} = \underbrace{\int_0^{q^*} D_s\left(q,s\right)dq}_{>0} - \underbrace{\sum_{i=1}^{N}\left(\int_0^{q^{i*}} S_s^i\left(q^i,s\right)dq^i\right)}_{>0}; \tag{2.30}$$

which can be either positive or negative. The first term is the *efficiency gain* of the standard, and the second term is the *aggregate implementation cost*. Hidden within this welfare result is however the rent transfer from consumers to producers (the second terms on the right hand sides of Equations (2.27) and (2.28)).

Equations (2.22) and (2.30) are equal if implementation costs are identical across all producers. However, standards may involve different implementation costs for different producers. For example, if a standard imposes the use of a specific input factor which one producer can source costlessly while other producers must incur an implementation cost, the impact of an increase in the standard has different impacts on producers' profits (e.g. the input factor 'land' in geographical indication regulations). The aggregate implementation cost may still be the same as in the second case, but distributed heterogeneously among producers.

To clarify the effects of these potentially different implementation costs, assume there are two producers, A and B, with respective inverse supply functions $S^A\left(q^A\right)$ and $S^B\left(q^B,s\right)$. In other words, producer A does not incur implementation costs while producer B does. Following the Equations in (2.25), it must be that

$$\begin{aligned}\frac{\partial q^{A*}}{\partial s} S_q^A\left(q^{A*}\right) &= S_s^B\left(q^{B*}, s\right) + \frac{\partial q^{B*}}{\partial s} S_q^B\left(q^{B*}, s\right) \\ &= D_s\left(q^*, s\right) + \frac{\partial q^*}{\partial s} D_q\left(q^*, s\right) \qquad > 0.\end{aligned} \tag{2.31}$$

Assuming that the initial equilibrium output is the same for both producers $\left(q^{A*} = q^{B*}\right)$ and that their respective supply curves have the same slope at this equilibrium $\left(S_q^A\left(q^{A*}\right) = S_q^B\left(q^{B*}, s\right)\right)$, it must be that $\frac{\partial q^{A*}}{\partial s} > \frac{\partial q^{B*}}{\partial s}$. It also follows that $\frac{\partial q^{A*}}{\partial s} > 0$ while the sign of $\frac{\partial q^{B*}}{\partial s}$ is undetermined. Hence the impact of the higher standard on output is positive for producer A whereas producer B's output increases less or even decreases. From Equation (2.28), it is therefore obvious that

$$\frac{\partial \Pi^A}{\partial s} = q^{A*}\left[\frac{\partial q^{A*}}{\partial s} S_q^A\left(q^{A*}\right)\right] > 0\,; \tag{2.32}$$

and

$$\frac{\partial \Pi^A}{\partial s} > \frac{\partial \Pi^B}{\partial s} = \underbrace{-\int_0^{q^{B*}} S_s^B\left(q^B, s\right) dq^B}_{<0} + \underbrace{q^{B*}\left[S_s^B\left(q^{B*}, s\right) + \frac{\partial q^{B*}}{\partial s} S_q^B\left(q^{B*}, s\right)\right]}_{>0}. \tag{2.33}$$

The impact of a more stringent standard on producer A's profits is always positive (as in the first case) and larger than the impact on producer B's profits which may be either positive or negative (as in the second case). Thus, if the implementation cost of producer B is sufficiently large, it may be that producer B's profits decrease with the more stringent standard, while producers A's profits increase. Therefore, if a government is able to choose between different implementation setups, the government may construct its public standard such as to benefit certain producer groups.

In summary, the public standard in this example involves an efficiency gain, an implementation cost for producer B, and rent transfers from consumers to both producers (this can easily be inferred from Equations (2.31), (2.32), and (2.33)). A more stringent standard always results in a profit increase for producer A, while the impact on aggregate welfare, consumer surplus, and producer B's profits is ambiguous, depending on the relative sizes of the efficiency gain, the individual implementation cost, and demand and supply elasticities.

In conclusion, the different cases in this chapter demonstrate that public standards may have different – positive or negative – effects on consumers, different types of producers, and social welfare, depending on supply and demand price elasticities, the standard's efficiency gain, the standard's implementation cost which may differ among producers, and the standard's impact on the rent distribution between various market players. These results provide support for our political-economic approach to analyze governments' standard-setting behavior.

Chapter 3. Trade, Development, and the Political Economy of Public Standards

"Under the German [trade] law of 1880 imports of livestock were controlled for 'sanitary reasons'. By 1889 the government had all but closed the borders to imports of live animals. ... A law of 1900 prohibited imports of sausages, canned meat and meat with preservatives; imports of pickled and salted meat had to be in pieces of at least 4 kg; imports of meat (other than pickled or salted) had to consist of whole beef carcasses or half pig carcasses, could enter only at certain ports and on certain days, and were subject to high inspection fees. If the quality of imported meat was judged doubtful, it was destroyed, though domestic meat of similar quality could be sold."[1]

Tracy (1989)

"Les frontières ne sont, pour ainsi dire, jamais plus ouvertes que quand vous les déclarez fermées"[2]

Van Naemen (1897)

3.1. Introduction[3]

In the last decades, the world market is experiencing a proliferation of standards. A growing number of public standards are being introduced globally, in a broad range and rich variety of areas, including nutrition (e.g. low fat), health (e.g. low lead or pesticide residue), safety (e.g. no small toy parts, equipment safety measures), environment (e.g. organic, no genetically modified organisms, low carbon dioxide emission) and social concerns (e.g. no child labor).

Trade economists have mostly interpreted this growth in the number and form of public standards as a political economy response to the constraints being imposed by

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[1] Tracy (1989, p. 91-92)

[2] "The borders are, in a way of speaking, never more open than when you declare them closed." (Chambre des Représentants (Nov. 18, 1897), cited in Van Molle 1989, p. 230). This was Parliamentary Representative Van Naemen's reaction in Belgian parliament to the government's 1897 decision to restrict imports of livestock because of 'the danger of imports of diseases'. From a health point of view, the official closing of the borders had a perverse effect as it induced massive smuggling without any health inspection.

[3] This chapter is based on joint research with Johan F.M. Swinnen (see Swinnen and Vandemoortele 2008; Swinnen and Vandemoortele 2009; Swinnen and Vandemoortele 2011a).

international trade agreements on traditional trade restrictions.[4] As the use of tariffs is progressively more limited, new forms of non tariff barriers (NTBs) are increasingly used (e.g. Baldwin 2001; OECD 2001; Sturm 2006). In this interpretation public standards are just a new form of NTBs and protection-in-disguise.[5] For example Fischer and Serra (2000) find that standards are biased against imports and favor domestic producers. Bredahl *et al*. (1987) illustrate this with the USA's implementation of a larger minimum size requirement on vine-ripened tomatoes – mainly imported from Mexico – than on green tomatoes produced in Florida. Anderson *et al*. (2004) argue that governments raise genetically modified (GM) food standards as protection against imports.[6] Fulton and Giannakas (2004) point out that producers prefer GM labeling when they have low returns on GM food. In their infamous example, Otsuki *et al*. (2001) claim that an EU standard on aflatoxins reduced health risk by approximately 1.4 deaths per billion a year, while decreasing African exports of cereals, dried fruits and nuts to Europe by 64 percent.[7] Krueger (1996) concludes that, although it is not possible to generalize about labor standards' effects, many economists still argue that international labor standards are protectionist instruments.[8]

[4] In this chapter we focus on public standards. For a discussion of the relation between public and private standards, see e.g. Henson (2006), McCluskey and Winfree (2009) and Chapter 5 of this dissertation.

[5] For literature related to the effects of standards as barriers to trade, see for example Barrett (1994), Sykes (1995), Thilmany and Barrett (1997), Schleich (1999), Suwa-Eisenmann and Verdier (2002), Barrett and Yang (2001).

[6] See also Baltzer (2010) who argues that domestic producers always favor more restrictive GM standards because of positive border costs.

[7] The conclusions of Otsuki *et al*. (2001) are disputed in recent empirical work by Xiong and Beghin (2010).

[8] In an earlier contribution, Bockstael (1984) argues that the same holds for domestic quality standards. She argues that these are mainly redistributive instruments and do not enhance welfare – they protect certain producer interests.

However, this trade-protection interpretation of public standards appears to conflict with some basic empirical observations. Many public standards, such as EU GM regulations, are introduced following demands by consumers, not producers. In fact, in many cases producers have opposed their introduction. If public standards would be merely protectionist instruments producers would support their introduction and consumers would oppose them. Tian (2003) demonstrates that an increase in the minimum required 'environmental friendliness' of imported goods is not necessarily protectionist in effect as it may hurt domestic firms and increase imports. In the framework of Marette and Beghin (2010) a standard is anti-protectionist when foreign producers are more efficient than domestic producers at addressing consumption externalities by the standard.

These observations are in line with insights from the literature on the economics of quality standards. For example, Ronnen (1991), Boom (1995) and Valletti (2000) all find positive effects of minimum quality standards on consumers' welfare, but find mixed effects on overall welfare. Leland (1979) shows that, in general, the effect of a minimum quality standard on welfare is ambiguous. In a vertical product differentiation framework Ronnen (1991) shows that minimum quality standards increase welfare under Bertrand competition between firms, while Valletti (2000) finds that welfare decreases but under Cournot competition. Additionally, Winfree and McCluskey (2005) show that minimum quality standards may improve welfare by serving as a common reputation device in markets where consumers cannot trace the producer of a good, and producers sell at a common price and share a collective reputation which creates incentives to free-ride and produce low quality goods.

This chapter integrates these different perspectives in an open economy framework and develops a formal political economy model of public standards. Our analysis has three specific objectives, which are addressed in three parts of the chapter. The first objective is to develop a political economy model of public standards in which both producers and consumers are actively and simultaneously lobbying. Our model assumes that standards benefit consumers because standards guarantee that products satisfy certain characteristics preferred by consumers. Producers' production costs increase with implementation of the public standard. We show that either producers or consumers may gain or lose, depending on the resulting market prices in an open economy where importers also have to satisfy the standards. With these potential welfare effects, we derive the political equilibrium and analyze how this equilibrium is affected by several political and economic characteristics.

Our second objective is to derive if and why the politically optimal standard changes with development. Empirically one observes important differences in the use of public standards across countries and there appears a positive correlation between public standards and income. An important question is what causes this correlation. Some have simply argued that rich consumers (countries) desire higher standards (Maertens and Swinnen 2007; Wilson and Abiola 2003). We find that the impact of development on governments' choice of standards is more complex and depends on several factors – including, besides consumer preferences, compliance costs and enforcement problems.

Our third objective is to analyze if or when public standards are protectionist instruments. In this third part of the chapter we compare the political equilibrium with the social optimum and derive under which conditions public standards can be considered ‘protectionism’. We show that politically optimal public standards may be either too high (‘over-standardization’) or too low (‘under-standardization’) – a situation which is similar to other forms of price and trade policy which governments use to tax or subsidize certain sectors (Krugman 1987; Grossman and Helpman 1994).

Our work is related to – but distinct from – the literature on the harmonization of standards in the context of international trade agreements and regionalism, including studies on the WTO’s sanitary and phyto-sanitary (SPS) agreement and trade disputes (see e.g. Hooker 1999). For example Chen and Mattoo (2008) analyze whether regional agreements on (the harmonization of) standards enhance or reduce trade. Bredahl and Forsy (1989) study the harmonization of SPS standards, and Baldwin (2001) discusses the WTO’s role in this harmonization process. Also Kinsey (1993), Bagwell and Staiger (2001), and Battigalli and Maggi (2003) look at the role of the WTO in regulating standards. Costinot (2008) compares the performance of the WTO’s national treatment principle and the EU’s mutual recognition principle with respect to product standards. In our analysis we do not consider international standards or harmonization of standards across countries.

3.2. The Model

A key issue is obviously how to model standards. The approaches in the literature differ importantly. Some (such as Bockstael 1984; Ronnen 1991; Valletti 2000) assume that consumers can costlessly observe product characteristics ex ante (hence ‘search’ characteristics), while others (such as Leland 1979) assume that consumers are ex ante uncertain about the characteristics of the product (hence ‘experience’ or ‘credence’ characteristics). In the latter case standards can improve upon the unregulated market equilibrium by reducing information asymmetries between consumers and producers. Yet other studies (such as Copeland and Taylor 1995; Fischer and Serra 2000; Anderson *et al.* 2004; Tian 2003; Besley and Ghatak 2007) model the effect of standards as their impact on consumption externalities. This could relate to, for example, standards on catalytic converters in cars or GM foods. Most studies consider that the introduction of standards implies compliance costs for producers (amongst many others Leland 1979; Ronnen 1991; Valletti 2000), and this holds both for domestic producers and those in countries (interested in) exporting to the country that imposes the standard (Henson and Jaffee 2007; Suwa-Eisenmann and Verdier 2002).

Consider therefore an economy where consumers have heterogeneous preferences for a public standard.[9] A standard which guarantees certain quality/safety features of a product affects utility as it reduces or solves information asymmetries. Therefore a standard induces to consume more of the product through an increased willingness to pay, ceteris paribus. For example consumers who perceive health problems with certain (potential) ingredients or production processes may increase consumption if they are guaranteed the absence of these elements. We call this the standard's 'consumption effect'. To model this, assume that individuals consume at most one unit of the good and that their preferences are described by the following utility function (see Tirole 1988):[10]

[9] The standards under analysis have a direct effect on the utility of consumers. Hence these standards are 'quality standards' (see Fischer and Serra 2000) but for simplicity we refer to them as 'standards'.

[10] Our approach of modelling standards is consistent with the standard approach in the literature on minimum quality standards (see e.g. Ronnen 1991, Jeanneret and Verdier 1996, Valletti 2000).

$$u_i = \begin{cases} \phi_i(\varepsilon + s) - p & \text{if he buys the good with standard } s \text{ at price } p; \\ 0 & \text{if he does not buy,} \end{cases} \tag{3.1}$$

where ϕ_i is the preference parameter. Consumers with a higher ϕ_i have a higher willingness to pay for a product with a public standard s and the non-standard-related value ε of the product.[11] A higher s refers to a more stringent standard. ϕ_i is uniformly distributed over the interval $[\phi - 1, \phi]$ with $\phi \geq 1$ and $i \in \{1, \ldots, N\}$. Consumers with $\phi_i < p/(\varepsilon + s)$ do not consume the product which implies that the market is 'uncovered'. The aggregate demand function[12] is:

$$c(p,s) = N\left(\phi - p/(\varepsilon + s)\right). \tag{3.2}$$

On the production side, we assume that production is a function of a sector-specific input factor that is available in inelastic supply. All profits made in the sector accrue to this specific factor. The unit cost function $g(q,s) = k(q,s) + t(s)$ depends on output produced (q) and the level of the standard in that sector (s), and is composed of production costs $k(q,s)$ and transaction costs $t(s)$.[13]

We assume that a standard imposes some production constraints or obligations which increase production and transaction costs. The idea behind this assumption is that

[11] We assume that the non-standard-related value ε and the public standard s are additively separable in the utility function, and that consumer preferences for ε and s follow the same distribution.

[12] For the remainder of this analysis we assume that $p/(\varepsilon + s) \leq \phi$ holds such that aggregate consumption is always positive. The (exogenous) constant ε ensures that consumption is positive when the standard is zero.

[13] This approach has two advantages. First it allows to differentiate between different types of costs in our analysis of the relation between development and the political economy of public standards. Second, it allows to distinguish between standards with scale neutral cost effects $(t(s))$ and standards that reinforce (dis)economies of scale $(k(q,s))$.

all standards can be defined as the prohibition to use a cheaper technology. Examples are the prohibition of an existing technology (e.g. child labor) or of a technology that has not yet been used but that could potentially lower costs (e.g. GM technology). Also traceability standards can be interpreted as a prohibition of cheaper production systems which do not allow tracing the production. Therefore, standards may increase the production costs $k(q,s)$ because of the obligation to use a more expensive production technology $\left(\frac{\partial k}{\partial s} > 0\right)$. Standards may also increase the transaction costs $t(s)$ because of control and enforcement costs related to the standard $\left(\frac{\partial t}{\partial s} > 0\right)$.[14] This implies that the unit costs increase with higher standards $\left(\frac{\partial g}{\partial s} > 0\right)$ for $s > 0$.[15]

The model assumes a small open economy where domestic firms are price takers and domestic prices of imported goods equal world prices. We assume that when the country imposes a standard, the production costs of the imported goods also rise as the standard is also imposed on imported goods – and is equally enforced. This leads to a price increase, henceforth called the standard's 'marginal price effect' $\left(\frac{\partial p}{\partial s} > 0\right)$. More specifically, the unit cost function of foreign (f) producers is:

$$g^f\left(q^f,s\right) = k^f\left(q^f,s\right) + t^f\left(s\right), \tag{3.3}$$

[14] We implicitly assume that control and enforcement costs are born by producers.

[15] Modelling the cost of standards with a unit cost function that is increasing in the standard is consistent with e.g. Fischer and Serra (2000) and Tian (2003).

where $k^f\left(q^f,s\right)$ are production costs, $t^f\left(s\right)$ transaction costs and q^f is foreign production. The world price p then equals the unit costs of the foreign producers and we have that $p\left(s\right)=g^f\left(q^f,s\right)$ and $\frac{\partial p}{\partial s}=\frac{\partial g^f}{\partial s}$.

A key result is that both producers and consumers may either gain or lose from (a change in) the standard. Consider first the producer effects. Producers' profits are equal to

$$\Pi_p\left(s\right)=\max_q\left\{q\cdot\left(p\left(s\right)-g\left(q,s\right)\right)\right\}, \tag{3.4}$$

and by the envelope theorem the marginal effect of a standard on producers' profits $\Pi_p\left(s\right)$ is equal to

$$\frac{\partial \Pi_p}{\partial s}=q\cdot\left(\frac{\partial p}{\partial s}-\frac{\partial g}{\partial s}\right). \tag{3.5}$$

Producers' profits decrease with an increase of the standard when the marginal unit cost increase $\frac{\partial g}{\partial s}$ is larger than the marginal price effect $\frac{\partial p}{\partial s}$. When the marginal unit cost increase is smaller than the marginal price effect, the sector-specific capital owners gain from an increase of the standard.

Aggregate consumer surplus can be written as:

$$\Pi_c\left(s\right)=N\int_{p/(\varepsilon+s)}^{\phi}u_i\mathrm{d}\phi_i=N\frac{\left(\varepsilon+s\right)}{2}\left(\phi-\frac{p}{\left(\varepsilon+s\right)}\right)^2. \tag{3.6}$$

The impact of a marginal change in the standard on aggregate consumer surplus equals

$$\frac{\partial \Pi_c}{\partial s}=\frac{N}{2}\left(\phi^2-\left(\frac{p}{\varepsilon+s}\right)^2\right)-\frac{\partial p}{\partial s}c\left(p,s\right). \tag{3.7}$$

Aggregate consumer surplus increases with the standard if the marginal 'consumption effect' $\frac{N}{2}\left(\phi^2-\left(\frac{p}{\varepsilon+s}\right)^2\right)$ is larger than the marginal increase in the cost of consumption $\frac{\partial p}{\partial s}c\left(p,s\right)$. Vice versa, if the marginal increase in the cost of consumption outweighs the beneficial marginal consumption effect, aggregate consumer surplus decreases with the standard.

Finally, we define social welfare $W\left(s\right)$ as the sum of (domestic) producer profits and consumer surplus in this sector, i.e.

$$W\left(s\right)\equiv\Pi_p\left(s\right)+\Pi_c\left(s\right). \tag{3.8}$$

3.2.1. The Political Equilibrium

Consider a government that maximizes its own objective function which, following the approach of Grossman and Helpman (1994), consists of a weighted sum of contributions from interest groups and social welfare. Similar to Grossman and Helpman (1994), we restrict the set of policies available to politicians and only allow them to implement a public standard. We assume that both producers and consumers are organized into politically active interest groups and that they lobby simultaneously. This assumption differs from Grossman and Helpman (1994), Anderson *et al*. (2004), and Cadot *et al*. (2004). We believe it is not realistic to assume that consumers are not organized – or do not effectively lobby – on issues related to public standards. There is substantive evidence that consumers and producers lobby governments on issues of public standards.[16]

The 'truthful' contribution schedule of the specific-capital owners' interest group is equal to the function $C_p(s) = \max\{0; \Pi_p(s) - b_p\}$, in which the constant b_p represents the share of profits that producers do not want to invest in lobbying the government.[17] One could also interpret this constant b_p as a minimum threshold, a level of profits or surplus below which producers believe the return from lobbying is less than its cost. Similarly, the truthful contribution schedule of the consumers' interest group is of the form $C_c(s) = \max\{0; \Pi_c(s) - b_c\}$, with $\Pi_c(s)$ the aggregate consumer surplus as defined earlier. The constant b_c can be interpreted in the same way as in the contribution schedule of the specific-capital owners. The government's objective function, $V(s)$, is a weighted sum of the contributions of producers (weighted by α_p), the contributions of consumers (weighted by α_c), and social welfare, where α_j $(j = p,c)$ represents the relative lobbying strength:

$$V(s) = \alpha_p C_p(s) + \alpha_c C_c(s) + W(s). \tag{3.9}$$

The government chooses the level of the public standard to maximize its objective function (3.9). Each potential level of the standard corresponds to a certain level of producer profits and consumer surplus, and hence also to a certain level of producer and

[16] In reality, consumer lobbying does not only occur through consumer organizations but also through political parties representing consumer interests. See also Gulati and Roy (2007) on lobbying of both producers and consumers with respect to environmental standards.

[17] The common-agency literature (e.g. Bernheim and Whinston 1986) states that a truthful contribution schedule reflects the true preferences of the interest group. In our political economy model this implies that lobby groups set their lobbying contributions in accordance with their expected profits and how these are marginally affected by the standard. We refer to Appendix A.1 for a proof of the truthfulness of the contribution schedules.

consumer contributions. This is driven by the functional form and the truthfulness of the contribution schedules. The government receives higher contributions from producers (consumers) if the imposed standard generates higher producer profits (consumer surplus). Conversely, the government receives less producer or consumer contributions if the standard decreases respectively producer profits or consumer surplus. Therefore maximizing the contributions from producers (consumers) by choosing the level of standard is equivalent to maximizing producer profits (consumer surplus). The government thus chooses the level of the standard that maximizes the weighted sum of producer profits, consumer surplus, and social welfare. The politically optimal standard, s^*, is therefore determined by the following first order condition, subject to $s^* \geq 0$:[18]

$$\left(1+\alpha_p\right)\left[q^*\left(\frac{\partial p}{\partial s}-\frac{\partial g}{\partial s}\right)\right]+\left(1+\alpha_c\right)\left[\frac{N}{2}\left(\phi^2-\left(\frac{p^*}{\varepsilon+s^*}\right)^2\right)-c^*\frac{\partial p}{\partial s}\right]=0. \qquad (3.10)$$

c^* and q^* denote respectively aggregate consumption and domestic production in the political optimum and p^* the equilibrium price.

The first term in Equation (3.10) captures the marginal impact of a public standard on domestic producers' profits weighted by their lobbying strength $\left(1+\alpha_p\right)$. As we explained earlier this marginal impact may be positive or negative. The second term represents the weighted marginal impact of a public standard on aggregate consumer surplus which may also be positive or negative.

[18] See Appendix A.2. We assume that the domestic producers' unit cost function $g(q,s)$ and the world price $p(s)$ (i.e. the foreign producers' unit cost function) are sufficiently convex in the standard ($\frac{\partial^2 g}{\partial s^2} > 0$, $\frac{\partial^2 p}{\partial s^2} = \frac{\partial^2 g^f}{\partial s^2} > 0$, see e.g. Ronnen 1991; Valletti 2000; Fischer and Serra 2000) such that $V(s)$ is concave in s and that first order condition (3.10) determines a global maximum.

Optimality condition (3.10) implicitly defines s^* as a function of several variables, such as relative lobbying strength (α_j), consumer preferences (ϕ), and the marginal unit cost increase of domestic and foreign producers. The latter is reflected in the marginal price effect $\left(\frac{\partial p}{\partial s}\right)$. The impact of the exogenous variables (α_j, ϕ) on the politically optimal standard can be formally derived through comparative statics. We refer to Appendix A.3 for the formal derivations and restrict ourselves here to the presentation and discussion of the effects.

First, it is obvious from Condition (3.10) that a change in the political weights α_j $(j = p, c)$, capturing exogenous differences in the political weights of lobby groups, affects s^*. When the political weight of a lobby group increases exogenously, it implies that its contributions are more effective in influencing the decisions of the government. However the sign of the effect on s^* depends on the marginal benefit of s^* for the interest groups. More specifically, an increase in α_j leads to a higher standard s^* $\left(\frac{\partial s^*}{\partial \alpha_j} > 0\right)$, if and only if interest group j gains from increasing the standard beyond s^*, i.e. if $\frac{\partial \Pi_j}{\partial s} > 0$ at s^*. In this case the government sets the optimal standard at a higher level if α_j increases, and vice versa.

Second, an exogenous change in the preferences of consumers, ϕ, affects the politically optimal standard, s^*.[19] A shift in consumer preferences affects the aggregate

[19] Under our assumptions, a change in ϕ only affects the boundaries of the preference distribution, not the distribution itself. Therefore ϕ is a measure for the average consumer preferences.

demand and consumer surplus. Higher consumer preferences for quality lead to higher consumer surplus and higher contributions in favor of a public standard, which induce the government to set a higher public standard, i.e. $\frac{\partial s^*}{\partial \phi} > 0$, and vice versa.[20]

Third, the marginal cost increases of domestic and foreign producers affect the politically optimal standard. Higher marginal unit costs of domestic producers $\left(\frac{\partial g}{\partial s}\right)$ reduce the benefits of a standard for domestic producers, ceteris paribus. This leads to a lower standard as producers reduce their contributions in favor of a public standard. The marginal unit cost increase of foreign producers is reflected in the marginal price effect of a public standard $\left(\frac{\partial g^f}{\partial s} = \frac{\partial p}{\partial s}\right)$, as the international market price equals the unit costs of foreign producers.

Notice that a higher marginal unit cost increase for foreign producers may increase or decrease the politically optimal standard, depending on other factors. On the one hand, the resulting higher marginal price effect reduces consumer benefits and their contributions. On the other hand, it increases profits and contributions of domestic producers. The size of these effects and the net effect depends on the relation between domestic production and consumption and on the functional form of the various functions. As a result, standards may move in either direction with changes in the

[20] This is conditional on $\phi > \frac{\partial p}{\partial s}$ at s^*. Violation of this condition would however imply that the individual willingness to pay for a marginal increase of the standard is negative at s^*, even for the individual with the highest preference for quality $(\phi_i = \phi)$. We abstract from this case.

marginal cost increase of foreign producers, depending on the relative benefits and the political weights of the different lobby groups.

Finally, an important general implication from this discussion is that either consumers or producers may lobby in favor or against a standard, and that the political equilibrium may be affected by various factors.

3.3. Development and the Political Economy of Public Standards

We can now use these results to explain the empirically observed positive relationship between standards and economic development. It is often argued that this relationship simply reflects consumer preferences. While our model confirms that income-related preferences (ϕ) play a role, it also suggests a more complex set of causal factors which affect the relationship between development and the political economy of public standards. Our analysis suggests several reasons for the wide variety in standards across the world, and in particular between developing ('poor') and developed ('rich') countries.

Define I as the country's per capita income, i.e. its level of economic development, and z as an indicator of the quality of the institutions in the country. Studies find that the quality of institutions (including institutions for enforcement of contracts and public regulations) is positively correlated with development $\left(\frac{\partial z}{\partial I} > 0\right)$ (North 1990). The impact of development on the politically optimal level of the public standard s^* can then be derived as:

$$\frac{\partial s^*}{\partial I} = \frac{\partial s^*}{\partial \phi}\frac{\partial \phi}{\partial I} + \left(\frac{\partial s^*}{\partial t_s}\frac{\partial t_s}{\partial z} + \frac{\partial s^*}{\partial k_s}\frac{\partial k_s}{\partial z}\right)\frac{\partial z}{\partial I}, \qquad (3.11)$$

where $t_s = \frac{\partial t}{\partial s}$ and $k_s = \frac{\partial k}{\partial s}$.

The first term is positive because lower income levels (I) are typically associated with lower consumer preferences for quality and safety standards as reflected in differences for ϕ in Equation (3.11), with ϕ smaller for poorer countries $\left(\frac{\partial \phi}{\partial I} > 0\right)$. Because the effect on aggregate consumer surplus of a public standard is lower for lower ϕ, consumer contributions are lower in developing nations than in rich countries and this results in a lower politically optimal standard level in poor countries $\left(\frac{\partial s^*}{\partial \phi} > 0\right)$.

This is consistent with international survey evidence on consumer preferences for GM standards. Rich country consumers are generally more opposed to GM than poor country consumers. Consumers in rich countries have less to gain from biotech-induced farm productivity improvements compared to developing country consumers who have much to gain from cheaper food (McCluskey *et al*. 2003). This argument is also consistent with empirical observations that consumers from developed countries have generally higher preferences for other applications of biotechnology, such as medical applications (Costa-Font *et al*. 2008; Hossain *et al*. 2003; Savadori *et al*. 2004) which have more (potential) benefits for richer consumers.

The second and third term in Equation (3.11) capture how the quality of institutions affects the relationship between development and the political economy of public standards. The impact of standards on both production and transaction costs depends on the quality of a country's institutions z.

The second term is positive (with $\frac{\partial z}{\partial I} > 0$). Lower quality of institutions implies that enforcement and control costs of standards (i.e. the increase in transaction costs with higher standards) are higher such that $\frac{\partial t_s}{\partial z} < 0$. These higher enforcement costs lead to a lower politically optimal standard $\left(\frac{\partial s^*}{\partial t_s} < 0 \right)$.

The third term is also positive. While poor countries, with low wages and less urban pressure on land use, may have a cost advantage in the production of raw materials, better institutions of rich countries lower the marginal increase in production costs caused by standards $\left(\frac{\partial k_s}{\partial z} < 0 \right)$. A lower marginal increase in production costs could result from higher education and skills of producers, better public infrastructure, easier access to finance, etc. These factors induce a higher public standard as $\frac{\partial s^*}{\partial k_s} < 0$.

3.3.1. Development and Pro- & Anti-Standard Coalitions

The combination of the factors which we discussed above is likely to induce a shift of the political equilibrium from low standards to high standards with development. If we define a 'coalition' as both groups having the same preferences, i.e. either $s = 0$ (anti) or $s > 0$ (pro), then in extreme cases, the variations in the mechanisms identified here may result in a pro-standard coalition of consumers and producers in rich countries. In rich countries, in addition to consumers, also producers may support standards as they enhance their competitive position against imports as compliance may be less costly for domestic producers compared to importers. In contrast, an anti-standard coalition may be present in poor countries as, in addition to producers, consumers may also oppose standards since they may be more concerned with low prices than standards. Formally, a pro-standard coalition exists when both $\frac{N}{2}\left(\phi^2 - \left(\frac{p}{\varepsilon + s}\right)^2\right) > c\frac{\partial p}{\partial s}$ and $q\frac{\partial p}{\partial s} > \frac{\partial g}{\partial s}$ at $s = 0$, and vice versa for an anti-standard coalition.

3.4. Trade and the Political Economy of Public Standards

An important aspect of public standards which has attracted substantial attention is their potential use as instruments of 'protection in disguise' (Vogel 1995). This is also reflected in the rapid increase of notifications of new SPS measures to the WTO (see Figure 3.1). Among other things, member countries have to notify new SPS measures to the WTO when these measures have a significant effect on trade. This rapid increase in SPS measures notifications raises concerns on the potential protectionist nature of public standards. In fact, most studies on the political economy of standards in open economy models consider standards as protectionist instruments (Anderson *et al*. 2004; Fischer and Serra 2000; Sturm 2006).

To analyze this issue with our model it is important to clarify some key elements in the relationship between trade and standards. As we show in this section, standards can be set to benefit (or 'protect') producer or consumer interests. Hence, it is important to first define 'protectionism' as producer protectionism. As with tariffs and trade restrictions, standards may either harm or benefit producers. Hence, unlike other studies suggest, there is no ex ante reason to see standards as producer protectionism. We show that, while almost all standards affect trade, there is no simple relation between 'trade distortions' and 'producer protection'.

The rest of this section is organized as follows. We first identify the key factors which characterize the relationship between trade and standards and its effects. Then we identify under which conditions standards reduce trade, i.e. act as 'trade barriers', or enhance trade, i.e. act as 'trade catalysts'. Next we identify when there is 'over-standardization' and 'under-standardization' and finally we combine these insights to evaluate the validity of the 'standards-as-protection' argument.

3.4.1. Comparative Advantage and Compliance with Standards

Trade and politically optimal standards are interrelated in several ways. First, trade affects the net impact of standards on producers and consumers as reflected in Equation (3.10) and hence also the political contributions and their relative influence. For a given level of consumption (c), with larger imports $(m \equiv c - q)$ and lower domestic production (q), the effect of standards on aggregate producer profits is smaller and hence producers' contributions and influence on policy lower. In the extreme case without domestic production $(q = 0)$, only consumer interests affect government policy. Formally, the first term in Equation (3.10) drops out and the political equilibrium condition equals the optimality condition for consumers. Vice versa, for a given level of domestic production more imports and higher consumption levels imply that the effects on total consumer surplus are larger and therefore consumer contributions and their influence on policy higher.

Second, standards may affect the comparative advantage in production between domestic and foreign producers. There are two potential cost effects. At the political optimum s^* the marginal effect of a standard on domestic producer profits is

$$\frac{\partial \Pi_p}{\partial s} = q^*\left(\frac{\partial p}{\partial s} - \frac{\partial g}{\partial s}\right) = q^*\left(\frac{\partial g^f}{\partial s} - \frac{\partial g}{\partial s}\right) = q^*\left[\left(\frac{\partial k^f}{\partial s} - \frac{\partial k}{\partial s}\right) + \left(\frac{\partial t^f}{\partial s} - \frac{\partial t}{\partial s}\right)\right]. \quad (3.12)$$

First, standards may affect the production costs of domestic and foreign producers differently, i.e. $\frac{\partial k}{\partial s} \neq \frac{\partial k^f}{\partial s}$ at s^*. This is the argument used by Anderson *et al*. (2004) to explain why EU producers lobby against GM food: they argue that producers in countries such as the US and Brazil have a comparative production cost advantage in the use of GM technology and that it is therefore rational for EU producers to support (rather than oppose) cost-increasing standards to ban GM food. This argument makes assumptions on the nature of the supply functions and the technology, which may not hold in general. Standards increase production cost advantages when they reinforce scale economies (reflected in a downward pivot of the supply function) but not when they have a scale neutral impact or when they create scale diseconomies (causing an upward pivot of the supply function). Differences in these effects induce differences in reactions to standards by domestic producers. However the effects are conditional. Producers oppose standards more (or support them less) if they have a comparative disadvantage and standards reinforce this $\left(\frac{\partial^2 k}{\partial q \partial s} > 0\right)$, compared to when standards are scale neutral $\left(\frac{\partial^2 k}{\partial q \partial s} = 0\right)$. The opposite holds when standards reduce the comparative disadvantage vis-à-vis foreign producers $\left(\frac{\partial^2 k}{\partial q \partial s} < 0\right)$.[21]

[21] Similarly, producers would support standards more (or oppose less) if they have a comparative advantage and standards reinforce this – and vice versa. However, our model focuses on the import case.

Second, standards may also affect comparative advantages through differences in transaction costs $\left(\text{i.e. if } \frac{\partial t}{\partial s} \neq \frac{\partial t^f}{\partial s} \text{ at } s^*\right)$. The relative (domestic versus foreign) impact of standards on production costs and transaction costs may be quite different. Countries with high production costs (importers) may be more efficient at implementing or complying with standards. In such cases, standards shift the cost difference between domestic producers and foreign producers in terms of the final cost of the product. As a consequence, such comparative (transaction) cost advantage of complying with a standard (see e.g. Salop and Scheffman 1983, and Baldwin 2001 for examples) leads to higher producer contributions in favor of the standard, rather than against it $\left(\frac{\partial t}{\partial s} < \frac{\partial t^f}{\partial s} \text{ at } s^*\right)$.[22] Vice versa, when $\frac{\partial t}{\partial s} > \frac{\partial t^f}{\partial s}$ at s^* domestic producers contribute less in favor of the standard.

In Figure 3.2 we illustrate the case of different transaction costs. We use a simple graph with parallel shifts of supply curves to simplify the comparison of producer profits before and after the introduction of the standard (our theoretical model is more general). The increase in transaction costs is depicted by an upward shift in the supply curve (S) and the price effect by an upward shift in the horizontal supply function of the outside world that determines the price (P). When the shift in domestic supply (to S^1) is equal to the shift in the foreign supply (to P^s), producers' profits do not change; hence they are indifferent. When the domestic transaction cost increase is smaller than the foreign one

[22] While we do not formally model instrument choice here, if a government has the choice between different standards that induce the same effect on consumption, it would be inclined to enforce a standard that is less costly for the domestic sector, or to forbid the use of a technology in which the domestic sector has a comparative disadvantage. Fischer and Serra (2000) argue therefore that governments tend to use minimum standards that are biased against imports.

(represented by the shift to S^2), producers' profits increase because the price effect is larger than the transaction cost effect. The gain in profits is the light grey area and the politically optimal standard will be higher than the consumers' optimum. In contrast, a large upward shift in supply (S^3) – implying higher transaction costs of implementing the standard – results in a decrease in producer profits. The resulting loss is the dark grey area and the politically optimal standard will be below the consumers' optimum.

Notice that, although these factors do relate standards and trade, they do not say anything about standards being trade distorting or protectionist measures.

3.4.2. Standards as Catalysts or Barriers to Trade?

In our model, standards (almost) always affect trade. Only in very special circumstances do standards not affect trade. This is when the effect on domestic production exactly offsets the effect on consumption. Define $D(c,s)$ as the inverse demand function with $D_c = \frac{\partial D}{\partial c} < 0$ and $D_s = \frac{\partial D}{\partial s} > 0$. Similarly, define $A(q,s)$ as the inverse supply function with $A_q = \frac{\partial A}{\partial q} > 0$ and $A_s = \frac{\partial A}{\partial s} > 0$. The effect of standards on trade (imports) is:[23]

$$\frac{\partial m}{\partial s} = \frac{D_s}{|D_c|} + \frac{A_s}{A_q} - \left(\frac{A_q + |D_c|}{A_q |D_c|}\right)\frac{\partial p}{\partial s}. \tag{3.13}$$

Notice that the sign of Equation (3.13) may be positive or negative. If the sign of (3.13) is negative standards are 'trade barriers', i.e. they reduce trade. However, the sign of (3.13) can also be positive, and then imports increase and standards work as 'catalysts to trade'. This is the case when the marginal consumption gain (loss) from the standard is larger

[23] See also Appendix A.4.

(smaller) than the marginal gain (loss) from the standard in domestic production. Moreover, as we discuss next, whether trade flows increase or decrease upon introduction of a standard in itself does not automatically relate to (or is not necessarily equivalent to) producer protectionism.

3.4.3. Over- and Under-Standardization

To assess whether public standards are set at sub-optimal levels we use the same framework to identify optimal policy as is used in evaluating tariffs in traditional trade theory, that is by comparing to the socially optimal trade policy. The political equilibrium is said to be suboptimal when the politically optimal tariff t^* differs from the socially optimal tariff $t^\#$. In a small open economy, this analysis leads to the well-known result that the socially optimal tariff level is zero and free trade is optimal, i.e. a positive tariff that constrains trade is harmful to social welfare.

Similarly, we compare the politically optimal standard s^* with the socially optimal standard $s^\#$ in a small open economy. To determine $s^\#$ we maximize the domextic welfare function as defined in Equation (3.8).[24] The socially optimal standard $s^\#$ is determined by:[25]

$$\left[q^\# \frac{\partial p}{\partial s} - \frac{\partial g}{\partial s}\right] + \left[\frac{N}{2}\left(\phi^2 - \left(\frac{p^\#}{\varepsilon + s^\#}\right)^2\right) - c^\# \frac{\partial p}{\partial s}\right] = 0 . \tag{3.14}$$

[24] This is consistent with the standard definition in the international trade literature: the socially optimal policy maximizes domestic welfare (see e.g. Dixit and Norman 1980; Grossman and Rogoff 1995; Feenstra 2004; Gaisford and Kerr 2007). Interestingly, Fischer and Serra (2000) define the socially optimal standard as a measure that maximizes domestic welfare as if all producers were domestic. Since in our model the effect of a standard on the world price equals the change in unit costs of foreign producers, their profits are not affected by the standard and our definition of the social optimum is equivalent to the definition of Fischer and Serra (2000).

[25] This first order condition is subject to $s^\# \geq 0$; otherwise $s^\# = 0$.

$c^{\#}$ and $q^{\#}$ denote respectively aggregate consumption and domestic production in the social optimum and $p^{\#}$ the equilibrium price. Analogous to Condition (3.10), the first term in Equation (3.14) captures the impact on producers and the last term shows the effect of a standard on total consumer surplus. The interpretation of the different effects is analogous to the discussion following Condition (3.10).

It is clear from comparing Conditions (3.10) and (3.14) that the politically optimal standard s^* only equals the socially optimal standard $s^{\#}$ if $\alpha_p = \alpha_c$ in the political equilibrium, and/or if both $\frac{\partial \Pi_p}{\partial s}$ and $\frac{\partial \Pi_c}{\partial s}$ equal zero at $s^{\#}$. Notice that $s^{\#} > 0$ is possible.[26] In that case trade flows may change upon the imposition of the standard, but this change is socially optimal, i.e. it increases domestic welfare.

If the above condition is not fulfilled i.e. if α_p and α_c are different in the government's objective function, the political and social outcomes are different.[27] Again however, the diversion between both optima may be in either direction. Hence 'over-standardization' $\left(s^* > s^{\#}\right)$ or 'under-standardization' $\left(s^* < s^{\#}\right)$ may result (see Table 3.1 for an overview).

If $\alpha_p > \alpha_c$, over-standardization $\left(s^* > s^{\#}\right)$ results when producers' profits increase with a higher standard $\left(\frac{\partial \Pi_p}{\partial s} > 0\right)$ at $s^{\#}$ and in under-standardization otherwise.

[26] This is for example consistent with the theoretical analysis of Lapan and Moschini (2004) who find that a standard prohibiting the sale of GM products in Europe may enhance European welfare.

[27] We do not discuss the case with different lobby weights where $\frac{\partial \Pi_p}{\partial s} = \frac{\partial \Pi_c}{\partial s} = 0$ at $s^{\#}$, implying that $s^{\#}$ is optimal for both lobby groups. In that case neither consumers nor producers have incentives to lobby for a different level of the standard, and $s^* = s^{\#}$.

In this case the over-standardization creates higher profits for producers than in the social optimum. Hence this over-standardization distorts trade to the advantage of the domestic sector. Inversely with $\frac{\partial \Pi_p}{\partial s} < 0$ at $s^{\#}$, the resulting under-standardization (given that $s^{\#} > 0$) reduces the negative effect of the standard on producers' profits. Hence domestic producers benefit from this under-standardization such that it serves as protection in disguise. Figure 3.3 illustrates the latter case, and shows that imports are smaller at the political optimum than at the social optimum, but still higher than without a standard. Hence, the introduction of a protectionist standard may increase trade, albeit less than what is socially optimal.

In a similar fashion, $\alpha_c > \alpha_p$ results in over-standardization when $\frac{\partial \Pi_c}{\partial s} > 0$ and in under-standardization when $\frac{\partial \Pi_c}{\partial s} < 0$ at $s^{\#}$. Whether these suboptimal standards are 'protectionist' or not depends on the impact of standards on producers. However, at $s^{\#}$, $\frac{\partial \Pi_p}{\partial s}$ and $\frac{\partial \Pi_c}{\partial s}$ always have opposite signs (except for the trivial case where both equal zero and $s^* = s^{\#}$). Hence when over-standardization results $\left(\frac{\partial \Pi_c}{\partial s} > 0\right)$, producers are negatively affected by this over-standardization with respect to their situation in the social optimum as $\frac{\partial \Pi_p}{\partial s} < 0$ at $s^{\#}$. The politically optimal standard s^* is then, although suboptimal, not 'protectionist'. Vice versa, producers are also hurt by under-standardization $\left(\frac{\partial \Pi_c}{\partial s} < 0\right)$ as $\frac{\partial \Pi_p}{\partial s} > 0$ at $s^{\#}$. Hence, in both cases the suboptimal standards result in trade distortions that do not protect domestic producers. Figure 3.4

provides an illustration of the latter case, and shows that the politically optimal standard reduces trade albeit to a lower extent than what would be socially optimal. Hence the politically optimal standard acts as a barrier to trade although it does not protect the domestic producers' interests.

3.5. Discussion: Rational or Biased Perceptions

So far, we have assumed that consumers have rational expectations and unbiased perceptions of standards. However, studies claim that perceptions of the public may differ importantly from expert opinions on a diversity of issues (e.g. Flynn *et al*. 1993; Savadori *et al*. 2004). If so, it is clear that biased perceptions can be an important factor in the political economy of public standards.

Without going into detail on the micro-foundations of perceptions, we just point out that our model can be easily extended to include biased perceptions. To illustrate this formally, define λ as a measure of the bias in perception of consumers: λ is equal to 1 if consumers' perceptions of the standard's effects are unbiased. λs is the standard perceived by consumers and s^{λ} is the politically optimal standard when perceptions are potentially biased. It is intuitive that a bias in the perception of consumers affects s^{λ} (See Appendix A.5 for the formal derivation of this result). A positive bias in consumer perceptions leads to increased consumer contributions, and hence higher politically optimal standards $\left(\frac{\partial s^{\lambda}}{\partial \lambda} > 0\right)$ given that an increase in the standard increases consumption at s^{λ} $\left(\frac{\partial c^{\lambda}}{\partial s} \geq 0 \text{ at } s^{\lambda}\right)$;[28] and vice versa for $\frac{\partial c^{\lambda}}{\partial s} < 0$ and low average consumer quality preferences.[29]

Several studies find that consumer perceptions are functions of the level of consumer trust in government regulators, attitudes toward scientific discovery, and media coverage (Curtis *et al*. 2004; Loureiro, 2003, Kalaitzandonakes *et al*. 2004). For example, a reason for the differences in perceptions across countries explored by Curtis *et al*. (2008) is the different organization and structure of the media in rich and poor countries. Mass media is the main source of information for consumers to form attitudes regarding many issues, including GM food (Hoban and Kendall 1993; Shepherd *et al*. 1998). Commercial media is more likely to highlight potential risks associated with biotechnology in its reporting (McCluskey and Swinnen 2004). The increased cost of media information in developing countries leads to lower media consumption and to a proportionately stronger reduction in risk reporting. In addition, government control of the media is stronger in poor countries. This may lead to a more positive coverage of new technologies such as biotechnology, which in turn may contribute to more favorable perceptions of GM food and biotechnology among consumers in these less developed countries. The public is most negative towards GM food in most of the developed countries, especially in the EU and Japan. The US is an exception as consumers are largely ambivalent about GM food. In less developed countries consumer attitudes

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[28] This is a sufficient but not a necessary condition for $\frac{\partial s^{\lambda}}{\partial \lambda} > 0$, see Appendix A.5.

[29] $c^{\lambda} = N\left(\phi - p\big/\left(\varepsilon + \lambda s^{\lambda}\right)\right)$ denotes the aggregate consumption in the political optimum when consumer perceptions are potentially biased.

toward GM food are less negative and in many cases positive (see Curtis *et al*. 2008 for a review of the evidence). Therefore, the media structure and information provision is likely to induce a more pro-standard attitude $\left(\frac{\partial \lambda}{\partial I} > 0\right)$ in rich countries than in poor, as increased access to media increases attention to risks and negative implications of low standards.

An additional related element is how the rural/urban population structure affects perceptions. McCluskey *et al*. (2003) find that people associated with agriculture are much more in favor of GM crops than urban consumers.[30] It is likely that consumers who are associated with agriculture have a better idea of the amount of pesticides used on non-GM crops than urban consumers, and hence of the benefits from GM food (such as insect resistant crops). As developing countries have a higher proportion of rural residents, this may contribute to explain the differences in preferences.

Hence, both perception factors may reinforce the effects of consumer preferences and quality of institutions in inducing a positive relationship between standards and development.

3.6. Conclusions

In this chapter we have developed a formal model of the political economy of public standards. We use our theoretical model to derive the political optimum and to analyze the different factors that have an influence on this political equilibrium. Under the assumption of a small open economy and simultaneous consumer and producer lobbying, the political weights of the respective groups influence the politically optimal public

[30] Unpublished research of Scott Rozelle and Jikun Huang confirms this result for China.

standard and the direction and magnitude of these effects depend on the standards' relative benefits to the different interest groups. Higher domestic costs related to the standard decrease the level of the public standard while an increase in the costs of foreign producers related to the standard may increase or decrease the politically optimal standard.

We also examine the positive relationship between standards and economic development. Higher income levels lead to more stringent standards because of higher consumer preferences for quality, less costly enforcement and lower production costs related to standards for domestic producers. In combination these factors may result in a pro-standard coalition of consumers and producers in rich countries and an anti-standard coalition in poor countries.

We also identify the key factors which characterize the relationship between trade and standards and its effects. Trade affects the net impact of standards on domestic producers and consumers and hence their political contributions. Standards may also affect the comparative production cost advantage between countries, which may lead to either higher or lower standards. Similarly, the relative (domestic versus foreign) transaction (enforcement and control) costs of standards affect the politically optimal standard.

Finally, our model provides an analytical framework to determine whether standards serve as protection in disguise, or not. We show that standards may be 'barriers' to trade but also 'catalysts' to trade, and that both 'under-' or 'over-standardization' may occur, depending on a variety of factors. Our findings imply that the effects of specific standards should be analyzed carefully before categorizing them as protectionist instruments.

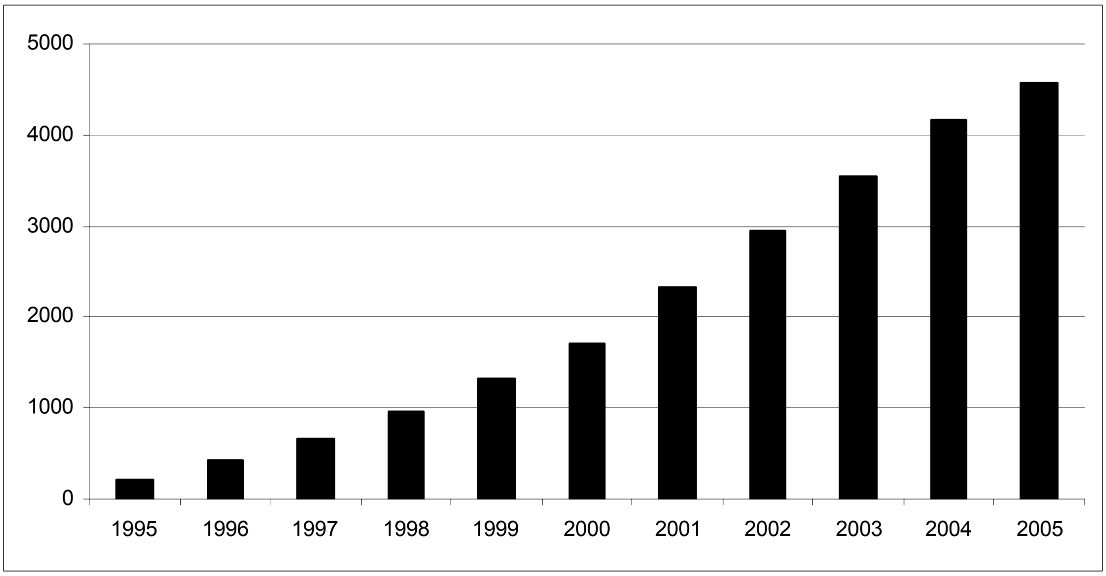
Several issues which we abstracted from in this analysis may be the subject of future research. First, we have focused on the government's decision process on standards, while not explicitly considering the potential influence of administrative agencies and bureaucracies on the implementation of the standard and on agenda-setting. Interest groups may try to recoup a legislative defeat by lobbying the administrative agencies that implement and enforce standards, thus potentially subverting original legislative intent. Second, as in the 'protection for sale' analysis of Grossman and Helpman (1994), we have analyzed the political economy of the standard-setting process of only one government, without accounting for strategic interactions with other governments, potentially through international organizations. However, similar to the 'trade wars and trade talks' analysis of Grossman and Helpman (1995), one may extend our analysis to include several countries that negotiate at an international level, multilaterally or bilaterally, on harmonizing or mutually recognizing each others' standards, while governments cater the interests of their domestic constituency and interest groups.

Tables

Table 3.1: Protectionist Characteristics of Standards with Different Political Weights

$\alpha_p > \alpha_c$		$\alpha_c > \alpha_p$	
$\frac{\partial \Pi_p}{\partial s} > 0$ over-standardization $s^* > s^\#$	$\frac{\partial \Pi_p}{\partial s} < 0$ under-standardization $s^* < s^\#$	$\frac{\partial \Pi_c}{\partial s} > 0$ over-standardization $s^* > s^\#$	$\frac{\partial \Pi_c}{\partial s} < 0$ under-standardization $s^* < s^\#$
Protectionist	Protectionist if $s^\# > 0$	Not protectionist	Not protectionist

Figures



Source: Henson (2006)

Figure 3.1: Notification of New SPS measures to the WTO

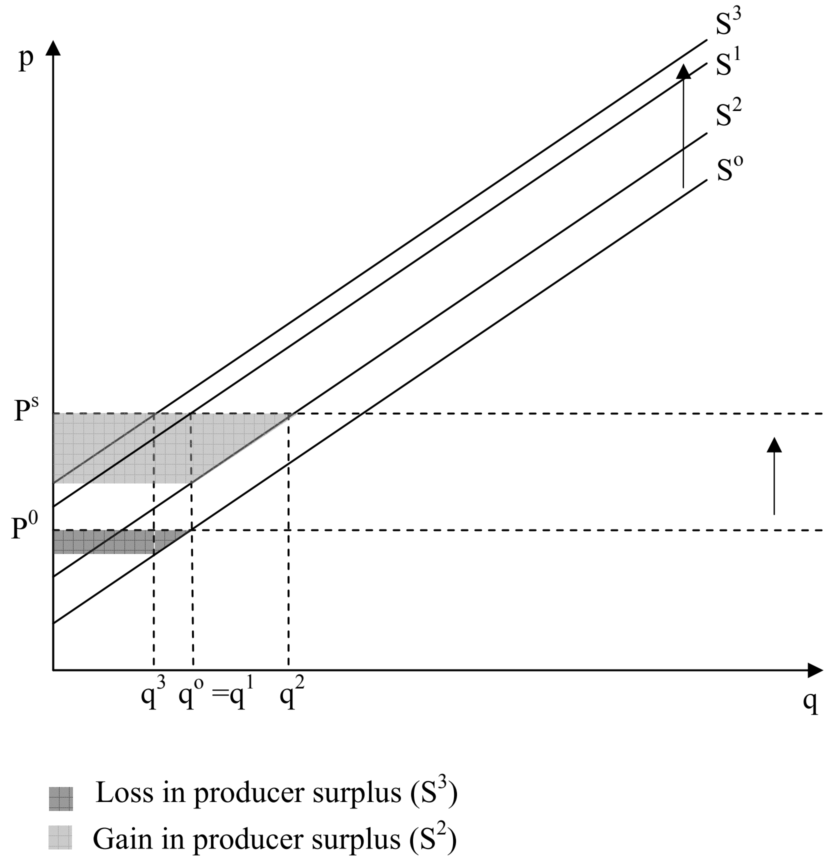
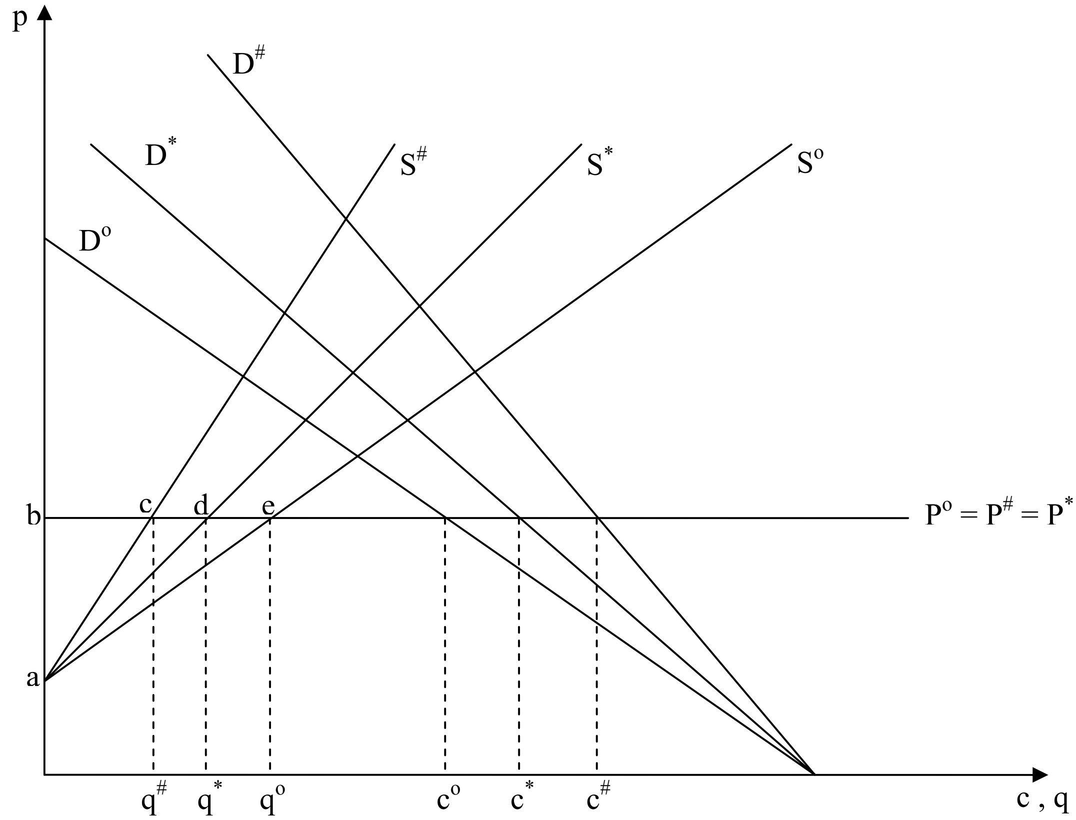
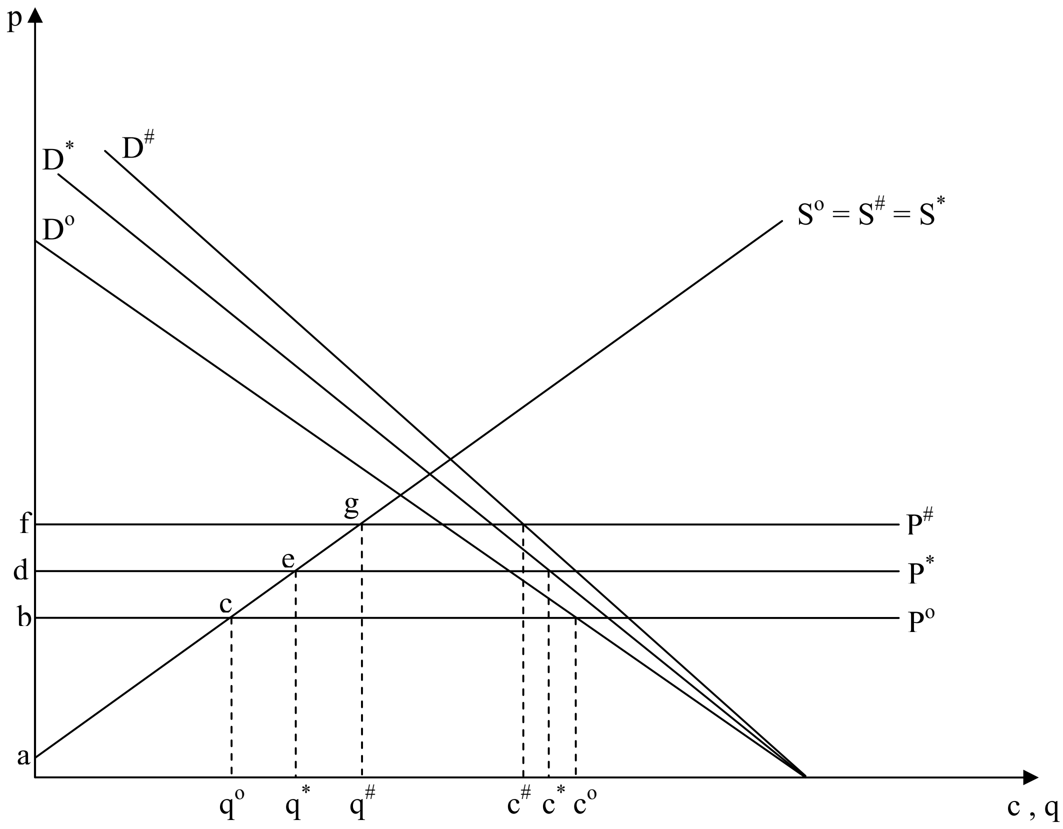


Figure 3.2: The Potential Effects of a Public Standard on Domestic Producers



The changes in supply S and demand D are represented by upward pivots for higher standards, where superscript 'o' denotes the situation without standards. For simplicity we assume that prices P are not affected by standards.
$\frac{\partial \Pi_c}{\partial s} > 0$ and $\frac{\partial \Pi_p}{\partial s} < 0$ at $s^{\#}$ and under-standardization $\left(s^* < s^{\#}\right)$ occurs given that $\alpha_p > \alpha_c$. Under-standardization is benefiting the domestic producers as their profits are higher compared to the social optimum (abd > abc). Notice also that $m^o < m^* < m^{\#}$, with imports $m = c - q$.

Figure 3.3: Under-Standardization Benefiting Domestic Producers



The changes in demand D and prices P are represented by respectively upward pivots and upward shifts for higher standards, where superscript 'o' denotes the situation without standards. Supply S is not affected by standards.

$\frac{\partial \Pi_c}{\partial s} < 0$ and $\frac{\partial \Pi_p}{\partial s} > 0$ at $s^{\#}$ and under-standardization $\left(s^* < s^{\#}\right)$ occurs when $\alpha_p < \alpha_c$. Under-standardization hurts domestic producers as their profits are lower compared to the social optimum (ade < afg). Notice also that $m^o > m^* > m^{\#}$, with imports $m = c - q$.

Figure 3.4: Under-Standardization Hurting Domestic Producers

A. Appendix

A.1. Proof of the Truthfulness of the Contribution Schedules

Define J as the set of active lobby groups i.e. $J=\{p,c\}$, s^* as the politically optimal standard, and C_j^* as the optimal contribution schedule for lobby group j. Following Lemma 2 of Bernheim and Whinston (1986) and Proposition 1 of Grossman and Helpman (1994), the equilibrium $\left(\left\{C_j^*\right\}_{j\in J}, s^*\right)$ is a subgame-perfect Nash equilibrium of the standard-setting game if and only if:

(a) C_j^* is feasible for all $j\in J$;

(b) s^* maximizes $\sum_{j\in J}\alpha_j C_j^*(s)+W(s)$;

(c) s^* maximizes $\Pi_k(s)-C_k^*(s)+\sum_{j\in J}\alpha_j C_j^*(s)+W(s)$ for every $k\in J$;

(d) for every $k\in J$ there exists a s^k that maximizes $\sum_{j\in J}\alpha_j C_j^*(s)+W(s)$ such that $C_k^*\left(s^k\right)=0$.

From Condition (c) we derive the first order condition

$$\frac{\partial\Pi_k^*\left(s^*\right)}{\partial s}-\frac{\partial C_k^*\left(s^*\right)}{\partial s}+\sum_{j\in J}\alpha_j\frac{\partial C_j^*\left(s^*\right)}{\partial s}+\frac{\partial W\left(s^*\right)}{\partial s}=0 \text{ for all } k\in J. \tag{A.15}$$

Maximization of the government's objective function (Condition (b)) requires the first order condition

$$\sum_{j\in J}\alpha_j\frac{\partial C_j^*\left(s^*\right)}{\partial s}+\frac{\partial W\left(s^*\right)}{\partial s}=0. \tag{A.16}$$

Taken together, Conditions (A.15) and (A.16) imply

$$\frac{\partial C_j^*\left(s^*\right)}{\partial s}=\frac{\partial \Pi_j^*\left(s^*\right)}{\partial s} \text{ for all } j\in J. \tag{A.17}$$

Condition (A.17) proves that all contribution schedules are locally truthful around s^*. This implies in our political economy model that lobby groups set their contributions in accordance with their expected profits and how these are marginally affected by the public standard.

A.2. Proof of the First Order Condition

Production: Domestic producers maximize profits by choosing the optimal quantity q. With $\Pi_p\left(s\right)=\max_q\left\{q\cdot\left[p-g\left(q,s\right)\right]\right\}$ this results in the first order condition $\frac{\partial \Pi_p}{\partial q}=p-g\left(q,s\right)-q\frac{\partial g}{\partial q}=0$; hence

$$p=g\left(q,s\right)+q\frac{\partial g}{\partial q}. \tag{A.18}$$

Expression (A.18) defines the optimal behavior of domestic producers in the equilibrium and implicitly defines q as a function $q\left(p,s\right)$. Deriving $\Pi_p\left(s\right)$ with respect to s, and making use of the envelope theorem and equilibrium condition (A.18) results in

$$\frac{\partial \Pi_p}{\partial s}=\frac{\partial q}{\partial s}\left(p-g\left(q,s\right)\right)+q\left(\frac{\partial p}{\partial s}-\frac{\partial g}{\partial s}-\frac{\partial g}{\partial q}\frac{\partial q}{\partial s}\right)=q\left[\frac{\partial p}{\partial s}-\frac{\partial g}{\partial s}\right]. \tag{A.19}$$

Consumption: Only consumers with $\phi_i > p/\left(\varepsilon+s\right)$ consume the product. Hence total consumer surplus is equal to $\Pi_c\left(s\right)=N\int_{p/\left(\varepsilon+s\right)}^{\phi} u_i \mathrm{d}\phi_i = N\frac{\left(\varepsilon+s\right)}{2}\left(\phi-\frac{p}{\left(\varepsilon+s\right)}\right)^2$. Deriving $\Pi_c\left(s\right)$ with respect to s results in

$$\frac{\partial \Pi_c}{\partial s} = \frac{N}{2}\left(\phi^2 - \left(\frac{p}{\varepsilon + s}\right)^2\right) - c\frac{\partial p}{\partial s}, \tag{A.20}$$

with $c(p,s) = N\left(\phi - p/(\varepsilon + s)\right)$.

Government: The government's objective function is $V(s) = \alpha_p C_p(s) + \alpha_c C_c(s) + W(s)$ in which the political weights α_j are exogenously given. We have that $\frac{\partial V}{\partial s} = \alpha_p \frac{\partial C_p}{\partial s} + \alpha_c \frac{\partial C_c}{\partial s} + \frac{\partial W}{\partial s}$. From the functional form and the truthfulness of the contribution functions we have that $\frac{\partial C_p}{\partial s} = \frac{\partial \Pi_p}{\partial s}$ and $\frac{\partial C_c}{\partial s} = \frac{\partial \Pi_c}{\partial s}$ around the politically optimal s^* (see Condition (A.17)) and from Equation (3.8) follows that $\frac{\partial W}{\partial s} = \frac{\partial \Pi_\mathrm{p}}{\partial s} + \frac{\partial \Pi_c}{\partial s}$ so that $\frac{\partial V}{\partial s} = (1+\alpha_p)\frac{\partial \Pi_\mathrm{p}}{\partial s} + (1+\alpha_c)\frac{\partial \Pi_c}{\partial s}$ around the optimum. The government maximizes its objective function with respect to s $\left(\frac{\partial V}{\partial s} = 0\right)$ subject to $s \geq 0$. Using the Expressions (A.19) and (A.20) we obtain the result that:

$$\frac{\partial V}{\partial s} = (1+\alpha_p)\left[q^*\left(\frac{\partial p}{\partial s} - \frac{\partial g}{\partial s}\right)\right] + (1+\alpha_c)\left[\frac{N}{2}\left(\phi^2 - \left(\frac{p^*}{\varepsilon + s^*}\right)^2\right) - c^*\frac{\partial p}{\partial s}\right] = 0. \tag{A.21}$$

This first order condition determines the politically optimal standard under the condition that $s^* \geq 0$; in any other case $s^* = 0$. c^* and q^* denote respectively consumption and domestic production at the political optimum, with $c^* = N\left(\phi - p^*/(\varepsilon + s^*)\right)$.

A.3. Comparative Statics

Comparative statics on s^* apply only when $s^* > 0$ in Condition (A.21). For cases in which Condition (A.21) results in $s^* = 0$, comparative statics results are trivial and equal to zero.

Condition (A.21) implicitly defines s^* as a function of several variables. Hence:

$$\frac{\partial s^*}{\partial x} = -\frac{\partial^2 V / \partial s \partial x}{\partial^2 V / \partial s^2}. \tag{A.22}$$

From our assumptions on the convexity of $g(q,s)$ and $p(s)$ in s, it follows that $\partial^2 V / \partial s^2 < 0$.[31] Hence the sign of $\frac{\partial s^*}{\partial x}$ is determined by (is the same as) the sign of $\partial^2 V / \partial s \partial x$.

Political weight of producers α_p:

$\frac{\partial^2 V}{\partial s \partial \alpha_p} = q^* \left(\frac{\partial p}{\partial s} - \frac{\partial g}{\partial s} \right)$ which is equal to $\frac{\partial \Pi_\text{p}}{\partial s}$ at s^*. Therefore $\frac{\partial s^*}{\partial \alpha_p}$ has the same sign as $\frac{\partial \Pi_\text{p}}{\partial s}$ at s^*.

Political weight of consumers α_c:

$\frac{\partial^2 V}{\partial s \partial \alpha_c} = \frac{N}{2} \left(\phi^2 - \left(\frac{p^*}{\varepsilon + s^*} \right)^2 \right) - c^* \frac{\partial p}{\partial s}$ which is equal to $\frac{\partial \Pi_c}{\partial s}$ at s^*. Therefore $\frac{\partial s^*}{\partial \alpha_c}$ has the same sign as $\frac{\partial \Pi_c}{\partial s}$ at s^*.

[31] See footnote 18.

Consumer preferences ϕ:

$\frac{\partial^2 V}{\partial s \partial \phi} = (1+\alpha_c) N\left(\phi - \frac{\partial p}{\partial s}\right)$. This expression is positive, and hence $\frac{\partial s^*}{\partial \phi} > 0$, if $\phi > \frac{\partial p}{\partial s}$ at s^*. Violation of this condition would imply that the individual willingness to pay for a marginal increase of the standard is negative at s^*, even for the individual with the highest preferences $(\phi_i = \phi)$. We abstract from this case.

A.4. Effect of a Standard on Imports

Deriving consumption $c(p,s) = N(\phi - p/(\varepsilon + s))$ with respect to s is equal to

$$\frac{\partial c}{\partial s} = \frac{N}{\varepsilon + s}\left(\frac{p}{\varepsilon + s} - \frac{\partial p}{\partial s}\right). \tag{A.23}$$

Making use of the inverse demand function $D(c,s) = (\phi - c/N)(\varepsilon + s)$ we can rewrite (A.23) as:

$$\frac{\partial c}{\partial s} = \frac{D_s - \partial p/\partial s}{|D_c|}, \tag{A.24}$$

with $D_c = \frac{\partial D}{\partial c} < 0$ and $D_s = \frac{\partial D}{\partial s} > 0$.

Similarly, deriving the equilibrium condition for producers (Condition (A.18)) with respect to s gives

$$\frac{\partial q}{\partial s} = \frac{\partial p/\partial s - \partial g/\partial s - q \cdot \partial^2 g/\partial q \partial s}{2 \cdot \partial g/\partial q + q \cdot \partial^2 g/\partial q^2}. \tag{A.25}$$

Making use of the inverse supply function $A(q,s) = g(q,s) + q\frac{\partial g}{\partial q}$ (see Expression (A.18)) we can rewrite (A.25) as:

$$\frac{\partial q}{\partial s} = \frac{\partial p/\partial s - A_s}{A_q}, \tag{A.26}$$

with $A_q = \dfrac{\partial A}{\partial q} > 0$ and $A_s = \dfrac{\partial A}{\partial s} > 0$.

Imports m are defined as $m \equiv c - q$, hence using Expressions (A.24) and (A.26):

$$\frac{\partial m}{\partial s} = \frac{\partial (c-q)}{\partial s} = \frac{D_s}{|D_c|} + \frac{A_s}{A_q} - \left(\frac{A_q + |D_c|}{A_q |D_c|} \right) \frac{\partial p}{\partial s}, \tag{A.27}$$

which cannot be signed unambiguously.

A.5. Consumer Perceptions

We define λ as a measure for the bias in perception of consumers: λ is equal to 1 if consumers' perceptions of the standard's effects are unbiased. λs is the standard perceived by consumers and we redefine consumer utility as

$$u_i = \begin{cases} \phi_i (\varepsilon + \lambda s) - p & \text{if he buys the good with standard } s \text{ at price } p; \\ 0 & \text{if he does not buy.} \end{cases} \tag{A.28}$$

The politically optimal standard, s^λ, is then determined by the following first order condition, subject to $s^\lambda \geq 0$:

$$\frac{\partial V}{\partial s} = (1+\alpha_p)\left[q^\lambda \left(\frac{\partial p}{\partial s} - \frac{\partial g}{\partial s} \right) \right] + (1+\alpha_c)\left[\frac{N\lambda}{2} \left(\phi^2 - \left(\frac{p^\lambda}{\varepsilon + \lambda s^\lambda} \right)^2 \right) - c^\lambda \frac{\partial p}{\partial s} \right] = 0\,. \tag{A.29}$$

$c^\lambda (p,s) = N\left(\phi - p/\left(\varepsilon + \lambda s^\lambda\right)\right)$ and q^λ denote respectively the aggregate consumption and domestic production in the political optimum and p^λ is the equilibrium world price. Deriving Expression (A.29) with respect to λ, we get

$$\frac{\partial^2 V}{\partial s \partial \lambda} = \left(1+\alpha_c\right)\left[\frac{N}{2}\left(\phi^2 - \left(\frac{p^\lambda}{\varepsilon + \lambda s^\lambda}\right)^2\right) + \frac{s^\lambda p^\lambda}{\varepsilon + \lambda s^\lambda}\frac{\partial c^\lambda}{\partial s}\right]. \tag{A.30}$$

A sufficient but not necessary condition for this expression to be positive is that $\frac{\partial c^\lambda}{\partial s}$ is positive at s^λ. Hence, when consumption is increasing in the standard at s^λ, we find that $\frac{\partial s^\lambda}{\partial \lambda} > 0$. However, when average consumer preferences ϕ are low such that $\phi^2 < \left(\frac{p^\lambda}{\varepsilon + \lambda s} - \frac{2s}{N}\frac{\partial c^\lambda}{\partial s}\right)\frac{p^\lambda}{\varepsilon + \lambda s}$ for $\frac{\partial c^\lambda}{\partial s} < 0$ at s^λ, we find that $\frac{\partial s^\lambda}{\partial \lambda} < 0$.

Chapter 4. On Butterflies and Frankenstein: A Dynamic Theory of Technology Regulation

"A small blue butterfly sits on a cherry tree in a remote province of China. As is the way of butterflies, while it sits it occasionally opens and closes its wings. It could have opened its wings twice just now; but in fact it moved them just once – and the miniscule difference in the resulting eddies of air around the butterfly makes the difference between whether, two months later, a hurricane sweeps across southern England or harmlessly dies out over the Atlantic."
Smith (1991, p. 247)

"If they want to sell us Frankenfood, perhaps it's time to gather the villagers, light some torches and head to the castle."
Lewis (1992)

4.1. Introduction

In many cases regulation and standards are introduced when preferences change (e.g. regarding social issues), environmental conditions change (e.g. climate change) or when new technologies become available (e.g. nuclear energy, genetic modification (GM)). These changes induce new policy questions to either allow (approve) new technologies or not; to try to change behavior in response of environmental and social concerns, or not.

There are major differences in technology regulation among countries, reflected in the abundance of differences in labor standards, food safety and quality standards, environmental standards, etc. A particular case is the difference in GM technology regulation between the EU and the US. Since the end of the 1990s, EU legislation has put a de facto moratorium on the approval of GM products whereas the US has chosen to rely on pre-existing laws considering GM products as substantially equivalent to conventional ones (Sheldon 2002; van Meijl and van Tongeren 2004). This difference has traditionally been attributed to either differences in consumer preferences, or to trade protectionist motives. Neither of these arguments provides a satisfactory explanation – at least not in isolation – and lacks a dynamic perspective.

The 'different consumer preferences' argument advances that European consumers are more risk averse and concerned with food safety, and therefore distrust biotechnology more, whereas US consumers are indifferent toward GM products (Curtis *et al*. 2004). However, according to Paarlberg (2008), consumers on both sides of the Atlantic tend to dislike GM technology. Additionally, this difference between EU and US consumer preferences is not evident from a historical perspective either. There has been an important shift in the difference between consumer and environmental protection policies in the EU and US, as illustrated by Vogel (2003, p. 557):

> *"[f]rom the 1960s through the mid 1980s American regulatory standards tended to be more stringent, comprehensive and innovative than in either individual European countries or in the EU. However, since around 1990 the obverse has been true; many important EU consumer and environmental regulations are now more precautionary than their American counterparts."*

Moreover, surveys on consumer attitudes with respect to biotechnology that illustrate these differences in consumer preferences are endogenous to GM regulation. In countries where GM products are available consumer preferences may shift in favor of this technology, while inversely consumers may distrust GM technology more in countries where GM products have been banned.

A related argument is that European consumers have only limited confidence in national public bodies. Trust in regulatory authorities is significantly higher in the US than in Europe, which is said to explain why citizens' demands for GM regulation are stronger in Europe (Gaskell *et al*. 1999; Nelson 2001). However, this would – somewhat paradoxically – imply that European consumers demand more regulation from authorities in which they have lower trust.

A second argument focuses on the interests of the agrochemical and seed industry and farmers. Biotechnology regulation is said to support agrochemical companies, either by creating higher returns on investment in biotechnology or by protecting against the comparative disadvantage from not investing in biotechnology (Graff and Zilberman 2004). In this view, the European ban on GM products serves as a protectionist non-tariff barrier to trade (Lapan and Moschini 2004), and protects the European agrochemical firms who are dominant in the traditional crop-protection market (Anderson and Jackson 2006; Graff and Zilberman 2007). Additionally, Anderson *et al*. (2004) argue that EU farmers lobby in favor of GM regulation because farmers in countries such as the US and Brazil have a comparative advantage in applying biotechnology. Therefore, it is argued, it is rational for EU farmers to support regulation that restricts the use of biotechnology. However, EU farmers were initially less opposed to GM technology according to Bernauer (2003), and US and EU GM regulations were initially moving in the same direction (Vogel 2001). These observations seem to contradict the static trade protection argument.

There exists an extensive literature on the welfare effects of biotechnology and biotechnology regulation. The effect of efficiency-enhancing biotechnology on social welfare depends crucially on the extent of consumer aversion to GM products (Moschini 2008).[32] Studies also show that the welfare effects of biotechnology regulation are

[32] The early literature ignored this potential consumer aversion and estimated the welfare impact of biotechnology innovations measuring traditional consumer and producer surpluses (Alston *et al*. 1995). Even when accounting for market power of innovating biotechnology companies (Moschini and Lapan 1997), studies found considerable welfare gains from the introduction of new GM products (Falck-Zepeda

complex. Lapan and Moschini (2004) and Veyssiere and Giannakas (2006) show that the welfare effects of GM regulation depend on consumer preferences, segregation costs, efficiency gains from the GM technology, and the market power of the innovating companies. Fulton and Giannakas (2004) demonstrate that the introduction of GM products and the regulation of biotechnology may have different welfare effects on different groups in society – such as consumers, farmers, seed companies, and innovating life science companies. This inherent rent-distribution may induce different preferences for biotechnology regulation and conflicting pressures on governments which demands a political economy analysis (Josling *et al*. 2003).

Therefore, building on our previous chapter on the political economy of standards and regulation (see also Swinnen and Vandemoortele 2008; 2009; 2011a), this chapter develops a general and dynamic political economy model of technology regulation. Our framework allows to combine both arguments of differences in consumer preferences and producer protectionism to provide a more nuanced explanation for the different biotechnology regulations in the EU and the US, and why this difference may persist.

First, our formal model shows that there exists a critical level of consumer preferences below which no technology regulation is imposed. Hence small variations in consumer preferences may determine whether a country imposes technology regulation or not. If consumer preferences are identical between countries and constant over time, countries adopt the same technology regulation and stick to the status quo independent of which technology regulation was initially imposed.

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et al. 2000) that were shared among consumers, farmers, and agro-chemical innovators (Moschini *et al*. 2000). Recent studies which integrate consumer aversion to GM products find that the welfare impact of biotechnology is ambiguous (Fulton and Giannakas 2004; Lapan and Moschini 2004; Lence and Hayes 2005; Sobolevsky *et al*. 2005).

Second, when consumer preferences are different between countries and constant over time, different technology regulations may be imposed, and these differences may persist because of producer interests that change over time. If a government chooses to allow a technology, it continues to allow that technology independent of what the other government decides. If a government however chooses to ban that technology, it may continue to do so in the long run depending on the relative impacts of both regulatory options on consumers and producers, and their political power. A larger political power of producers leads to a larger range of situations where the technology is banned in the long run, even though consumers prefer allowing it. In these situations producer interests are translated into policy persistence.

Third, we show that even a temporary difference in consumer preferences between countries, a 'butterfly', may create a difference in technology regulation that may persist after the difference in consumer preferences has disappeared. We show that this hysteresis[33] in technology regulation is driven by producer protectionist motives.

Our work is related to several other articles on hysteresis in socio-economic behavior and policy. For example, Dixit (1989a) shows that output price uncertainty leads to investment hysteresis for certain ranges of entry and exit costs, and Dixit (1989b) and Baldwin and Krugman (1989) demonstrate that exchange rate fluctuations create similar hysteresis in firms' export decisions. Hysteresis is also shown to exist in labor markets where firing and hiring costs lead to persistence in unemployment (e.g. Lindbeck and Snower 1986; Belke and Göcke 1999). Our model is different from these contributions, both in the source of variation (small consumer preference variations) that triggers

[33] Hysteresis is defined as *"permanent effects of a temporary stimulus"* (Göcke 2002) and originates from physics and magnetism (Cross and Allan 1988). See Göcke (2002) for an overview of various concepts of hysteresis as applied in economics.

technology investment (or not), and in the hysteresis effect (persistence in technology regulation due to producer protectionism).[34]

Our chapter is structured as follows. Section 4.2 advances a general and dynamic political economy model of technology regulation. The next three sections apply this model to three different cases. In the first case (Section 4.3), consumer preferences are identical between countries and constant over time. In the second case (Section 4.4), consumer preferences are different between countries and constant over time. In the third case (Section 4.5 – the 'butterfly' case), consumer preferences are only temporarily different between countries. Section 4.6 discusses the implications of our model, and Section 4.7 extends the model in several directions. Section 4.8 concludes.

4.2. The Political Economy of Technology Regulation: A Dynamic Model

Assume two identical open economies $k = A, B$, with between them symmetric transportation costs (which could be small, but positive). In both countries we consider the same sector in which one product is produced and consumed. Two production technologies can be applied to create this product. The technologies differ in their cost-efficiency, and consumers have some aversion to the 'cheap' technology. All consumers rank products manufactured with the cheap technology as being of lower quality than products produced with the 'expensive' technology, but are heterogeneous in their willingness to pay for this quality difference. One example is child labor – which is cheap – but consumers object to its use. Another example is the installation of expensive

[34] Our chapter is also linked to research on path-dependence in technical standards and technical lock-in by historical events (Arthur 1989). This type of lock-in is driven by network externalities, increasing returns to adoption, or learning by doing. See e.g. David 1985; Farrell and Saloner 1985; Cowan 1990; and Puffert 2002 for some historical cases.

catalytic converters that, as preferred by consumers, reduce carbon dioxide emissions. A last example is conventional farming that uses non-GM seed versus biotechnology that applies GM seed. Using biotechnology is cheaper (Falck-Zepeda *et al*. 2000; Lapan and Moschini 2007), but consumers have some aversion to GM products (Curtis *et al*. 2004). The applied production technology is a 'credence' feature of the product: consumers cannot verify which technology has been used, even after consumption of the good (Roe and Sheldon 2007).

4.2.1. Technology Regulation and Standards

In every period $t = 1,2$, each country k's government has to decide whether to approve the cheap technology or not by setting a standard s_t^k. We assume that there are only two possible levels (high and low) of this standard, i.e. $s_t^k \in \{s_L, s_H\}$ with $s_H > s_L$, where s_L refers to a baseline safety and/or quality requirement satisfied by both technologies (see also Moschini *et al*. 2008). If the government sets $s_t^k = s_H$, the cheap technology is prohibited in country k at time t.

All domestic producers have to comply with the standard – whether they produce for the home or foreign market – and equally all foreign producers who export to this country.[35] We assume that only the government can guarantee consumers that a good has been produced with the expensive technology. This implies that a producer who produces according to s_H is not able to market his good as a high quality product in a country where the government allows the use of the cheap technology (s_L), although the

[35] These assumptions are consistent with biotechnology regulation. Regulations prohibit the production of GM crops, independent of whether they are eventually sold on domestic or foreign markets.

producer is allowed to sell his product on that market $(s_H > s_L)$.[36] We abstract from government enforcement or credibility issues concerning the implementation of the regulation.

4.2.2. Producers

We assume that production is a function of a sector-specific input factor that is available in inelastic supply. All profits made in the sector accrue to this specific factor. In line with Besley and Ghatak (2007), we assume that there are more than three firms active in each country and that firms compete on prices. Aggregate producer profits at time t in country k are

$$\Pi_t^{p,k}\left(s_t^k\right) = \max_{p_t^k}\left\{x_t^k \cdot \left[p_t^k - c_t^k\left(s_t^k, s_{t-1}^k\right)\right] + L\right\}, \tag{4.1}$$

where p_t^k is the price of the good; x_t^k is the quantity produced; $c_t^k\left(s_t^k, s_{t-1}^k\right)$ is the marginal cost; and L is the sector-specific factor owners' total labor income, realized in some other sector(s).[37] Following Amacher *et al*. (2004) and consistent with Spence (1977), Dixit (1980), and Dong and Saha (1998), we use a specific form for the cost function:

$$c_t^k\left(s_t^k, s_{t-1}^k\right) = b\left(s_t^k\right)^2 + a\left(s_t^k - s_{t-1}^k\right)^2, \tag{4.2}$$

where a and b are positive parameters. The first term, $b\left(s_t^k\right)^2$, represents the 'cost of quality'. As is typical in the vertical differentiation literature, it is a quadratic term: the

[36] Because we assume Bertrand competition with more than three active firms per country (see Section 4.2.2), this assumption is not essential to our results. However, it substantially reduces notational complexity and allows us to keep the analysis tractable.

[37] See also Grossman and Helpman (1994). This labor income ensures that producers' welfare is positive and their lobbying contributions credible.

marginal cost function is increasing and convex in the level of the standard (see e.g. Ronnen 1991; Valletti 2000). The technology allowed under s_H is more expensive than under s_L: $b(s_H)^2 > b(s_L)^2$. The second term, $a\left(s_t^k - s_{t-1}^k\right)^2$, represents the 'investment cost' which is an increasing and convex function of the difference between the standard of the current period and the standard of the previous period. If governments switch regulation between periods, producers need to adjust to the new regulation and incur a one-period increase in their marginal cost. This cost component can be interpreted as a capacity investment along the lines of Spence (1977) and Dixit (1980), which depends on the current and previous periods' regulations. All other production costs are normalized to zero.

We assume that $bs_L > a(s_H - s_L)$ to ensure that producing under the low cost technology s_L is cheaper than under the expensive technology s_H, even when producing under s_L involves an investment cost of switching from s_H to s_L.[38]

4.2.3. Consumers

We impose a vertical differentiation representation of heterogeneous consumer preferences based on Spence (1976), Mussa and Rosen (1978) and Tirole (1988). The underlying assumption is that if products with both technologies were available at the same price, all consumers would choose the high standard product. Individuals in country

[38] Given that the expensive technology was in use before, producing with the expensive technology costs bs_H^2, whereas producing with the cheap technology requires investment and costs $bs_L^2 + a(s_H - s_L)^2$. The former costs are larger than the latter if $b(s_H + s_L) > a(s_H - s_L)$, which is true under our assumption.

k and period t consume at most one unit of the good and their preferences are described by the following utility function:

$$u_i = \begin{cases} \phi_i s_t^k - p_t^k & \text{if consumer } i \text{ buys the good with standard } s_t^k \text{ at price } p_t^k \\ 0 & \text{if consumer } i \text{ does not buy,} \end{cases} \tag{4.3}$$

where ϕ_i is consumer i's preference parameter.[39] Consumers with higher ϕ_i have a higher willingness to pay for a product of higher quality, i.e. with a more stringent standard s_t^k. Consumers with $\phi_i < p_t^k / s_t^k$ do not consume the product. We assume that ϕ_i is uniformly distributed over the interval $\left[\phi_t^k - 1, \phi_t^k\right]$ with $\phi_t^k \geq 1$ and $i \in \left\{1, \ldots, N_t^k\right\}$. The number of consumers N_t^k is constant over time and identical between countries, i.e. $N_t^k = N$. The aggregate demand function

$$D_t^k\left(p_t^k, s_t^k\right) = N\left(\phi_t^k - p_t^k / s_t^k\right), \tag{4.4}$$

is presumed to be positive at market equilibrium. Consumer surplus in country k at time t is

$$\begin{aligned} \Pi_t^{c,k}\left(s_t^k\right) &= N \int_{p_t^k / s_t^k}^{\phi_t^k} \left(\phi_i s_t^k - p_t^k\right) d\phi_i \\ &= \frac{N s_t^k}{2}\left(\phi_t^k - p_t^k / s_t^k\right)^2 . \end{aligned} \tag{4.5}$$

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[39] Our approach of modeling standards is common in the literature on vertical differentiation and GM technology (see for example Fulton and Giannakas 2004; Moschini *et al.* 2008) and consistent with the standard approach in the literature on minimum quality standards (see e.g. Ronnen 1991, Jeanneret and Verdier 1996, Valletti 2000).

4.2.4. The Government

The government maximizes a weighted sum of contributions from interest groups and social welfare as in Grossman and Helpman (1994; 1995). Social welfare $W_t^k\left(s_t^k\right)$ is defined as the sum of producer profits and consumer surplus:

$$W_t^k\left(s_t^k\right) \equiv \Pi_t^{p,k}\left(s_t^k\right) + \Pi_t^{c,k}\left(s_t^k\right). \tag{4.6}$$

Interest groups offer contributions to the government conditional on the policy chosen by the government. For simplicity, we assume that only producers are politically organized, and that an interest group cannot contribute to a foreign government.[40] The government's objective function, $\Pi_t^{g,k}\left(s_t^k\right)$, is

$$\Pi_t^{g,k}\left(s_t^k\right) \equiv \alpha C_t^{p,k}\left(s_t^k\right) + W_t^k\left(s_t^k\right), \tag{4.7}$$

where $C_t^{p,k}\left(s_t^k\right)$ is the 'truthful'[41] contribution schedule of the producers' interest group; and α represents its relative lobbying strength. Because the government's regulatory choice is dichotomous, this 'truthful' contribution function need only to comprise two numbers (see Grossman and Helpman 1995), i.e. the contributions associated with allowing the cheap technology, $C_t^{p,k}\left(s_L\right)$, or banning it, $C_t^{p,k}\left(s_H\right)$. We therefore define

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[40] This assumption makes the derivation simpler but is not essential for the results. Consumer interests still play a role but through the social welfare function in the government's objective function.

[41] The common-agency literature (e.g. Bernheim and Whinston 1986) argues that a truthful contribution schedule must reflect the true preferences of the interest group. In our political economy model this requires that interest groups set their lobby contributions in accordance with their expected profits linked to the different levels of the public standard.

the truthful contribution function of the producers' interest group as $C_t^{p,k}\left(s_t^k\right) \equiv \Pi_t^{p,k}\left(s_t^k\right)$.[42]

4.2.5. Time Framework

We assume that agents do not take future periods into consideration when making decisions, i.e. they have a 'myopic planning horizon' (Göcke 2002). Another potential assumption would be that agents have perfect foresight, so that the various agents' economic and political decisions in period 1 would be affected by their expectations of the optimal behavior of all agents in period 2. However, under this alternative assumption of perfect foresight it would not be possible to analyze sudden 'black swan' events, i.e. events that are unexpected but have potentially large consequences, since agents would expect and foresee such events. Yet, as we will argue further on, this is precisely what happened in the case of biotechnology regulation in Europe. Unexpected food safety crises triggered consumer aversion to biotechnology in Europe (Bernauer 2003; Vogel 2003; Graff and Zilberman 2007; Scholderer 2005). Hence, although our assumption of myopic agents may be a rather extreme one, it allows us to analyze this particular case. The analysis under the alternative assumption of perfect foresight would be more complex and would generate some additional potential equilibria, but the model's outcomes with myopic agents would still hold albeit for a smaller range of parameter values.

[42] Our approach is equivalent to assuming that the producers' interest group represents only a small fraction of the population since its contribution schedule does not take into account the effects of regulation on consumer surplus (see also Lopez and Matschke 2006).

Each period consists of several sequential moves which take place simultaneously in both countries. At the beginning of each period, agents take stock of the existing technologies. The producers' interest group then proposes its contribution schedule to the government that chooses the standard. Upon the policy selection, producers make the necessary investments if the level of the standard has altered between periods. Finally, products are produced and sold, and the producers' interest group makes its political contributions.

A government maintains the existing standard if and only if

$$\Pi_t^{g,k}\left(s_t^k = s_{t-1}^k\right) \geq \Pi_t^{g,k}\left(s_t^k \neq s_{t-1}^k\right), \tag{4.8}$$

or equivalently, if

$$\alpha C_t^{p,k}\left(s_t^k = s_{t-1}^k\right) + W_t^k\left(s_t^k = s_{t-1}^k\right) \geq \alpha C_t^{p,k}\left(s_t^k \neq s_{t-1}^k\right) + W_t^k\left(s_t^k \neq s_{t-1}^k\right). \tag{4.9}$$

In the remainder of this chapter, we assume that only the expensive technology is available before period 1, and that therefore, by default, governments set their standard to $s_0^A = s_0^B = s_H$. This resembles a situation where the expensive technology is a conventional existing technology, and the cheap technology is an innovation that becomes available in period 1.[43]

In the next sections, we analyze the governments' regulatory choices under different scenarios: (i) when consumers in both countries have identical preferences, and these preferences are constant over time; (ii) with different consumer preferences

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[43] We focus our analysis on the default option $s_0^k = s_H$ because this resembles best the issue of biotechnology regulation. Oppositely, for issues such as child labor or carbon dioxide emissions, the expensive technology is an innovation that becomes available in period 1. In these cases the default option is to allow the cheap technology, $s_0^k = s_L$, and conditions for regulatory hysteresis can be obtained in the same analytical framework as presented here. We discuss this in more detail at the end of Section 4.5.

between countries and preferences constant over time; and (iii) with a temporary difference in consumer preferences (a 'butterfly').

4.3. Case (i): Constant and Identical Consumer Preferences between Countries

Consider the case where consumers in both countries have identical preferences, $\phi_t^A = \phi_t^B$ for $t = 1, 2$, that are constant over time, $\phi_1^k = \phi_2^k$ for $k = A, B$. Under our assumptions, both countries are identical and with Bertrand competition and positive trade costs, there is no international trade. Thus, it suffices to look at one country.

Period 1

The cheap technology becomes available in both countries. Prohibiting its use $\left(s_1^k = s_H\right)$ results in a marginal cost of $c_1^k\left(s_H\right) = b\left(s_H\right)^2$, while allowing it $\left(s_1^k = s_L\right)$ requires investment to switch between regulations and the marginal cost is $c_1^k\left(s_L\right) = b\left(s_L\right)^2 + a\Delta^2$, where $\Delta \equiv s_H - s_L$. Under the assumption of Bertrand competition with more than three producers in each country, the market price equals the marginal cost of domestic producers, $p_1^k = c_1^k$, and $\Pi_1^{p,k}\left(s_H\right) = \Pi_1^{p,k}\left(s_L\right) = L$. Hence, producers are indifferent to the level of the standard in period 1.

Since price equals marginal cost, consumer surplus $\Pi_1^{c,k}$ is equal to $\frac{Ns_H}{2}\left(\phi_1^k - bs_H\right)^2$ for $s_1^k = s_H$ and $\frac{Ns_L}{2}\left(\phi_1^k - bs_L - a\frac{\Delta^2}{s_L}\right)^2$ for $s_1^k = s_L$. Consumers prefer to ban the cheap technology if $\Pi_1^{c,k}\left(s_H\right) - \Pi_1^{c,k}\left(s_L\right) \geq 0$, or equivalently, if

$$\phi_1^k \geq \phi_1^{c,k} = \frac{1}{\left(\sqrt{s_H} - \sqrt{s_L}\right)} \left[b\left(s_H^{3/2} - s_L^{3/2}\right) - a\frac{\Delta^2}{\sqrt{s_L}} \right], \tag{4.10}$$

where $\phi_1^{c,k}$ is the consumers' critical preference value in country k and period 1.[44] In other words, the consumers' critical preference value is the level of preferences below which consumers prefer allowing the cheap technology.

As producers are indifferent, the government follows consumers' interests and the government's critical preference value $\phi_1^{g,k}$ coincides with the consumers' one. Thus, the government prohibits the cheap technology if and only if

$$\phi_1^k \geq \phi_1^{g,k} = \frac{1}{\left(\sqrt{s_H} - \sqrt{s_L}\right)} \left[b\left(s_H^{3/2} - s_L^{3/2}\right) - a\frac{\Delta^2}{\sqrt{s_L}} \right]. \tag{4.11}$$

Result 1: *With* $bs_L > a\Delta$ *and* $\phi_1^A = \phi_1^B$ *for* $k = A, B$*:*

- $\forall \phi_1^k \in \left[\phi^{\min}, \phi_1^{g,k}\right) : s_1^k = s_L$*;*
- $\forall \phi_1^k \in \left[\phi_1^{g,k}, \infty\right) : s_1^k = s_H$*;*

with $\phi_1^{g,k} = \frac{1}{\left(\sqrt{s_H} - \sqrt{s_L}\right)} \left[b\left(s_H^{3/2} - s_L^{3/2}\right) - a\frac{\Delta^2}{\sqrt{s_L}} \right]$*;* $\phi^{\min} = b\left(s_H + s_L\right) + a\Delta$.

Result 1 implies that, given equal consumer preferences between countries, a critical preference value $\phi_1^{g,k}$ exists such that if consumer preferences ϕ_1^k are strictly lower than

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[44] Consumer surplus is convex in ϕ_t^k so $\Pi_t^{c,k}\left(s_H\right) - \Pi_t^{c,k}\left(s_L\right) = 0$ has two solutions in ϕ_t^k. Our analysis is restricted to the domain $\phi_t^k \geq \phi^{\min} = b\left(s_H + s_L\right) + a\Delta$, where higher consumer preferences for quality lead to larger consumer surplus differences between high and low quality.

$\phi_1^{g,k}$, country k's government allows the cheap technology and the politically optimal standard is $s_1^k = s_L$. If ϕ_1^k is higher than $\phi_1^{g,k}$, the politically optimal standard is $s_1^k = s_H$ and the government prohibits the cheap technology. Result 1 thus shows that a minor difference in consumer preferences can lead to important differences in technology regulation. As can be seen from Equation (4.11), this result is partly driven by the binary nature of the regulation, i.e. that governments either allow or ban the cheap technology.

A larger marginal 'cost of quality', represented by parameter b, results in a larger critical preference value of the government $\phi_1^{g,k}$, i.e. $\frac{\partial \phi_1^{g,k}}{\partial b} > 0$, and thus in a larger range of consumer preferences ϕ_1^k for which the cheap technology is allowed. This is intuitive: for larger b the additional 'cost of quality' of producing with the expensive technology is larger, so consumers pay relatively more for the high quality product. Thus consumer preferences for quality need to be larger to support the prohibition of the cheap technology, which is reflected in a larger $\phi_1^{g,k}$.

A higher 'investment cost' of switching between regulations, represented by a larger value of a, reduces the government's critical preference value $\phi_1^{g,k}$ $\left(\frac{\partial \phi_1^{g,k}}{\partial a} < 0\right)$. With higher adjustment costs, consumers pay relatively more for the low quality product and are thus less in favor of allowing the cheap technology. This is represented by a lower critical preference value $\phi_1^{g,k}$ and thus a smaller range of ϕ_1^k for which $s_1^k = s_L$.

Period 2

The analysis of the political equilibrium in period 2 depends on the outcome in period 1, i.e. whether $s_1^k = s_H$ or $s_1^k = s_L$. Suppose first that $\phi_1^k \geq \phi_1^{g,k}$ such that $s_1^k = s_H$, i.e. the cheap technology is prohibited in period 1 (see Result 1). The political equilibrium is then the same as in the previous period, since in both periods $s_{t-1}^k = s_H$ and consumer preferences are constant. The government's critical preference value in period 2 is the same as in period 1, $\phi_2^{g,k} = \phi_1^{g,k}$, and since $\phi_2^k = \phi_1^k$ it follows that $\phi_2^k \geq \phi_2^{g,k}$. Hence, if the political equilibrium is to prohibit the cheap technology in the first period and consumer preferences are constant, the ban on the cheap technology remains in the second period, i.e. $s_2^k = s_H$.

Second, suppose that $\phi_1^k < \phi_1^{g,k}$ such that $s_1^k = s_L$ and producers invested in the cheap technology in period 1. For the same reasons as in the previous period, producers are again indifferent to the level of the standard in period 2. However, because production costs and prices are different from period 1, the consumers' critical preference value – and also the government's critical preference value since producers are indifferent – changes with respect to period 1. Production under the cheap technology is less costly in period 2 as there is no longer a cost of switching $\left(c_2^k\left(s_L\right) = b\left(s_L\right)^2 < c_1^k\left(s_L\right)\right)$. Oppositely, production with the expensive technology is more costly because switching is necessary $\left(c_2^k\left(s_H\right) = b\left(s_H\right)^2 + a\Delta^2 > c_1^k\left(s_H\right)\right)$. The government's critical preference value in period 2 is then

$$\phi_2^{g,k} = \phi_2^{c,k} = \frac{1}{\left(\sqrt{s_H} - \sqrt{s_L}\right)}\left[b\left(s_H^{3/2} - s_L^{3/2}\right) + a\frac{\Delta^2}{\sqrt{s_H}}\right]. \tag{4.12}$$

Comparing Equations (4.11) and (4.12) shows that $\phi_2^{g,k} > \phi_1^{g,k}$, and given constant consumer preferences, we find that $\phi_2^k < \phi_2^{g,k}$. Hence, if the cheap technology is allowed in the first period and consumer preferences are constant, the political equilibrium is to continue allowing the cheap technology in the second period, i.e. $s_2^k = s_L$.

Result 2: *With* $bs_L > a\Delta$, $\phi_t^A = \phi_t^B$ *and* $\phi_1^k = \phi_2^k$ *for* $t = 1,2$ *and* $k = A,B$ *:*

- $\forall \phi_t^k \in \left[\phi^{\min}, \phi_1^{g,k}\right) : s_t^k = s_L$ *;*
- $\forall \phi_t^k \in \left[\phi_1^{g,k}, \infty\right) : s_t^k = s_H$ *;*

with $\phi_1^{g,k} = \dfrac{1}{\left(\sqrt{s_H} - \sqrt{s_L}\right)}\left[b\left(s_H^{3/2} - s_L^{3/2}\right) - a\dfrac{\Delta^2}{\sqrt{s_L}}\right]$; $\phi^{\min} = b\left(s_H + s_L\right) + a\Delta$.

As summarized in Result 2, our dynamic political economy model shows that, if consumer preferences are identical between countries and constant over time, governments impose the same regulation in each period. Moreover, Result 2 shows that once a government has imposed a certain regulation while both technologies are available, it endorses the status quo. Result 2 also implies that minor differences in consumer preferences can lead to different technology regulations which persist over time.

4.4. Case (ii): Constant and Different Consumer Preferences between Countries

Without loss of generality, we assume that country A's consumers have higher preferences for quality than country B's consumers. Preferences remain constant over time: $\phi_1^A = \phi_2^A > \phi_1^B = \phi_2^B$.

Period 1

The analysis of the political equilibrium in period 1 is similar to that of case (i). The cheap technology becomes available in both countries. Prohibiting that technology results in a marginal cost of $c_1^k(s_H) = b(s_H)^2$, while approving it requires investment and the marginal cost is $c_1^k(s_L) = b(s_L)^2 + a\Delta^2$. Under the assumption of Bertrand competition with more than three producers in each country, the market price equals the marginal cost of the domestic producers, $p_1^k = c_1^k$, and $\Pi_1^{p,k}(s_H) = \Pi_1^{p,k}(s_L) = L$ if producers only supply their own domestic market.

The above outcome is always the case in period 1. Producers only supply their own market when standards are the same (see case (i)), but also when standards are different between both countries. Consider for example the situation where $s_1^A = s_H$ and $s_1^B = s_L$ such that $c_1^A(s_H) = b(s_H)^2$ and $c_1^B(s_L) = b(s_L)^2 + a\Delta^2$. First, it is prohibited for country B's producers to export to country A because they produce under a lower standard than what is required in country A $(s_1^B < s_1^A)$. Second, country A's producers are allowed to export to country B as they produce under a sufficiently stringent standard $(s_1^A > s_1^B)$. However, the inability of country A's producers to market their products as 'high quality' on country B's market prevents them from exporting since they incur a higher marginal cost $\left(c_1^A > c_1^B\right)$. In summary, producers do not export even with different standards because country A's producers cannot compete on country B's market due to higher marginal costs, while country B's producers cannot compete on country A's market due to lower technology standards. Therefore, producers only supply their domestic markets. This implies that $\Pi_1^{p,k}\left(s_H\right) = \Pi_1^{p,k}\left(s_L\right) = L$, and hence that producers are indifferent to the level of the standard in period 1.

Since the default situation is the same as in case (i) for both countries, the consumers' critical preference value $\phi_1^{c,k}$ is given by Equation (4.10) for $k = A, B$. From our assumption that $\phi_t^A > \phi_t^B$ follow three potential orderings of consumer preferences. First, if $\phi_1^B < \phi_1^A < \phi_1^{c,k}$, the analysis is the same as in case (i) and $s_t^k = s_L \;\; \forall t, k$. Likewise, if $\phi_1^{c,k} < \phi_1^B < \phi_1^A$, $s_t^k = s_H \;\; \forall t, k$. The third ordering, $\phi_1^B < \phi_1^{c,k} < \phi_1^A$, is the most interesting one and will be analyzed here.

It follows that country A's consumers prefer banning the cheap technology $\left(\phi_1^A > \phi_1^{c,A}\right)$ while country B's consumers are in favor of allowing it $\left(\phi_1^B < \phi_1^{c,B}\right)$. As producers are indifferent between the two technologies, the government's critical preference value is $\phi_1^{g,k} = \phi_1^{c,k}$ for $k = A, B$. Hence, country A's government bans the cheap technology $\left(s_1^A = s_H\right)$, while country B's government allows it $\left(s_1^B = s_L\right)$. This difference in regulation is due to different consumer preferences, and the differences in consumer preferences need not be large to result in different regulations. This is summarized in Result 3.

Result 3: *With* $bs_L > a\Delta$ *and* $\phi^{\min} < \phi_1^B < \phi_1^{c,k} < \phi_1^A$ *for* $k = A, B$ *:*

- $s_1^A = s_H$ *and* $s_1^B = s_L$ *;*

with $\phi_1^{c,k} = \dfrac{1}{\left(\sqrt{s_H} - \sqrt{s_L}\right)}\left[b\left(s_H^{3/2} - s_L^{3/2}\right) - a\dfrac{\Delta^2}{\sqrt{s_L}}\right]$; $\phi^{\min} = b\left(s_H + s_L\right) + a\Delta$.

Period 2

Given the outcome in period 1, the countries enter period 2 with different regulations, i.e. $s_1^A = s_H$ and $s_1^B = s_L$. This implies that in period 2 the marginal costs under selected standards are different between the countries. We first analyze country B's political equilibrium for each regulation selected by country A.

Suppose first that country A switches between regulations such that $s_2^A = s_L$ and $c_2^A\left(s_L\right) = b\left(s_L\right)^2 + a\Delta^2$. Country B's producers are then indifferent regarding the standard. Under $s_2^B = s_H$, country B's domestic market is protected from imports by a more stringent standard $\left(s_2^B > s_2^A\right)$ and country B's market price is $p_2^B = c_2^B\left(s_H\right) = b\left(s_H\right)^2 + a\Delta^2$. Under $s_2^B = s_L$, country B's producers competitively dominate country A's producers on prices since $c_2^B\left(s_L\right) = b\left(s_L\right)^2 < c_2^A\left(s_L\right)$, but these additional exports do not result in positive profits for country B's producers since they compete on prices. The market price in both countries is then $p_2^k = c_2^B\left(s_L\right)$. Hence, given $s_2^A = s_L$, $\Pi_2^{p,B}\left(s_H\right) = \Pi_2^{p,B}\left(s_L\right) = L$. Country B's consumers are however not indifferent, since the quality levels and corresponding market prices are different for $s_2^B = s_L$ and $s_2^B = s_H$. If the cheap technology is allowed, consumers benefit from lower prices than in period 1 as the investment cost has already been incurred by country B's producers, whereas if the expensive technology is imposed, investment is needed to switch. The consumers' critical preference value, $\phi_2^{c,B}$, is then given by Equation (4.12) which is higher than in period 1 (Equation (4.10)): $\phi_2^{c,B} > \phi_1^{c,B}$. In combination with constant consumer preferences and $\phi_1^B < \phi_1^{c,B}$, it follows that $\phi_2^B < \phi_2^{c,B}$. Country B's consumers thus prefer allowing the cheap technology. Since country B's producers are indifferent, the government of country B follows consumers' preferences and the political-economic optimum, given that $s_2^A = s_L$, is $s_2^B = s_L$.

Second, suppose that country A maintains its ban such that $s_2^A = s_H$ and $c_2^A(s_H) = b(s_H)^2$. Country B's producers are then in favor of maintaining the status quo, i.e. $s_2^B = s_L$. Under $s_2^B = s_L$, country B's producers competitively dominate country A's producers on prices since $c_2^B(s_L) < c_2^A(s_H)$ and country A's product cannot be sold on B's market as a high quality good. In contrast, with $s_2^B = s_H$, exports from A to B are allowed $(s_2^A = s_2^B)$ and cheaper $(c_2^A(s_H) < c_2^B(s_H))$,[45] since country B's producers need to invest in switching technologies while country A's producers do not. Hence country B's producers are driven out of their own market with $s_2^B = s_H$, and therefore favor $s_2^B = s_L$. Country B's consumers are indifferent neither. With $s_2^B = s_L$, country B's domestic market price is $p_2^B = c_2^B(s_L)$, while for $s_2^B = s_H$, the domestic market price is

[45] This requires that transportation costs are smaller than the difference between $c_2^A(s_H)$ and $c_2^B(s_H)$. We assume that transportation costs are sufficiently small, such that we do not need to introduce them algebraically.

$p_2^B = c_2^A(s_H)$ since imports from A are allowed and cheaper. With these prices, the consumers' critical preference value for country B in period 2, $\phi_2^{c,B}$, is

$$\phi_2^{c,B} = \frac{1}{\left(\sqrt{s_H} - \sqrt{s_L}\right)}\left[b\left(s_H^{3/2} - s_L^{3/2}\right)\right]. \tag{4.13}$$

Comparing Equations (4.13) and (4.10), one observes that $\phi_2^{c,B} > \phi_1^{c,B}$ and hence $\phi_2^B < \phi_2^{c,B}$ so that country B's consumers prefer to allow the cheap technology. As a result, since both country B's producers and consumers favor allowing the cheap technology, it is in the interest of country B's government to endorse this status quo, i.e. $s_2^B = s_L$, given that $s_2^A = s_H$.

To summarize, the political-economic optimum for country B's government is to continue its policy of allowing the cheap technology, i.e. $s_2^B = s_L$, irrespective of country A's regulation in period 2. Hence, once country B's government has chosen to allow the cheap technology, it endorses the status quo in future periods and supports the cheap technology, irrespective of the behavior of the other country's government. This policy persistence is summarized in the following result:

Result 4: *With* $bs_L > a\Delta$, $\phi_1^k = \phi_2^k$ *and* $\phi^{\min} < \phi_1^B < \phi_1^{c,k} < \phi_1^A$ *for* $k = A, B$:

- $s_2^B = s_L$, *independent of* s_2^A;

with $\phi_1^{c,k} = \frac{1}{\left(\sqrt{s_H} - \sqrt{s_L}\right)}\left[b\left(s_H^{3/2} - s_L^{3/2}\right) - a\frac{\Delta^2}{\sqrt{s_L}}\right]$; $\phi^{\min} = b\left(s_H + s_L\right) + a\Delta$.

Given this result, we only need to consider $s_2^B = s_L$ when evaluating country A's strategic response. If $s_2^A = s_L$, the marginal cost of country A's producers is $c_2^A(s_L) = b(s_L)^2 + a\Delta^2$ since they need to invest in switching. In contrast, country B's producers already made this investment and produce at $c_2^B(s_L) = b(s_L)^2$. In that case, profits of country A's producers are $\Pi_2^{p,A}(s_L) = L - aN\Delta^2\left[\phi_2^A - bs_L\right]$ since $p_2^A = c_2^B < c_2^A$ due to cheaper imports from country B.[46] If $s_2^A = s_H$, country A's producers are protected from imports by a more stringent standard since $s_2^A > s_2^B$, such that under price competition $p_2^A = c_2^A(s_H) = b(s_H)^2$ and $\Pi_2^{p,A}(s_H) = L$. Accordingly, country A's producers always endorse the status quo in period 2, since

$$\Pi_2^{p,A}(s_H) - \Pi_2^{p,A}(s_L) = aN\Delta^2\left[\phi_2^A - bs_L\right] > 0. \qquad (4.14)$$

Country A's consumers may or may not favor the status quo in period 2. If $s_2^A = s_L$, consumers buy low quality but cheap imports and consumer surplus equals $\Pi_2^{c,A}(s_L) = \frac{Ns_L}{2}\left(\phi_2^A - bs_L\right)^2$. If $s_2^A = s_H$, consumers buy high quality at a high price, and $\Pi_2^{c,A}(s_H) = \frac{Ns_H}{2}\left(\phi_2^A - bs_H\right)^2$. Hence:

$$\Pi_2^{c,A}(s_H) - \Pi_2^{c,A}(s_L) = \frac{Ns_H}{2}\left(\phi_2^A - bs_H\right)^2 - \frac{Ns_L}{2}\left(\phi_2^A - bs_L\right)^2, \qquad (4.15)$$

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46 This rests on the implicit assumption that country A's producers remain active in their domestic market, for example due to exit costs that are larger than $aN\Delta^2\left[\phi_2^A - bs_L\right]$. To ensure credible contributions from the producers' interest group, we assume that L is large enough such that $\Pi_2^{p,A}(s_L)$ is positive.

which may be positive or negative and equals zero at the consumers' critical preference value, $\phi_2^{c,A}$, i.e.

$$\phi_2^{c,A} = \frac{1}{\left(\sqrt{s_H} - \sqrt{s_L}\right)} \left[b\left(s_H^{3/2} - s_L^{3/2}\right) \right]. \tag{4.16}$$

Comparing values (4.16) and (4.10) reveals that $\phi_2^{c,A} > \phi_1^{c,A}$. There are two situations according to the level of country A's consumer preferences, ϕ_2^A. First, if $\phi_1^{c,A} < \phi_2^{c,A} < \phi_2^A$, country A's consumers favor the status quo in period 2, i.e. $s_2^A = s_H$. As a result, it is optimal for country A's government to set $s_2^A = s_H$ since country A's producers also endorse the status quo.

In the second situation, $\phi_1^{c,A} < \phi_2^A < \phi_2^{c,A}$, country A's consumers are in favor of allowing the cheap technology in period 2, in contrast to the first period. The reason for this change in consumers' interests is that in period 2 the low quality good can be imported from country B at a lower price than in period 1 when it was still more expensive due to the investment cost. In this situation, a coalition switch takes place between period 1 and 2, since both producer interests (from being indifferent to favoring s_H) and consumer interests (from favoring s_H to favoring s_L) change.

Which regulation is then optimal for country A's government depends on the relative differences in producer profits and consumer surpluses between the two regulatory options, and the relative weight of producers' contributions in the government's objective function (α). Inserting Equations (4.14) and (4.15) into Equations (4.6) and (4.7) gives

$$\Psi = (1+\alpha) aN\Delta^2 \left[\phi_2^A - bs_L \right] + \frac{Ns_H}{2}\left(\phi_2^A - bs_H \right)^2 - \frac{Ns_L}{2}\left(\phi_2^A - bs_L \right)^2 , \tag{4.17}$$

with $\Psi = \Pi_2^{g,A}(s_H) - \Pi_2^{g,A}(s_L)$. By definition of $\phi_2^{g,A}$, $\Psi = 0$ at $\phi_2^A = \phi_2^{g,A}$. Observe that the second and third term of Equation (4.17) together are identical to Equation (4.15) which equals zero at $\phi_2^{c,A}$. From Equation (4.14) it then follows that $\Psi > 0$ at $\phi_2^A = \phi_2^{c,A}$. The derivative of Equation (4.17) with respect to ϕ_2^A is positive for $\phi_2^A > \phi^{\min}$:

$$\frac{\partial \Psi}{\partial \phi_2^A} > 0 . \tag{4.18}$$

Combining these three findings, it follows that

$$\phi_2^{g,A} < \phi_2^{c,A} . \tag{4.19}$$

This inequality implies that for a certain range of consumer preferences, $\phi_2^A \in \left[\phi_2^{g,A}, \phi_2^{c,A} \right)$, lobbying by the producers' interest group is sufficiently powerful to induce country A's government to uphold the regulatory status quo even though consumers prefer to allow the cheap technology. For $\phi_2^A \in \left[\phi_1^{c,A}, \phi_2^{g,A} \right)$, the producers' interest group fails in pushing its agenda and the optimal decision for country A's government is to allow the cheap technology.

The value of $\phi_2^{g,A}$ depends on the political power of the producers' interest group, α. From Equation (4.17) follows that

$$\frac{\partial \Psi}{\partial \alpha} > 0 . \tag{4.20}$$

We find by the implicit function theorem and using Equations (4.18) and (4.20) that

$$\frac{d\phi_2^{g,A}}{d\alpha} = -\frac{\partial \Psi / \partial \alpha}{\partial \Psi / \partial \phi_2^A} < 0 . \tag{4.21}$$

Equation (4.21) implies that the government's critical preference value, $\phi_2^{g,A}$, decreases if the political power of the producers' interest group, α, increases. Intuitively, if the producers' interest group has more influence on the government, the range $\left[\phi_2^{g,A}, \phi_2^{c,A}\right)$ for which the government chooses to endorse the status quo expands. In the special case where α is sufficiently high such that $\phi_2^{g,A} \leq \phi_1^{c,A}$, country A's government always prohibits the cheap technology since $\phi_1^{c,A} < \phi_1^A = \phi_2^A$. We summarize the results for the optimal behavior of country A's government in Result 5.

Result 5: *With* $bs_L > a\Delta$, $\phi_1^k = \phi_2^k$ *and* $\phi^{\min} < \phi_1^B < \phi_1^{c,k} < \phi_1^A$ *for* $k = A,B$, *and* $\Psi = 0$ *at* $\phi_2^A = \phi_2^{g,A}$, *then:*

- $s_1^A = s_H$; $s_1^B = s_2^B = s_L$;
- $\phi_1^{c,A} < \phi_2^{c,A}$; $\phi_2^{g,A} < \phi_2^{c,A}$;
- *for* $\phi_2^A \geq \phi_2^{g,A}$: $s_2^A = s_H$;
- *for* $\phi_2^A < \phi_2^{g,A}$: $s_2^A = s_L$;
- $\dfrac{d\phi_2^{g,A}}{d\alpha} < 0$;

with $\phi_1^{c,k} = \dfrac{1}{\left(\sqrt{s_H} - \sqrt{s_L}\right)}\left[b\left(s_H^{3/2} - s_L^{3/2}\right) - a\dfrac{\Delta^2}{\sqrt{s_L}}\right]$, $\phi_2^{c,k} = \dfrac{1}{\left(\sqrt{s_H} - \sqrt{s_L}\right)}\left[b\left(s_H^{3/2} - s_L^{3/2}\right)\right]$;

$\phi^{\min} = b\left(s_H + s_L\right) + a\Delta$.

Our dynamic political economy model shows that differences in consumer preferences between countries may lead to differences in technology regulation. These regulatory differences may persist over time, however not only because of the differences in consumer preferences but also for reasons of producer protectionism. This is driven by the investment cost that induces producers in both countries to switch from being indifferent in the first period to supporting the status quo in the second period. If a government chooses to allow the cheap technology, its optimal policy is the regulatory status quo no matter what the other government decides. If a government chooses to ban the cheap technology, it prefers the regulatory status quo depending on the relative impacts on consumers and producers of both regulatory options, and the political power of the producers' interest group. A larger political power of the producers' interest group leads to a larger range of circumstances where the status quo is maintained, even though consumers oppose it. Different technology regulations are initiated by differences in consumer preferences, but persistence in these regulatory differences is motivated by producers' interests.

4.5. Case (iii): A Temporary Difference in Consumer Preferences

In this section, we show that even if the difference in consumer preferences is only temporary and potentially small (a 'butterfly'), hysteresis in technology regulation and long-lasting regulatory differences between countries may emerge. To this end, we assume that consumer preferences are different between countries in period 1 but identical in period 2. There are two potential scenarios. In the first scenario, country A's consumer preferences are higher in period 1, $\phi_1^A > \phi_1^B$, but in period 2 they fall to the level of those in country B, $\phi_2^A = \phi_2^B$, which have remained constant $\left(\phi_1^B = \phi_2^B\right)$. In the second scenario, country A's consumer preferences are also higher in period 1, $\phi_1^A > \phi_1^B$, but in period 2 country B 's consumer preferences rise to the level of those in country A, $\phi_2^A = \phi_2^B$, which have remained constant $\left(\phi_1^A = \phi_2^A\right)$.

Scenario 1: $\phi_1^A > \phi_1^B = \phi_2^B = \phi_2^A$

Assume, consistent with $\phi_1^A > \phi_1^B$, that $\phi_1^A \underset{\rightarrow}{\geq} \phi_1^{c,k}$ and $\phi_1^B \underset{\rightarrow}{\leq} \phi_1^{c,k}$, with $\phi_1^{c,k}$ as in Equation (4.10). The difference between ϕ_1^A and ϕ_1^B is only minor since both approach $\phi_1^{c,k}$ respectively from above and below.[47] In line with Result 3, the governments' optimal choices in period 1 are respectively $s_1^A = s_H$ and $s_1^B = s_L$. Country A 's government prohibits the cheap technology, while country B 's government allows it.

In period 2, country A 's consumer preferences fall to the level of those in country B $\left(\phi_2^A = \phi_2^B = \phi_1^B \underset{\rightarrow}{\leq} \phi_1^{c,k}\right)$. A potential cause for this shift could be that country A 's consumers learn from country B 's positive experiences with the cheap technology. Following Result 4, the political-economic equilibrium in country B is to unconditionally uphold the status quo whereas according to Result 5, country A 's political-economic equilibrium depends on the political power of the producers' interest group. If α is sufficiently high such that $\phi_2^{g,A} \leq \phi_2^A$, the producers' interest group lobbies successfully to endorse the status quo although consumers prefer to allow the cheap technology $\left(\phi_2^A \underset{\rightarrow}{\leq} \phi_1^{c,k} < \phi_2^{c,k}\right)$. If however the producers' interest group is politically weak (α low) such that $\phi_2^A < \phi_2^{g,A}$, the government allows the cheap technology. Table 4.1 summarizes the first scenario.

[47] In terms of chaos theory, the situation in period 1 is a *hypersensitive* one (Smith 1991), meaning that other states arbitrarily close to the hypersensitive one could eventually lead to highly divergent dynamical behavior.

This scenario shows that if the producers' interest group in country A has sufficient political power, both countries remain having different technology regulations, even though consumer preferences are identical. The 'butterfly', the temporary difference in consumer preferences, triggers different initial regulatory choices and investment which lead to a coalition switch in country A as consumer and producer interests change. Country A's producers lobby successfully to uphold the status quo in period 2 which protects them from cheaper imports, while consumers prefer the cheap technology. Hence the temporary difference in consumer preferences leads to initial differences in regulation, but it are the producer protectionist motives that cause hysteresis and long-lasting differences in technology regulation.[48]

In Figure 4.1 we illustrate the interests of country A's producers in upholding the status quo where for simplicity world demand is assumed constant and equal to 1. The default situation is that initially only the expensive technology is available, i.e. $s_0^k = s_H$, $p_0^A = p_0^B = bs_H^2$, and the equilibrium is at E_0. In period 1, because of the temporary difference in consumer preferences, country B allows the cheap technology while country A prohibits it ($s_1^B = s_L$ and $s_1^A = s_H$). The marginal cost and price are lower in country B, although country B's producers incur an investment cost $\left(p_1^B = bs_L^2 + a\Delta^2 < bs_H^2 = p_1^A \right)$. Due to the different regulations and marginal costs, the markets are separated and the equilibrium is different for each country (E_1^A and E_1^B). In period 2, country B sticks unconditionally to the status quo such that its marginal cost

[48] In the classification of Göcke (2002), this hysteresis effect is a form of 'non-ideal relay hysteresis', which is part of the group 'microeconomic hysteresis'. This group shares the common feature that a certain critical value must be passed to induce persistent hysteresis effects.

and price decrease further $\left(p_2^B = bs_L^2 < p_1^B\right)$, and its equilibrium is at E_2^B. If country A would also allow the cheap technology, country A's producers would produce at marginal cost $bs_L^2 + a\Delta^2$. These are higher than in country B because the latter do not need to switch and have gained a first-mover advantage in the cheap technology. In that case, country A's equilibrium would be at $\tilde{E}_2^A$ and country A's producers would suffer a decrease in profits equal to $a\Delta^2/2$ in the figure. If however country A upholds its status quo, country A's equilibrium is at E_2^A, the markets remain separated, and country A's producers do not suffer a decrease in profits. Hence successful lobbying by country A's producers leads to hysteresis in technology regulation and long-lasting regulatory differences.

Scenario 2: $\phi_1^B < \phi_1^A = \phi_2^A = \phi_2^B$

Define government B's critical preference value as $\phi_2^{g,B}$ which has two important properties:[49] $\phi_2^{g,B} > \phi_2^{c,k}$ and $d\phi_2^{g,B}/d\alpha > 0$. These properties imply that if the producers' political power is sufficiently strong in country B, the status quo in technology regulation is maintained $\left(s_2^B = s_L\right)$ for an additional range of consumer preferences $\phi_2^B \in \left[\phi_2^{c,k}, \phi_2^{g,B}\right)$.[50]

[49] The derivations of these properties are similar to those of $\phi_2^{g,A}$ (Equations (4.18) to (4.21)).

[50] Since we assumed in the previous cases that $\phi_k^B < \phi_1^{c,k}$ and found that $\phi_1^{c,k} < \phi_2^{c,k}$, the range $\phi_2^B \in \left[\phi_2^{c,k}, \phi_2^{g,B}\right)$ was never relevant. This explains why we did not introduce $\phi_2^{g,B}$ before.

Table 4.2 summarizes the second scenario. Assume that in period 1, $\phi_1^A > \phi_2^{c,k}$ and $\phi_1^B < \phi_1^{c,k}$, which is consistent with $\phi_1^A > \phi_1^B$ since $\phi_1^{c,k} < \phi_2^{c,k}$ (defined by respectively Equations (4.10) and (4.16)). According to Result 3, $s_1^A = s_H$ and $s_1^B = s_L$. In period 2 consumer preferences increase in country B so that $\phi_2^B = \phi_2^A = \phi_1^A$.[51] Since $\phi_2^A > \phi_2^{c,k}$, country A's government continues banning the cheap technology, $s_1^A = s_H$ (see Result 5). Whether country B's government chooses the status quo or not depends on the political power of the producers' interest group in country B. If the producers' interest group has sufficient political power (α high) such that $\phi_2^{g,B} > \phi_2^B$, the status quo is endorsed although consumers prefer the expensive technology $\left(\phi_2^B > \phi_2^{c,k}\right)$. If α is low such that $\phi_2^{g,B} \le \phi_2^B$, the producers' interest group in country B is unsuccessful at pushing for the status quo, and the cheap technology is prohibited.

This scenario demonstrates that if the producers' interest group has sufficient political power in country B, its government continues allowing the cheap technology although consumers want to ban it, and the regulatory difference between the countries persists although consumer preferences are identical. The temporary difference in consumer preferences triggers different regulatory choices and investment in period 1. Because country A's producers gain a first-mover advantage by not switching technologies in the first period, they produce in period 2 at lower marginal costs with the expensive technology. By lobbying to uphold the status quo in technology regulation, country B's producers protect themselves from this competitive disadvantage. Hence

[51] A potential cause for this shift could be that in period 1 the cheap technology caused damage in country B which altered country B's consumer preferences and confirmed consumers' concerns in country A.

also in the second scenario, the temporary difference in consumer preferences leads to different initial regulations, but it is again a producer protectionist motive that causes hysteresis in technology regulation and long-lasting differences in regulation between countries.

In conclusion, our dynamic political economy model shows that in the second period producers in both countries favor technology regulation that excludes foreign imports, due to technology-specific investments (or the absence of these investments) that were triggered by a temporary difference in consumer preferences in the first period. The model shows that policy persistence in (differences in) technology regulation may occur because governments cater domestic producers' interests, creating hysteresis in technology regulation.

These results are not driven by the assumption that the default option is the expensive technology, i.e. that $s_0^k = s_H$. We focused our analysis on this case because it resembles best the issue of biotechnology regulation, but our results hold also for issues where the default option is to allow the cheap technology, i.e. $s_0^k = s_L$, for example for child labor and carbon dioxide emissions. It is possible to show that also under this alternative default option a critical preference value exists above which consumers prefer the expensive technology. Subsequently, under very similar assumptions that consumer preferences are different between countries, the government of the country with the highest consumer preferences would switch to the expensive technology while the other country's government would stick to the cheap one. It can then be shown that, for constant consumer preferences, the government that initially switches to the expensive technology always endorses the regulatory status quo in the long run, independent of the other country's regulation. The government that initially allows the cheap technology may also support the regulatory status quo, even though its consumers may wish to ban the cheap technology, when its producers have sufficient political power. Producers in that country would lobby to continue allowing the cheap technology to protect themselves from imports from the country that adopted the expensive technology. Hence, also under this different default option, producer lobbying could lead to policy persistence and long-run differences in technology regulation. Similar results of hysteresis in technology regulation can be obtained when differences in consumer preferences are only temporary.

4.6. Discussion and Implications

Our model indicates that the dynamic interaction between consumer preferences and protectionist motives plays an important role in (differences in) technology regulation. We now apply the insights from our model to explain the difference in biotechnology regulation between the US and EU.

The food scares that plagued Europe in the second half of the 1990s, such as the *bovine spongiform encephalopathy* (BSE, commonly known as the 'mad cow' disease), the food and mouth disease, and dioxin crises triggered (temporarily) higher consumer preferences for quality and safety in Europe (Bernauer 2003; Vogel 2003; Graff and Zilberman 2007; Scholderer 2005). In line with case (ii) for permanently higher European consumer preferences, or with the first scenario of case (iii) for temporarily higher European consumer preferences, these different consumer preferences induced differences in initial GM regulations and investments between the US and Europe. The US allowed GM technology (country B) while the EU de facto prohibited it (country

A). Because of these different initial regulations producers' interests changed: US producers became supporters of GM technology, while European producers became opponents. By subsequently lobbying their governments to protect their home markets, producers obtained the regulatory status quo and created hysteresis in biotechnology regulation. Hence the producers' interests are the reason that the differences in GM regulation persist, both for a difference in preferences that is permanent (case (ii)) or temporary (scenario 1 of case (iii)). This argument is supported by Graff and Zilberman (2004) who argue that GM regulation in name of consumer interests may equally support agrochemical companies and farmers by protecting them against the comparative disadvantage from either investing or not investing in GM technology. It is also in line with the simulation results of van Meijl and van Tongeren (2004) who find that the European ban on GM generates higher incomes for European producers than when Europe would allow GM products. It are thus differences in consumer preferences that created initial differences in GM regulation, but producer interests that lead to hysteresis in GM regulation. This is also consistent with the fact that, before the food safety crises, European producers were less opposed to GM technology (Bernauer 2003) and that initially EU and US GM regulations were on the same track (Vogel 2001).

The main cause of this regulatory hysteresis is that producers incur a cost of switching between different technologies. This is in line with Coate and Morris (1999, p. 1332) who argue that

> "*It is clear that the phenomena of [policy] persistence is driven by the existence of switching costs which drive a wedge between the firm's willingness to pay for the policy […].*"

The important implication is that if one would aspire changing biotechnology regulation in Europe, one would need to ensure that European producers have the possibility to adjust their production technology without losing profits to foreign imports. This fits well some of the recent German regulations on biotechnology. Germany allows cultivation of the 'Amflora' potato, a GM crop developed by the German chemicals group BASF while at the same time Germany bans cultivation and sale of GM maize (MON 810) produced by the US company Monsanto, despite the fact that both crops have been approved for cultivation at EU level. This suggests that Germany is providing time for its producers to switch between conventional and GM technology without losing domestic market share to foreign imports.

However, the EU has also adopted additional GM regulations that (unintentionally) increased producers' switching costs. Since the late 1990s, the EU mandates the labeling of GM products to guarantee that consumers are able to choose between GM and non-GM products (Carter and Gruère 2003). Yet, this regulation increases producers' costs of switching to GM technology because it would require additional expensive investments in identity preservation and segregation if GM technology were to be allowed (Bullock and Desquilbet 2002; Lapan and Moschini 2004). Hence the results of our model suggest that this mandatory labeling further strengthened European producers' opposition towards GM technology.

If it are instead the US consumer preferences that are temporarily lower, the second scenario of case (iii) explains the difference in GM regulation between the US and EU. In this view, temporarily lower US consumer preferences triggered differences in initial GM regulation. However US producers' interests are then the reason that differences in biotechnology regulation persist even if there is no longer a difference in consumer preferences. If the US producers' interest group has sufficient political power, they succeed in obtaining the regulatory status quo, which allows using GM technology. For example, Charles (2001) provides a fascinating account of the views and strategies of influential persons within Monsanto and other biotechnology-related companies and how their views changed the companies lobbying activities during certain periods. Charles (2001) also argues that the Reagan administration was very much opposed to additional regulations, and according to Stewart *et al.* (2002) the Bush administration explicitly decided to push for GM technology. These factors put higher political weight on producers' interests in the US which, according to our model, leads to a continuation of the approval of GM technology in the US, even if US consumers would oppose it, and causes regulatory hysteresis.

4.7. Extensions to the Model

It is possible to extend our model in several directions – we merely indicate some of them, where possible in application to GM technology. First, we have assumed that consumer preferences in the second period are independent from regulation in the first period, i.e. that $\phi_2^k = \phi_1^k + f\left(s_1^k\right)$ with $f\left(s_1^k\right) = 0$. However, it is not unlikely that consumer preferences are affected by previous regulation, for example because the experience of (not) consuming GM products alters consumer preferences. In countries where GM products are available consumer preferences may shift in favor of this technology, while inversely consumers may distrust GM technology more in countries where GM products have been banned.[52] Extending the model by assuming that $f\left(s_H\right)>0$ and $f\left(s_L\right)<0$ would reinforce our results. For example, consider case (ii) where consumer preferences are higher in period 1 in country A, and where consequently the cheap technology is banned in country A but not in country B $\left(s_1^A = s_H;\ s_1^B = s_L\right)$. The assumption that $\phi_2^k = \phi_1^k + f\left(s_1^k\right)$ with $f\left(s_H\right)>0$ and $f\left(s_L\right)<0$ implies that in period 2 consumer preferences in country A increase, whereas in country B consumer preferences decrease. It is straightforward from the previous analysis that Result 4 would not alter. Moreover, since then $\phi_2^A > \phi_1^A$, the range of situations where $\phi_2^A > \phi_2^{g,A}$ and $s_2^A = s_H$ would increase, thus extending the range where policy persistence in country A's technology ban occurs (see Result 5).

Another extension relates to the source of country differences. Hysteresis in differences in technology regulation may be caused by other factors than temporary differences in consumer preferences. For example, producers located in an environment favorable to technological innovation may have a comparative advantage in investing in a new technology. A temporary investment advantage can be modeled by assuming that country B's producers incur a lower investment cost than country A's producers in period 1 $\left(a_1^B < a_1^A\right)$. This temporarily lower investment cost may also lead to (persistence in) different technology regulations. Assume that consumer preferences for quality ϕ_t^k are constant and identical between countries. The lower value of a_1^B leads to a higher value of $\phi_1^{c,k}$ in both countries (see Equation (4.10)) since also country A's consumers could

[52] Media could play an important role in this – see e.g. McCluskey and Swinnen (2004); Kuzyk *et al.* (2005).

benefit from the lower investment cost by importing the low quality good. With $\phi_t^k < \phi_1^{c,k}$, country B's government would allow the cheap technology since country B's producers would be indifferent. Country A's producers would however oppose the cheap technology since they would be competitively dominated if the cheap technology were allowed, because $a_1^A > a_1^B$. Therefore country A's producers would lobby in favor of prohibiting the cheap technology, and $\phi_1^{g,A} < \phi_1^{c,k}$. If the political power of country A's producers would be sufficiently high such that $\phi_1^{g,A} < \phi_1^k$, country A's government would prohibit the cheap technology in the first period. The analysis of period 2, when $a_2^A = a_2^B$, is then similar to case (ii). Hence a temporary difference in investment costs may also lead to an initial difference in technology regulation which results in hysteresis in (differences in) technology regulation due to producer lobbying. According to Charles (2001), this was an important driver at Calgene, a biotechnology company located in Silicon Valley, US, that has been acquired by Monsanto in the meantime.

A third extension could be to specify the different subgroups that are aggregated in the group of 'producers'. In reality there exists considerable heterogeneity, both horizontally and vertically. For example, horizontally, there are different types of 'producers' who may vary in productivity and ability to apply different technologies. Vertically, the supply chain consists of different agents such as for example in the case of GM technology, farmers, seed companies, biotechnology companies, and producers of other inputs such as agro-chemical companies. These agents may have conflicting interests with respect to GM regulation (Fulton and Giannakas 2004). For example, biotechnology companies oppose GM technology regulation to fully exploit their innovations. In contrast, agro-chemical companies who produce traditional crop-protection products that are incompatible with or substitutes of GM technology favor biotechnology regulation in order to protect their market share in the crop protection market. On the other hand, if such an agro-chemical company sells chemicals that are complementary to biotechnology, they also oppose GM technology restrictions (Just and Hueth 1993). Seed companies may prefer to restrict GM technology or not, depending on how much market power the biotechnology firms have and how much the seed companies' margins are squeezed by the biotechnology companies. Additionally, GM regulation may entail further costs on seed companies such as segregation costs (Kalaitzandonakes *et al*. 2007). Similarly, farmers may oppose or favor GM regulation, depending on the impact on input and output prices and whether they incur extra costs (Veyssiere and Giannakas 2006). Depending on how these different agents in the supply chain interact, the distribution of market power in the supply chain, and the political power of the different agents, different outcomes may result. Separating out these different interest groups substantially complicates the analysis and is left for future research.

Finally, we have represented technology regulation by a one-dimensional and dichotomous standard, while in reality governments have a broad range of policy instruments at their disposal. For example, we have not allowed for labeling policies that would give consumers the opportunity to choose (see e.g. Golan *et al*. 2001; Fulton and Giannakas 2004; Moschini 2008). In the case of GM technology, governments may also impose maximum contamination levels. Biotechnology regulation may also distinguish between GM technology that is used for animal feed, or for food for human consumption. Of course, these various regulations may have different effects on different actors in the market, and interest groups who oppose GM regulation may still prefer one type of regulation over another.

4.8. Conclusions

This chapter advances a dynamic political-economic model of regulation, in which two countries' governments decide which of two technologies to allow in each of two periods. One technology allows to produce at lower marginal costs, but consumers have some (heterogeneous) aversion to it. Switching between technologies involves a one-time marginal cost increase. First we have demonstrated the existence of a critical (consumer) preference value above which the cheap technology is prohibited. A small variation in consumer preferences may thus determine whether a country bans a technology or not.

Second, our dynamic model showed that if consumer preferences are constant and identical between countries, countries adopt the same technology regulation and stick to the status quo independent of the initial technology regulation.

Third, constant but different consumer preferences between countries may lead to different technology regulations in the first period, depending on how the countries' consumer preferences are positioned with respect to the critical preference value. If different technologies are adopted in the first period, the government that initially allows the cheap technology always endorses the status quo in the long run, independent of the other country's regulation. The government that initially prohibits the cheap technology may also support the status quo in the long run, even though consumers may wish to change, because producers' interests switch around. Producers are initially indifferent but because of the switching cost they suffer a competitive disadvantage in applying the cheap technology. Therefore they lobby to maintain the ban on the cheap technology to protect themselves from cheaper imports from the country that adopts the cheap technology, and succeed if their political power is sufficiently strong. Hence producer lobbying, not consumer preferences, leads to policy persistence and long-run differences in technology regulation.

Fourth, the previous results may also hold when the difference in consumer preferences is only temporary. A temporary difference in consumer preferences may trigger different initial regulations, and thus different investments. In the next period, producers in both countries favor technology regulation that excludes foreign imports, due to technology-specific investments (or the absence of these). Hence, despite identical consumer preferences in the long run, regulatory differences may be long-lasting because governments respond to pressures of domestic producers, creating hysteresis in technology regulation. We have demonstrated that similar results may be obtained from temporary differences in company strategies that result in different investment costs.

This model illustrates that both consumer preferences and protectionist motives play an important role in explaining the differences in GM technology regulation between the EU and US. Higher consumer preferences for regulation in Europe due to food safety crises triggered differences in initial GM regulation. However the domestic producer interests, in Europe and the US, are the reason that differences in biotechnology regulation persist even if there is no longer a difference in consumer preferences. By contributing to the government to protect their home markets, European as well as US producers create hysteresis in biotechnology regulation and long-lasting regulatory differences.

The main cause of this regulatory persistence is the cost of switching between different technologies. This implies that in order to induce a change in technology regulation, one needs to ensure that producers can adjust their production technology without losing profits to foreign imports. This reduces producers' incentives to lobby in favor of a status quo in technology regulation, and would remove differences in regulation between countries, all else equal.

Tables

Table 4.1: A Temporary Difference in Consumer Preferences: Scenario 1 with $\phi_1^A > \phi_1^B = \phi_2^B = \phi_2^A$

t	A	B	s_t^k
1	$\phi_1^A \geq \phi_1^{c,k}$	$\phi_1^B \leq \phi_1^{c,k}$	$s_1^A = s_H$ $s_1^B = s_L$
2	$\phi_2^A < \phi_2^{c,k}$	$\phi_2^B < \phi_2^{c,k}$	$s_2^A = \begin{cases} s_H & \text{if } \phi_2^{g,A} \leq \phi_2^A \ (\alpha \text{ high}) \\ s_L & \text{if } \phi_2^{g,A} > \phi_2^A \ (\alpha \text{ low}) \end{cases}$ $s_2^B = s_L$

Table 4.2: A Temporary Difference in Consumer Preferences: Scenario 2 with $\phi_1^B < \phi_1^A = \phi_2^A = \phi_2^B$

t	A	B	s_t^k
1	$\phi_1^A > \left(\phi_2^{c,k} >\right) \phi_1^{c,k}$	$\phi_1^B < \phi_1^{c,k}$	$s_1^A = s_H$ $s_1^B = s_L$
2	$\phi_2^A > \phi_2^{c,k}$	$\phi_2^B > \phi_2^{c,k}$	$s_2^A = s_H$ $s_2^B = \begin{cases} s_L & \text{if } \phi_2^{g,B} > \phi_2^B \ (\alpha \text{ high}) \\ s_H & \text{if } \phi_2^{g,B} \leq \phi_2^B \ (\alpha \text{ low}) \end{cases}$

Figures

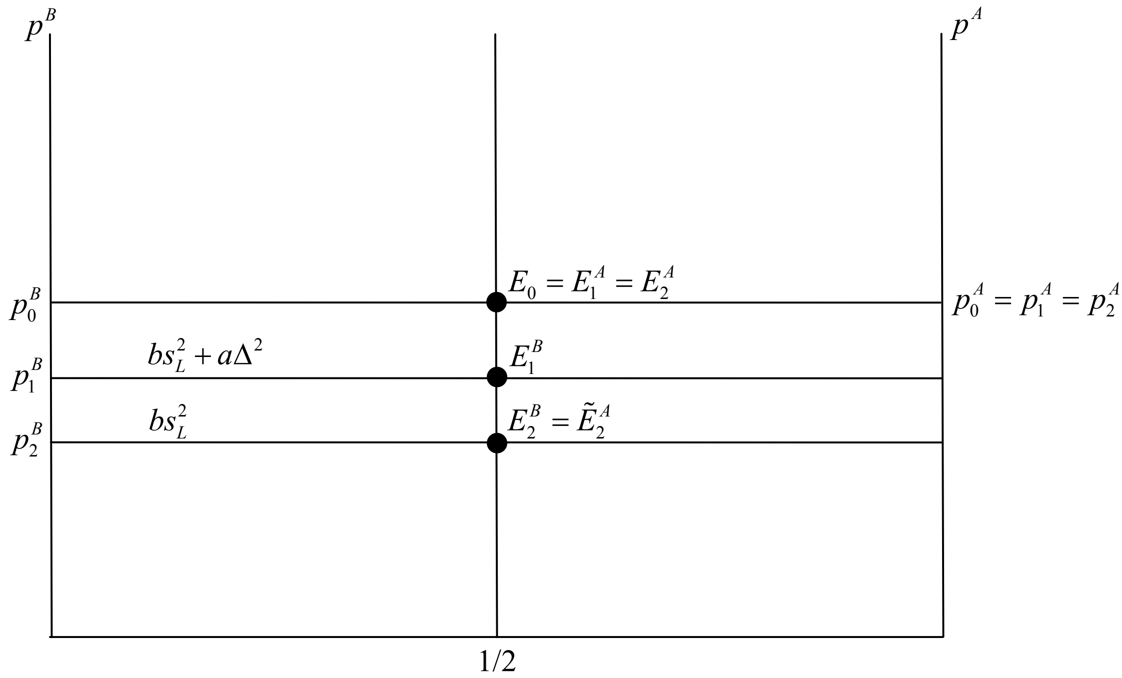

Figure 4.1: Interests at Stake of Country A's Producers to Maintain the Status Quo in Technology Regulation

Chapter 5. When are Private Standards more Stringent than Public Standards?

5.1. Introduction

Private standards, introduced by private companies, are increasingly important in the global market system (Henson and Hooker 2001; Henson 2004; Fulponi 2007). Retailers and producers have the possibility to introduce private standards in the same domains as in which the government imposes public standards, such as safety, quality, and social and environmental aspects of production, retail, and consumption.

Retailers and companies have a variety of motives to implement private standards. First, private standards may reduce consumers' uncertainty and information asymmetry about product characteristics such as safety, quality, and social and environmental aspects, thus increasing consumer demand. For example, Kirchhoff (2000) shows that firms may voluntarily reduce pollution to attract 'green' consumers if firms are able to signal their pollution abatement, for example through a private standard. Similarly, in a business to business environment, private standards allow to ensure and communicate product attributes about production, quality etc. which may facilitate firms to gear their activities to one another.

Second, firms may use private standards as strategic tools to differentiate their products, thus creating market segmentation and softening competition. A basic result from the vertical differentiation literature is that firms are able to reduce price competition and raise their profits by differentiating the (vertical) quality attribute of their products (see e.g. Spence 1976; Mussa and Rosen 1978; Tirole 1988). Such quality differences can be signaled by setting a private standard. Several other authors have shown that in a vertically differentiated market a minimum quality standard imposed by the government (a public standard) may raise welfare, depending on the type of competition between producers (see e.g. Leland 1979; Ronnen 1991; Boom 1995; Crampes and Hollander 1995; Valletti 1995; Winfree and McCluskey 2005). If the minimum quality standard is not prohibitively high such that it does not exceed the highest quality voluntarily supplied by producers, firms differentiate their quality levels: some produce at the minimum quality level while others produce at a higher quality level. The latter firms can signal their higher quality by setting a private standard that is more stringent than the public minimum quality standard (see e.g. Arora and Gangopadhyay 1995).

Third, private standards may also serve to preempt government regulations. For example, Lutz *et al*. (2000) show – in a vertical differentiation model with minimum quality standards – that high-quality firms may have an incentive to commit to a quality level before public standards are set, in order to induce the regulator to weaken public standards. They demonstrate that this results in welfare losses.[53] In the same line of reasoning, McCluskey and Winfree (2009) argue that an important advantage of private over public standards is that the former are more flexible in response to changes in consumer tastes and preferences, and to changes in technology. Therefore, by preempting public standards through setting their own private standards, firms may minimize the negative effect of standards on revenues. From a political economy perspective, Maxwell *et al*. (2000) argue that firms may strategically preempt costly political action through

[53] Lutz *et al*. (2000) assume that firms are the first movers in the standard-setting process by committing to a fixed quality level, whereas other papers on minimum quality standards (such as Leland 1979; Ronnen 1991; Valletti 2000; Boom 1995) typically assume the government to be the first mover in setting minimum quality standards.

voluntary private standards. They argue that a private standard raises consumers' welfare in the event that no public standard is imposed, which reduces consumers' incentives to lobby for a public standard in case political entry is costly for consumers. The authors show that this preempting private standard is more stringent than the public standard which would have been imposed in absence of the private standard.

Fourth, some authors have argued that instead of introducing private standards, firms may favor the imposition of a public standard that applies to all firms. Salop and Scheffman (1983) develop a model to show that a firm may demand stricter public standards if compliance is relatively more costly for its rivals. Similarly, Swinnen and Vandemoortele (2008; 2009; 2011a) show that domestic firms may lobby in favor of a public standard if the standard's marginal impact on production costs is larger for foreign than domestic firms. They show that if the political power of domestic firms is sufficiently large, standards may serve as protectionist instruments, either by over- or under-standardization. Maloney and McCormick (1982) argue that firms may benefit from public standards if the regulation increases marginal costs more than average costs. Their result holds either when entry is restricted, or when entry is free and the price effect exceeds the cost effect only for a subset of firms.

Empirical evidence shows that 80% to 90% of retailers assess their own private standards slightly or significantly higher than public standards (see Figure 5.1). So far, to the best of our knowledge, only two models may offer an explanation for this observation, i.e. why retailers set their private standards at higher levels than what is required by law – and both explanations have weaknesses. First, the explanation offered by the vertical differentiation literature is that those retailers who set their private standard at a higher level than the public minimum quality standard aim at differentiating themselves from other retailers that sell at the minimum quality standard, thus raising profits by reducing competition. However, this does not explain the phenomenon that organizations such as the BRC (British Retail Consortium) or the GLOBALG.A.P. (Global Partnership for Good Agricultural Practice) introduce private standards that are more stringent than public standards, and that these relatively stringent private standards are adopted by almost all retailers in European countries. Another important example is the Global Food Safety Initiative (GFSI), a standard-setting organization where leading retailers collaborate in developing collective private standards for food safety and/or sustainability (Fulponi 2007).

Second, the political economy model of Maxwell *et al*. (2000) offers another potential explanation for the relative stringency of private standards vis-à-vis public standards: private standards may preempt public standards if consumers' costs of getting politically organized are sufficiently high. This model explains why private standards are imposed in some domains where public standards are lacking. However, the model does not explain why private standards may be higher in areas where public standards already exist.[54]

The aim of this chapter is to provide an additional explanation for the observation that private standards may be set at higher levels than their public counterparts – even when implementation costs do not differ between public and private standards. In our analysis, we assume that both public and private standards positively affect consumer utility by reducing information asymmetries, and that they both involve implementation

[54] In the explanation of McCluskey and Winfree (2009), public standards are imposed (even though preempted by private standards) but at equal or higher levels than private standards.

costs for producers. Consumer utility and production costs are not affected differently by public and private standards, ceteris paribus, so differences in the level of public and private standards are not attributable to intrinsic differences between public and private standards. This is different from McCluskey and Winfree (2009) who assume that private standards are less costly to implement and may therefore be used to preempt public standards.

A key innovation of our model is that we explicitly account for the role of a third (private) party in private standard-setting. So far the literature has only considered two-agent models with 'producers' and 'consumers'. However in reality there are often more agents than 'final consumers' and 'primary producers', and the same model has been used to interpret various stages of the chain. Hence, traders, processors, or retailers could be either 'producers' or 'consumers' depending on the specific case being considered.

In our model we explicitly account for the role of a third private agent and we show that this may have important effects on private standard-setting. More specifically, we model a three-agent chain with producers, retailers, and consumers, where retailers transfer goods from producers to consumers. In reality many private standards are set by retailers or retailer groups – not by producers. Moreover, as our analysis will show, retailers' interests in setting private standards do not necessarily coincide with producers' interests. Retailers' optimal private standards may be suboptimal from the producers' perspective. Therefore we explicitly introduce a monopolist retailer that may set a private standard to regulate the same product characteristics as the government's public standard. The assumption that the retailer is a monopolist is a convenient approach to impose retailers' market power without introducing additional complexity to the model. We discuss later how this assumption – and thus retailers' market power – affects our results.[55]

The public standard is assumed to be determined in a political game where producers and the retailer have political power to influence the government's standard-setting process. We model this political economy game along the lines of the model in Chapter 3 which is based on the seminal model of Grossman and Helpman (1994). We assume there are no fixed costs of entering the political game. This assumption is different from Maxwell *et al*. (2000) who argue that private standards may preempt public regulation because the former reduce consumers' incentives to lobby for public standards in case political entry is costly.

Our analysis yields several findings. Most importantly, our analysis offers an explanation for the relative stringency of private standards vis-à-vis public standards. We show that a retailer may set its private standard at a higher level than the government's optimal public standard if the retailer is able to shift the burden of the private standard's implementation cost to producers. This outcome depends on the retailer's market power and producers' political influence. We show that also other factors such as the standard's efficiency gain, implementation cost, and rent transfer from the retailer to producers affect the relative stringency of private versus public standards. Additionally, we show that side payments from producers to the retailer may influence the outcome, i.e. the levels of private and public standards.

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[55] We denote the third party as the 'retailer', but this market player may be any intermediate between producers and consumers, e.g. a processing firm. For our analysis, the third party's relevant characteristics are that it acts as an intermediate between producers and consumers, and that it has some market power in exercising its function.

The chapter is structured as follows. Section 5.2 specifies the different market agents in our model, i.e. consumers, producers, and the monopolist retailer, and determines the market equilibrium for a given standard. Section 5.3 analyzes how a standard affects the different market players. In Section 5.4 we first determine the retailer's optimal private standard, and second we model the government's decision-making process on public standards which determines the government's optimal public standard. We then compare the levels of the retailer's optimal private standard and the government's optimal public standard to show under which conditions the private standard is set at a higher level than the public one, and which factors influence these conditions. Additionally, Section 5.4 analyzes to what extent retailers' market power is important to our results. Section 5.5 applies the model to the case of private standards that regulate developing countries' high-value export sectors. Finally, Section 5.6 extends the model by allowing for side payments by producers to influence the retailer's private standard-setting behavior, and analyzes how this affects our results. The last section concludes the chapter.

5.2. The Model

We first specify the different market players and the market equilibrium for a given standard, public or private. As in Chapter 3, we assume that consumers are ex ante uncertain about the characteristics of the product (see also Leland 1979). Standards may thus improve upon the unregulated market equilibrium by guaranteeing the presence or absence of respectively positive or negative experience or credence characteristics (Nelson 1970; Darby and Karni 1973) and by reducing asymmetric information between consumers and producers. Similar to most studies, we assume that the introduction of a standard involves implementation costs for producers (see e.g. Leland 1979; Ronnen 1991; Valletti 2000). We assume that private and public standards are intrinsically the same, i.e. that their impacts on consumer utility and production costs are not different, ceteris paribus, such that differences in levels of public and private standards are not attributable to intrinsic differences between public and private standards. A novel feature of our model is the inclusion of an intermediary agent – a retailer – that transfers products from producers to consumers. We limit our analysis to a closed-economy model to refrain from potential standards-as-barriers-to-trade issues.

5.2.1. Consumers

Consider a standard which guarantees certain quality/safety features of the product. Such a standard positively affects utility as it reduces or solves information asymmetries. Therefore a standard induces to consume more of the product through an increased willingness to pay, ceteris paribus. For example consumers who perceive health problems with certain (potential) ingredients or production processes may increase consumption if they are guaranteed the absence of these elements. To model this, we assume a representative consumer utility function $u(x,s)$ where x is consumption of the good, and s is the (public or private) standard. A higher s refers to a more stringent standard. Consumer utility is increasing and concave both in consumption $(u_x > 0; u_{xx} < 0)$ and the standard $(u_s > 0; u_{ss} < 0)$.[56] We further assume that $u_{xs} > 0$, i.e. that a standard has a

[56] In the remainder of the chapter, subscripts denote partial derivatives to x or s, and superscripts refer to consumers (C), producers (P), the retailer (R), social welfare (W), or the government (G).

larger marginal impact on consumer utility if consumption is larger. The representative consumer maximizes consumer surplus Π^C by choosing consumption x:

$$\Pi^C = \max_x \left[u\left(x,s\right) - px \right], \tag{5.1}$$

where p is the consumer price. The first order condition of this maximization problem is

$$\frac{\partial \Pi^C}{\partial x} = u_x - p = 0 . \tag{5.2}$$

Rewriting Equation (5.2) gives

$$p = u_x\left(x,s\right), \tag{5.3}$$

which implicitly defines the inverse demand function $p\left(x,s\right)$. The inverse demand function is downward sloping with $p_x = u_{xx} < 0$. For simplicity, u_{xxs} is assumed to be zero, i.e. the slope of the inverse demand function is not affected by the standard. Since $p_s = u_{xs} > 0$, a higher standard shifts the inverse demand function upwards. The reduced-form expression for consumer surplus is

$$\Pi^C\left(x,s\right) = u\left(x,s\right) - p\left(x,s\right)x . \tag{5.4}$$

5.2.2. Producers

We assume that production is a function of a sector-specific input factor that is available in inelastic supply. All profits made in the sector accrue to the specific factor owners, i.e. the producers. We assume that a standard imposes some production constraints or obligations which increase production costs. The idea behind this assumption is that all standards can be defined as the prohibition to use a cheaper technology. Examples are the prohibition of an existing technology (e.g. child labor) or of a technology that has not yet been used but that could potentially lower costs (e.g. GM technology). Also traceability standards can be interpreted as a prohibition of cheaper production systems which do not allow tracing the production.

To model this, consider a representative producer with cost function $c(x,s)$ that depends on output and the standard.[57] The cost function is assumed to be increasing and convex both in production $(c_x > 0; c_{xx} > 0)$ and the standard $(c_s > 0; c_{ss} > 0)$. We further assume that $c_{xs} > 0$, i.e. that a standard has a larger marginal impact on production costs for a larger output. Producers are price takers, maximizing their profits Π^P by setting output x:

$$\Pi^P = \max_x \left[wx - c(x,s) \right], \tag{5.5}$$

where w is the producer price. The first order condition of this maximization problem is

$$\frac{\partial \Pi^P}{\partial x} = w - c_x = 0. \tag{5.6}$$

Rewriting Equation (5.6) gives

$$w = c_x(x,s), \tag{5.7}$$

which implicitly defines the inverse supply function $w(x,s)$. The inverse supply function is upward sloping with $w_x = c_{xx} > 0$. For simplicity, c_{xxs} is assumed to be zero so that the slope of the inverse supply function is not affected by the standard. Since $w_s = c_{xs} > 0$, a higher standard shifts the inverse supply function upwards. The reduced-form expression for producer profits is

[57] Since in equilibrium consumption equals output, we use the same symbol x for both output and consumption.

$$\Pi^P\left(x,s\right)=w\left(x,s\right)x-c\left(x,s\right). \tag{5.8}$$

In the remainder of the analysis we assume that production costs are sufficiently convex and consumer utility sufficiently concave in s to ensure global maxima.

5.2.3. The Retailer

We assume that output is sold by producers to consumers through one intermediary agent – a monopolist retailer. This assumption is a convenient approach to model retailer market power without introducing additional complexity to the model. We discuss later how this assumption – and thus retailers' market power – affects our results. We will show that retailers' market power is one part of the explanation why some industry-wide private standards are more stringent than public standards.

The retailer's handling costs are normalized to zero. The monopolist retailer is a Stackelberg leader who sets consumer and producer prices such that, under optimal price-taking behavior of consumers and producers, consumption and output equal at a level that maximizes the retailer's profits, Π^R. This is formally equivalent to maximizing the retailer's profits with respect to quantity, x, using the inverse supply and demand functions (5.7) and (5.3) which represent the optimal price-taking behavior of consumers and producers and thus define producer and consumer prices for a given quantity. Formally, the retailer's profits are

$$\Pi^R=\max_x\left[\left(p\left(x,s\right)-w\left(x,s\right)\right)x\right], \tag{5.9}$$

where $p-w$ is the retailer's margin.

5.2.4. The Market Equilibrium

The first order condition of the retailer's profit maximization is

$$\frac{\partial \Pi^R}{\partial x} = p - w + x\left(p_x - w_x\right) = 0, \tag{5.10}$$

and hence the equilibrium quantity $x^*(s)$, for a given level of the standard s, is

$$x^*(s) = \frac{u_x - c_x}{c_{xx} - u_{xx}}. \tag{5.11}$$

Equation (5.11) is not a closed-form solution since both u_x and c_x depend on x. The denominator is always positive because the cost function is convex and the utility function concave in x. The numerator is positive if $u_x > c_x$, or according to Equations (5.3) and (5.7), if $p > w$. This condition – which we assume to hold throughout the chapter – assures a positive retailer margin and profits. The reduced-form expressions for consumer surplus, producer profits, and retailer profits at market equilibrium are respectively

$$\Pi^C(s) = u\left(x^*(s), s\right) - p\left(x^*(s), s\right)x^*(s); \tag{5.12}$$

$$\Pi^P(s) = w\left(x^*(s), s\right)x^*(s) - c\left(x^*(s), s\right); \tag{5.13}$$

$$\Pi^R(s) = \left[p\left(x^*(s), s\right) - w\left(x^*(s), s\right)\right]x^*(s). \tag{5.14}$$

5.3. The Impact of a Standard

Before determining the optimal public and private standards and how they compare, it is instructive to analyze the effect of a marginal change in the standard (whether public or private) on the market equilibrium, the interests of the different market players, and social welfare. The impact of a marginal change in the standard on the equilibrium quantity, $x^*(s)$, is

$$x_s^* = \frac{1}{2}\frac{u_{xs} - c_{xs}}{c_{xx} - u_{xx}}. \tag{5.15}$$

Equation (5.15) shows that the standard's marginal impact on the equilibrium quantity may be positive or negative. The equilibrium quantity increases with a more stringent standard if the upward shift in the inverse demand function, u_{xs}, is larger than the upward shift in the inverse supply function, c_{xs}; and vice versa.[58] In other words, a higher standard induces the retailer to transfer a larger quantity $(x_s^* > 0)$ if the standard's impact on the retailer's margin is positive $(p_s - w_s = u_{xs} - c_{xs} > 0)$. As Equations (5.10) and (5.11) show, a higher retailer margin allows the retailer to maximize its profits by setting a larger equilibrium quantity x^*.

Next, we derive the standard's marginal impact on the different market players' interests using the envelope theorem. The marginal change in consumer surplus, $\Pi^C(s)$, is

$$\frac{\partial \Pi^C(s)}{\partial s} = u_s - x^*(s)\left(u_{xs} + u_{xx}x_s^*\right). \tag{5.16}$$

It consists of the *efficiency gain*, u_s, i.e. the positive marginal utility impact because of reduced information asymmetries, minus the marginal change in consumption expenditures, $x^*(s)\left(u_{xs} + u_{xx}x_s^*\right)$. The marginal change in consumption expenditures per unit purchased is a consequence of both the higher willingness to pay for a product with a

[58] Since production costs are convex and consumer utility is concave in x, the denominator of Equation (5.15) is always positive.

higher standard $\left(u_{xs}>0\right)$ and the change in willingness to pay because of a marginal change in consumption x_s^*. The size of the latter change in willingness to pay is determined by the slope of the inverse demand function, u_{xx}. Because the marginal change in consumption may be either positive or negative, consumption expenditures may increase or decrease with the standard. Hence the standard's marginal impact on consumer surplus is ambiguous. If the efficiency gain is larger than the marginal change in consumption expenditures, consumer surplus increases with the standard; and vice versa.

The marginal change in producer profits, $\Pi^P\left(s\right)$, is

$$\frac{\partial\Pi^P\left(s\right)}{\partial s}=x^*\left(s\right)\left(c_{xs}+c_{xx}x_s^*\right)-c_s, \tag{5.17}$$

where the first term, $x^*\left(s\right)\left(c_{xs}+c_{xx}x_s^*\right)$, is the marginal change in producer revenues and the second term, c_s, is the *implementation cost*, i.e. the marginal cost increase due to the prohibition of using a cheaper technology. The marginal change in producer revenues per unit sold is a consequence of the higher marginal production costs due to a higher standard $\left(c_{xs}>0\right)$ and the change in marginal production costs because of a marginal change in output x_s^*. The size of the latter change in marginal production costs is determined by the slope of the inverse supply function, c_{xx}. Because the marginal change in output may be positive or negative, producer revenues may increase or decrease with the standard. Hence, the marginal impact of a standard on producer profits is also ambiguous. When the implementation cost is smaller than the marginal change in producer revenues, producer profits increase with the standard; and vice versa.

The marginal change in the retailer's profits, $\Pi^R(s)$, is

$$\frac{\partial \Pi^R(s)}{\partial s} = x^*(s)(u_{xs} - c_{xs}). \tag{5.18}$$

The factor $u_{xs} - c_{xs}$ is the marginal change in the retailer's margin and may be positive or negative, depending on the relative shifts of the inverse demand and supply functions. Hence the standard's marginal impact on the retailer's profits may be positive or negative. More specifically, the term $x^*(s)u_{xs}$ represents the marginal increase in the retailer's revenues because of the upward shift of the inverse demand function. The intuition is that, as consumers' willingness to pay is higher for a product with a more stringent standard, a higher standard allows the retailer to set a higher consumer price for a given level of consumption x^*. The higher consumer price results in higher revenues for the retailer but also in higher consumption expenditures for consumers (see Equation (5.16)). We therefore define $x^*(s)u_{xs}$ as the *rent transfer* from consumers to the retailer due to a higher standard. Similarly, the term $x^*(s)c_{xs}$ is the marginal increase in the retailer's expenditures due to the upward shift in the inverse supply function. With a higher standard, the retailer pays a higher producer price for a given level of output x^* to compensate producers for their higher marginal production costs. The higher producer price results in higher expenditures for the retailer and in higher producer revenues (see Equation (5.17)). Hence, we define $x^*(s)c_{xs}$ as the *rent transfer* from the retailer to producers because of a stricter standard. Equation (5.18) thus shows that the retailer's profits increase with a higher standard if the rent transfer from consumers is larger than the rent transfer to producers; and vice versa.

The second factor in Equation (5.18) is the same as the numerator of Equation (5.15) which implies that x_s^* has the same sign as $\frac{\partial \Pi^R(s)}{\partial s}$. This is in line with the discussion following Equation (5.15): an increase in the standard induces the retailer to transfer a larger quantity if the higher standard results in a higher retailer margin, or equivalently if the rent transfer from consumers is larger than the rent transfer to producers. Hence the equilibrium quantity only increases (decreases) if the retailer's margin and profits increase (decrease) in the standard.

We can now also analyze the standard's marginal impact on social welfare, $W(s)$, which is defined as the sum of consumer surplus, producer profits, and retailer profits:

$$W(s) = \sum_j \Pi^j(s), \text{ with } j = C, P, R. \tag{5.19}$$

The marginal change in social welfare is

$$\frac{\partial W(s)}{\partial s} = u_s - c_s + x^*(s) x_s^* (c_{xx} - u_{xx}), \tag{5.20}$$

and equals the direct welfare effects, i.e. the efficiency gain u_s minus the implementation cost c_s, plus an additional welfare gain (loss) if the equilibrium quantity increases (decreases). Therefore social welfare may increase or decrease with a higher standard, depending on the relative size of these factors. It is instructive to rewrite the third term in Equation (5.20):

$$\frac{\partial W(s)}{\partial s} = u_s - c_s + \frac{x^*(s)}{2}(u_{xs} - c_{xs}). \tag{5.21}$$

This shows that the third term is only positive if the standard's marginal impact on the retailer's profits is positive (see Equation (5.18)), i.e. if the rent transfer from consumers is larger than the rent transfer to producers.

In summary, it follows that all market players may gain or lose from a change in the standard, and that this change involves rent transfers between the different market players. Likewise, social welfare may either increase or decrease with a change in the standard, depending on the relative size of the efficiency gain, the implementation cost, and the different rent transfers.

5.4. Optimal Public and Private Standards

We analyze the optimal standard-setting behavior of both the retailer and the government. In line with the literature on minimum quality standards, we assume that the government moves first in setting its public standard (see e.g. Leland 1979; Ronnen 1991; Boom 1995; Valletti 2000). We solve the game by backward induction and therefore determine first the retailer's optimal private standard for a given level of the public standard. Second, we determine the government's optimal public standard and third, we compare the level of the retailer's optimal private standard, s^R, to the level of the government's optimal public standard, s^G. Finally, we analyze to what extent retailers' market power is important to our results.

5.4.1. The Retailer's Optimal Private Standard

Being the only intermediary agent between producers and consumers, the retailer is able to unilaterally impose a private standard.[59] The retailer maximizes its profits by imposing a private standard, given the market equilibrium in Equation (5.11) that takes into account the retailer's own optimal price-setting behavior and the consumers' and producers' optimal price-taking behavior. Formally, the retailer's optimal private standard, s^R, is determined by the following first order condition, subject to $s^R \geq s^G$:[60]

$$x^*\left(s^R\right)\left(u_{xs} - c_{xs}\right) = 0 . \tag{5.22}$$

Equation (5.22) shows that $u_{xs}x^*\left(s^R\right) = c_{xs}x^*\left(s^R\right)$ at s^R. Referring to the discussion following Equation (5.18), Equation (5.22) implies that the rent transfer from consumers to the retailer equals the rent transfer from the retailer to producers at s^R. This is intuitive: the retailer sets its private standard at the level where marginal revenues from increasing the private standard equal marginal expenditures. Additionally, abstracting from the trivial case where $x^*\left(s^R\right) = 0$, Equation (5.22) implies that $u_{xs} = c_{xs}$ at s^R, i.e. that the retailer sets its optimal private standard such that the shift in the inverse demand function is equal to the shift in the inverse supply function. From Equation (5.15), it also follows that $x_s^* = 0$ at s^R.

[59] In the categorization of Henson and Humphrey (2008), such a private standard is labeled as a 'de facto public standard' although it is issued by a private organization, i.e. the retailer. These assumptions are consistent with private standards set by retail consortiums such as the BRC, GLOBAL.G.A.P., and GFSI.

[60] This condition reflects that the standard which effectively regulates the market is $s = \max\left\{s^G; s^R\right\}$. Since the retailer moves second, he has no incentive to set a private standard that is lower than the public one, s^G, even if the retailer's optimal private standard is lower than the public standard. Hence, either the retailer sets its private standard at a higher level than or equal to the government's public standard (which is assumed to be given at this stage), or the retailer refrains from setting a private standard.

Before turning to the government's optimal public standard, we first discuss the marginal change in consumer surplus, producer profits, and social welfare at the retailer's optimal private standard. This will already reveal some of the factors that play a role in the comparison between the levels of the public and private standard. At s^R, the standard's marginal impact on consumer surplus is

$$\left.\frac{\partial \Pi^C(s)}{\partial s}\right|_{s=s^R} = u_s - x^*\left(s^R\right)u_{xs}, \qquad (5.23)$$

which equals the standard's efficiency gain minus the rent transfer to the retailer, and may be positive or negative. Consumer surplus increases at the retailer's optimal private standard if the efficiency gain is larger than the consumers' rent transfer to the retailer. Similarly, the standard's marginal impact on producer profits at s^R is

$$\left.\frac{\partial \Pi^P(s)}{\partial s}\right|_{s=s^R} = x^*\left(s^R\right)c_{xs} - c_s, \qquad (5.24)$$

which equals the rent transfer from the retailer to the producers minus the implementation cost. The sign of Equation (5.24) is also undetermined: producers' profits decrease at the retailer's optimal private standard if the implementation cost is larger than the retailer's rent transfer to producers; and vice versa.

These marginal effects demonstrate that only under very specific circumstances – depending on the efficiency gain, implementation cost, and the different rent transfers – the interests of consumers and producers coincide with the retailer's interest. This only happens when Equations (5.23) and (5.24) simultaneously equal zero at s^R. In any other case, the interests of the various market players differ.

From Equation (5.21) it follows that at s^R the standard's marginal impact on social welfare is

$$\left.\frac{\partial W(s)}{\partial s}\right|_{s=s^R} = u_s - c_s \,, \tag{5.25}$$

which may be positive or negative depending on the relative size of the efficiency gain and the implementation cost. Hence, the retailer's optimal private standard, s^R, equals the socially optimal standard, s^W, if and only if the efficiency gain equals the implementation cost $(u_s = c_s)$ at s^R. In any other case the optimal private standard is either higher (if $u_s < c_s$ at s^R) or lower (if $u_s > c_s$ at s^R) than the socially optimal standard. The cause for the potential welfare sub-optimality of the retailer's optimal private standard is that the retailer does not incorporate the direct utility and cost effects into its profit maximizing behavior – the retailer only cares about maximizing the net rent transfer whereas the welfare calculus does take the net direct effects into account.

Importantly, Equations (5.23) and (5.24) show that even if the private standard would be socially optimal ($u_s = c_s$ at s^R), the private standard would involve rent transfers and consumers and producers could gain or lose.

5.4.2. The Government's Optimal Public Standard

We now analyze the public standard-setting behavior of a government that is interested in both interest group contributions and social welfare. For this purpose we build on the political economy model of public standards as developed in Chapter 3.

Consider a government that maximizes its own objective function which, following the approach of Grossman and Helpman (1994), consists of a weighted sum of contributions from interest groups and social welfare. Similar to Grossman and Helpman (1994), we restrict the set of policies available to politicians and only allow them to implement a public standard s. We assume that producers and the retailer are politically organized into separate interest groups that lobby simultaneously and that consumers are not organized.[61]

The 'truthful' contribution schedules of the producers and retailer are of the form $C^k(s) = \max\{0, \Pi^k(s) - b^k \mid s \geq s^R\}$ with $k = P, R$.[62] b^k is a constant, a minimum level of profits the interest groups do not wish to spend on lobbying. The government's objective function, $\Pi^G(s)$, is a weighted sum of the interest group contributions, weighted by α^k, and social welfare, where α^k represents the relative lobbying strength of the interest groups:

$$\Pi^G(s) = \sum_k \alpha^k C^k(s) + W(s). \tag{5.26}$$

The government chooses the level of the public standard to maximize its objective function in (5.26). Each possible level of the public standard corresponds to a certain level of producer and retailer profits, and hence also to a certain level of producer and

[61] Our assumption that consumers do not lobby is not essential to our results. Consumer interests still play a role but through the social welfare function in the government's objective function.

[62] The common-agency literature (e.g. Bernheim and Whinston 1986) states that a truthful contribution schedule reflects the true preferences of the interest group. In our model this implies that lobby groups set their lobbying contributions in accordance with their expected profits and how these are marginally affected by the public standard. We refer to Appendix A.1 of Chapter 3 for a proof of the truthfulness of these contribution schedules. The contribution schedules are conditional on $s \geq s^R$ to reflect that the standard which effectively regulates the market is $s = \max\{s^G; s^R\}$. Contributions in favor of a public standard lower than the optimal private standard have no effect on the standard that regulates the market (s^R), and thus have no impact on the interest groups' profits. Hence contributions in the interval $s < s^R$ would not be truthful and therefore the contribution schedule is restricted to $s \geq s^R$. However, because the government moves first in setting its public standard, this restriction of the contribution schedules does not imply that the government is not able to set a public standard in the interval $s < s^R$.

retailer contributions. This is driven by the functional form and the truthfulness of the contribution schedules which imply that the government receives higher contributions from the producers' (retailer's) interest group if the public standard creates higher producer (retailer) profits. Conversely, the government receives less producer or retailer contributions if the public standard decreases their respective profits. Therefore maximizing the contributions from the producers' (retailer's) interest group by choosing the level of the public standard is equivalent to maximizing their respective profits, i.e. $\frac{\partial C^k(s)}{\partial s} = \frac{\partial \Pi^k(s)}{\partial s}$ for $s \geq s^R$. The government thus chooses the level of the public standard to maximize the weighted sum of producer profits, retailer profits, and social welfare.[63] The government's optimal public standard, s^G, is therefore determined by the following first order condition, subject to $s^G \geq s^R$:

$$\begin{aligned} &\alpha^P \left[x^*\left(s^G\right)\left(c_{xx}x_s^* + c_{xs}\right) - c_s \right] + \alpha^R \left[x^*\left(s^G\right)\left(u_{xs} - c_{xs}\right) \right] \\ &\qquad + \left[u_s - c_s + \frac{x^*\left(s^G\right)}{2}\left(u_{xs} - c_{xs}\right) \right] = 0. \end{aligned} \tag{5.27}$$

First order condition (5.27) implicitly defines s^G as a function of the lobbying strengths of the different interest groups $\left(\alpha^k\right)$, the efficiency gain $\left(u_s\right)$, the implementation cost $\left(c_s\right)$, the rent transfers $\left(x^*\left(s^G\right)u_{xs}\right.$ and $\left.x^*\left(s^G\right)c_{xs}\right)$, and the marginal change in producer revenues $\left(x^*\left(s^G\right)\left(c_{xx}x_s^* + c_{xs}\right)\right)$, all evaluated at s^G.

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[63] Because the retailer is a monopolist, strong interactions between the government and the monopolist may exist. In the extreme case that the retail sector is a 'state monopoly' and that the government is only concerned with the state monopoly's profits (i.e. the monopolist retailer's profits), the public standard would be set at the retailer's optimal private standard and the government's optimal public standard would coincide with the retailer's optimal private standard. Our assumption that the monopolist has some positive political power α^R – which could be large – is less extreme.

5.4.3. A Comparison of the Retailer's Optimal Private Standard to the Government's Optimal Public Standard

We now compare the government's optimal public standard, s^G, to the retailer's optimal private standard, s^R, and analyze which factors determine their relative levels. Since production costs are sufficiently convex and consumer utility sufficiently concave in s to ensure that both Π^G and Π^R are concave in s, it suffices to determine the sign of the standard's marginal impact on the government's objective function at s^R, $\left.\frac{\partial \Pi^G(s)}{\partial s}\right|_{s=s^R}$.

Because of concavity, if $\left.\frac{\partial \Pi^G(s)}{\partial s}\right|_{s=s^R} > 0$ then $s^R < s^G$, and vice versa. Inserting into Equation (5.27) the results of Equation (5.22) that $u_{xs} = c_{xs}$ and $x_s^* = 0$ at s^R, the expression for the standard's marginal impact on the government's objective function at s^R is

$$\left.\frac{\partial \Pi^G(s)}{\partial s}\right|_{s=s^R} = \underbrace{u_s - c_s}_{(1)} + \alpha^P \left[\underbrace{x^*\left(s^R\right) c_{xs} - c_s}_{(2)} \right], \tag{5.28}$$

which may be positive or negative. Part (1) of Equation (5.28) equals the marginal social welfare effect of the standard at s^R (see Equation (5.25)), and may be positive or negative depending on whether the efficiency gain, u_s, is respectively larger or smaller than the implementation cost, c_s. Part (2) represents the standard's marginal impact on producer profits at s^R (see Equation (5.24)). It consists of the rent transfer from the retailer to producers, $x^*\left(s^R\right)c_{xs}$, minus the standard's implementation cost, c_s, and is weighted by the political power of the producers' interest group, α^P. Part (2) may be positive or negative as well. Hence, a priori, it is not determined which of the two standards is more stringent. The retailer's optimal private standard may thus be higher or lower than the government's optimal public standard. We are particularly interested in the case where Equation (5.28) is negative, i.e. when the retailer's optimal private standard is more stringent than government's optimal public standard $\left(s^R > s^G\right)$, and which factors affect this.[64]

The key factors that lead to private standards being more stringent than public standards, i.e. $s^R > s^G$, are summarized by Equation (5.28). First, the rent transfer from the retailer to producers, $x^*\left(s^R\right)c_{xs}$, plays an important role. If either c_{xs} or $x^*\left(s^R\right)$ is smaller, the standard's marginal impact on producer profits at s^R (part (2) of Equation (5.28)) is more negative or less positive such that Equation (5.28) is more likely to be negative, and $s^R > s^G$. The upward shift in the inverse supply function, c_{xs}, measures how much the retailer additionally compensates the producers for an increase in the standard and a given level of the equilibrium output. A lower c_{xs} thus means that the rent transfer from the retailer to producers is lower, ceteris paribus, and that producers bear a larger share of the implementation cost. The rent transfer is also smaller relative to the implementation cost when the market is smaller ($x^*\left(s^R\right)$ lower). Hence, if either c_{xs} or $x^*\left(s^R\right)$ is smaller such that the retailer's rent transfer to producers is smaller, the

[64] Naturally, these same factors – in opposite direction – lead to the reverse situation where the retailer's optimal private standard is less stringent, i.e. $s^R < s^G$. However, this situation is not relevant since a private standard is redundant if less stringent than the public standard. Because the retailer moves second in setting its private standard, the retailer has no incentive to set a private standard that is lower than the public one. Hence, either the retailer sets its private standard at a higher level than the government's optimal public standard, or the retailer refrains from setting a private standard. As a consequence, it are the same factors as the ones we discuss (but in opposite direction) that explain the absence of private standards in specific markets.

producers' interest group lobbies in favor of a lower public standard and Equation (5.28) is more likely to be negative, i.e. $s^R > s^G$.

Second, when producer profits are marginally decreasing in the standard at s^R, i.e. when part (2) in Equation (5.28) is negative, a larger political power of the producers' interest group, α^P, increases the likelihood that Equation (5.28) is negative and $s^R > s^G$. When the producers' preferred level of the standard is lower than the retailer's optimal private standard, producers lobby in favor of a public standard that is lower than the retailer's optimal private standard. With a larger political power producers lobby more successfully, ceteris paribus, so that they are able to reduce the level of the government's optimal public standard.

Third, the size of the efficiency gain matters. If u_s is smaller, the marginal social welfare effect at s^R (part (1) of Equation (5.28)) is less positive or more negative. Hence, with a lower efficiency gain, Equation (5.28) is more likely to be negative such that $s^R > s^G$, ceteris paribus. A lower efficiency gain induces the government to set a lower public standard because of social welfare considerations, while the retailer does not take social welfare effects into account.

Fourth, the size of the implementation cost, c_s, affects both social welfare and producer profits. Equation (5.28) is more likely to be negative with a higher implementation cost, such that $s^R > s^G$. The intuition behind this result is that a higher implementation cost causes the government to set a lower public standard, not only because of social welfare considerations but also because the producers' interest group lobbies in favor of a lower public standard. In contrast, the retailer is not concerned with social welfare effects, so that the retailer's optimal private standard is not affected by a change in the implementation cost. Due to producer lobbying, a change in the implementation cost has a larger impact on Equation (5.28) than a similar change in the efficiency gain (but in opposite direction), ceteris paribus.

To summarize, the retailer's optimal private standard is more likely to be higher than the government's optimal public one for markets and standards where (a) the retailer's rent transfer to compensate producers for the standards' implementation cost is smaller ($x^*\left(s^R\right)c_{xs}$ small); (b) the producers' interest group has a relatively large political power (α^P high) given that producers prefer lower standards than the retailer ($c_s > x^*\left(s^R\right)c_{xs}$ at s^R); (c) standards generate a small efficiency gain (u_s small); and (d) standards entail a large implementation cost (c_s high). Under these conditions, it is more likely that the retailer sets its optimal private standard at a higher level than the government's optimal public standard. Hence these factors may explain the observation that in some sectors, private standards are more stringent than public ones.

5.4.4. Retailers' Market Power

In this section, we analyze to what extent retailers' market power is important to our results. So far, for the sake of reducing complexity, we have modeled retailers' market power by assuming that only one firm is active in the retail sector. To analyze how the results change when retailers have no market power we now consider a retail sector that is characterized by perfect competition.

The assumption of perfect competition among retailers has consequences for both the government's and retailers' optimal standard-setting behavior. First, in a perfectly competitive retail sector, each retailer i is identical and faces the same consumer and producer prices, respectively $p(x,s)$ and $w(x,s)$, where x is the sum of all quantities transferred by retailers, i.e. $x = \sum_i x_i$. An individual retailer i's profits are thus equal to $\Pi_i^R(s) = \left[p(x,s) - w(x,s)\right]x_i$. However, a retailer's average revenues $p\left(x^*,s\right)$ must equal average costs $w\left(x^*,s\right)$ in a stable and perfectly competitive market equilibrium, because of free entry and exit. As a consequence, retailers' profits are zero at market equilibrium for any potential level of the standard s. It then follows from the truthful contributions schedules specified above that under perfect competition the retailers' interest group never offers strictly positive contributions to the government. Therefore perfectly competitive retailers have no influence on the government's public standard-setting and the government's first order condition which determines s^G reduces to:

$$\left(1+\alpha^P\right)\left[x^*\left(s^G\right)\left(c_{xs}+c_{xx}x_s^*\right)-c_s\right]+u_s-x^*\left(s^G\right)\left(u_{xs}+u_{xx}x_s^*\right)=0. \qquad (5.29)$$

Second, retailers face additional constraints when setting private standards in a perfectly competitive retail sector. Retailers can only set individual private standards, i.e. there is no collusion in private standard-setting possible because this would be inconsistent with the perfect competition assumption that retailers have no market power. Moreover, perfect retail competition prevents a retailer from introducing an individual private standard with which producers are not willing to comply, i.e. a standard that reduces producers' profits, because then producers would only sell to other retailers that set a lower or no individual private standard. In other words, a retailer can only set an individual private standard, s_i^R, that has a positive marginal impact on producers' profits. Formally, the producers' incentive compatibility constraint is

$$\left.\frac{\partial \Pi^P}{\partial s}\right|_{s=s_i^R} = x^*\left(s_i^R\right)\left(c_{xs} + c_{xx}x_s^*\right) - c_s \geq 0 . \tag{5.30}$$

The same reasoning can be applied to consumers. Consumers are only willing to buy from a retailer that imposes an individual private standard if that private standard has a positive marginal impact on consumer surplus – otherwise consumers would only make purchases with other retailers who impose a lower or no individual private standard. The consumers' compatibility constraint is thus

$$\left.\frac{\partial \Pi^C}{\partial s}\right|_{s=s_i^R} = u_s - x^*\left(s_i^R\right)\left(u_{xs} + u_{xx}x_s^*\right) \geq 0 . \tag{5.31}$$

Inserting the producers' and consumers' incentive compatibility constraints (respectively Equations (5.30) and (5.31)) into the government's first order condition (5.29) implies that $\left.\partial \Pi^G \middle/ \partial s\right|_{s=s_i^R} \geq 0$. Because of concavity, it unambiguously follows that $s^G \geq s_i^R$. This result implies that perfectly competitive retailers have no incentives to impose individual private standards that are higher than the government's optimal public standard, and that retailers will therefore refrain from imposing private standards.[65]

This analysis shows that retailers' market power is a necessary condition for retailers' optimal private standards to be more stringent than the government's optimal public standard. Market power allows retailers to unilaterally impose private standards that violate producers' and/or consumers' incentive compatibility constraints, and that are potentially higher than the government's optimal public standard. We continue the

[65] This result would be different in an oligopolistic retail sector where several retailers have some market power. This situation has been extensively analyzed in the literature on vertical differentiation and minimum quality standards, for example by Spence (1976), Ronnen (1991), and Valletti (1995), and their results would carry over to our analysis. In an oligopolistic retail sector, retailers would be able to set different individual private standards – with some higher than the public standard – as strategic tools to create market segmentation and softening competition.

remainder of this chapter under the assumption of a monopolist retailer, i.e. that retailers have market power.

5.5. Application: Developing Countries' High Value Crop Exports

We use the example of developing countries' high value crop exports to developed countries to illustrate how the model's results and implications may carry over to real-world situations. Private standards are increasingly important in these export sectors. For example, Maertens and Swinnen (2009) document that the fresh and processed fruits and vegetables (FFV) sector is one of the most dynamic export sectors in developing countries and that FFV exports are increasingly confronted with tightening food standards set by large retailing companies. Maertens and Swinnen (2009) also argue that these private standards are frequently more stringent than their public counterparts.

In such high value crop export sectors as the FFV sector, consumers and the multinational retailer are typically located in the importing, developed country, and producers in the exporting, developing country. This has implications for the governments' objective functions in both countries. In the developed country, the government maximizes the sum of contributions from the retailer's interest group and social welfare, which comprises consumer surplus and the retailer's profits. In the developing country, the government maximizes the sum of contributions from the producers' interest group and social welfare, which only consists of producer profits.[66] The standard's marginal impact on the governments' objective functions at s^R, for respectively the developed (DC) and less-developed (LDC) country, is

[66] We thus assume that an interest group can only contribute to its own government, and that a government is only concerned with domestic welfare.

$$\left.\frac{\partial \Pi_{DC}^{G}\left(s\right)}{\partial s}\right|_{s=s^{R}} = u_{s} - x^{*}\left(s^{R}\right)u_{xs}\,; \tag{5.32}$$

and

$$\left.\frac{\partial \Pi_{LDC}^{G}\left(s\right)}{\partial s}\right|_{s=s^{R}} = \left(1+\alpha^{P}\right)\left[x^{*}\left(s^{R}\right)c_{xs} - c_{s}\right]. \tag{5.33}$$

If both Equations (5.32) and (5.33) are negative, the retailer's private standard is more stringent than both the developed and developing countries' public standards. From Equation (5.22) it follows that at the retailer's optimum $x^{*}\left(s^{R}\right)c_{xs} = x^{*}\left(s^{R}\right)u_{xs}$. Hence a necessary and sufficient condition for both Equations (5.32) and (5.33) to be simultaneously negative is that

$$u_{s} < x^{*}\left(s^{R}\right)c_{xs} < c_{s}\,. \tag{5.34}$$

Equation (5.34) demonstrates that the retailer's optimal private standard will be more stringent than the governments' optimal public standards in both the developed and developing countries if the efficiency gain (for the developed country's consumers) is smaller than the consumers' rent transfer to the retailer, and the implementation cost (for the developing country's producers) is larger than the retailer's rent transfer to producers.

Typically the implementation cost is relatively large in developing countries (c_{s} high), due to low human capital, imperfect capital markets, underdeveloped institutions, etc. Additionally, process standards such as for example traceability standards imposed by the GLOBALG.A.P. have a relatively low direct impact on consumers, i.e. u_{s} is low. If both factors are such that Equation (5.34) holds, the private standard set by the retailer will be more stringent than the public standards set by the developed and developing countries' governments. In combination, these factors may contribute to explaining why retailers' private standards are more stringent than public standards on developing countries' high value crop exports.

5.6. Extension: Side Payments

So far we have assumed that producers cannot directly influence the retailer's private standard-setting behavior. However, if producers are able to form into an interest group that influences the government's public standard-setting process, it is possible that they are also able to directly influence the retailer's private standard-setting behavior. In general, as Equation (5.24) shows, the producers' interests do not coincide with the retailer's interests. Therefore, producers may make side payments to convince the retailer of setting a private standard that is more aligned with the producers' interests.[67] This section analyzes how side payments from producers to the retailer may affect the results of our model, i.e. how the level of the retailer's optimal private standard compares to the level of the government's optimal public standard when side payments are possible.

To analyze the impact of these side payments, we need to make some additional assumptions. We assume that, after the public standard has been set by the government, the producers' interest group offers the retailer a truthful side payment schedule that specifies how much producers are willing to pay the retailer for each potential level of the private standard. The producers' truthful side payment schedule is of the form $S(s) = \max\left\{0, \Pi^P(s) - \Pi^P\left(\max\left\{s^G, s^R\right\}\right) \mid s \geq s^G\right\}$. The schedule implies that producers are willing to make side payments equal to at most the difference between their profits under a private standard s and their profits under the standard that regulates the market

[67] This is of course conditional on the retailer's optimal private standard being more stringent than the public one.

in the absence of side payments, i.e. $\max\left\{s^G, s^R\right\}$, where s^R and s^G are defined by respectively Equations (5.22) and (5.27). The side payments are restricted to the interval $s \geq s^G$ because, given that the market is regulated by the most stringent standard, side payments for a private standard that is lower than the public standard $\left(s < s^G\right)$ would have no impact on producers' profits, and would not be truthful.

Taking into account the producers' potential side payments, the retailer now maximizes $\Pi^R\left(s\right) + S\left(s\right)$ when setting its private standard. The retailer's optimal private standard with side payments, s^{RP}, is then determined by the following first order condition, subject to $s^{RP} \geq s^G$:[68]

$$x^*\left(s^{RP}\right)\left(u_{xs} + c_{xx}x_s^*\right) - c_s = 0. \tag{5.35}$$

Equation (5.35) is equivalent to setting the sum of the standard's marginal impact on the retailer's and producers' profits (respectively Equations (5.17) and (5.18)) equal to zero at s^{RP}. Hence, when setting a private standard with potential side payments, the retailer also takes the standard's marginal impact on producer profits into account. By making side payments to the retailer, producers obtain that the retailer internalizes the effect of a private standard on producer profits in its private standard-setting behavior. This implies that, when producer profits are marginally decreasing (increasing) in the standard at s^R, the optimal private standard with side payments s^{RP} is lower (higher) than s^R, given that s^{RP} is larger than s^G. In other words, the side payments induce the retailer to set a private standard that is more aligned with producers' interests.

[68] The standard that effectively regulates the market is now $s = \max\left\{s^G; s^{RP}\right\}$, and again the retailer has no incentive to set a private standard that is lower than the public one.

As a consequence, these side payments may also have an impact on how the levels of the government's optimal public standard and the retailer's private standard compare to one another. Before we compare these levels, we first determine the government's optimal public standard, s^G, in the presence of side payments. To account for the potential side payments, the truthful contribution schedules of the producers and the retailer are adjusted to respectively $C^P(s) = \max\left\{0, \Pi^P(s) - S\left(s^{RP}\right) - b^P \mid s \geq s^{RP}\right\}$ and $C^R(s) = \max\left\{0, \Pi^R(s) + S\left(s^{RP}\right) - b^R \mid s \geq s^{RP}\right\}$. The government's optimal public standard, s^G, is then determined by the following first order condition, subject to $s^G \geq s^{RP}$:

$$\begin{aligned}\alpha^P\left[x^*\left(s^G\right)\left(c_{xx}x_s^* + c_{xs}\right) - c_s\right] + \alpha^R\left[x^*\left(s^G\right)\left(u_{xs} - c_{xs}\right)\right] \\ + \left[u_s - c_s + \frac{x^*\left(s^G\right)}{2}\left(u_{xs} - c_{xs}\right)\right] = 0.\end{aligned} \tag{5.36}$$

Because the interest group's contribution schedules are truthful, i.e. because the interest groups set their lobbying contributions in accordance with how their expected profits are *marginally* affected by the public standard, the side payments have no impact on the government's optimal public standard and the first order condition in (5.36) is the same as without side payments in (5.27).

As in Section 5.4.3, to determine whether the retailer's optimal private standard with side payments is stricter than the government's optimal public standard, we need to determine the sign of the standard's marginal impact on the government's objective function at s^{RP}, i.e. $\left.\frac{\partial \Pi^G(s)}{\partial s}\right|_{s=s^{RP}}$. If $\left.\frac{\partial \Pi^G(s)}{\partial s}\right|_{s=s^{RP}} < 0$ then $s^{RP} > s^G$, and vice versa.

Using Conditions (5.35) and (5.36), the expression for the standard's marginal impact on the government's objective function at s^{RP} is

$$\left.\frac{\partial \Pi^{G}(s)}{\partial s}\right|_{s=s^{RP}} = \underbrace{u_s - c_s + \frac{x^*\left(s^{RP}\right)}{2}\left(u_{xs} - c_{xs}\right)}_{(1)} + \left(\alpha^P - \alpha^R\right)\left[\underbrace{x^*\left(s^{RP}\right)\left(c_{xx}x_s^* + c_{xs}\right) - c_s}_{(2)}\right], \tag{5.37}$$

which may be positive or negative. Part (1) of Equation (5.37) is the standard's marginal impact on social welfare at s^{RP}, and can be positive or negative (see Equation (5.21)). Part (2) of Equation (5.37) represents the standard's marginal impact on producer profits at s^{RP} which may also be positive or negative (see Equation (5.17)). The retailer's optimal private standard with side payments, s^{RP}, may thus be higher or lower than the government's optimal public standard, s^G.

To examine whether the retailer's optimal private standard compares differently to the government's optimal public standard with and without side payments, we need to compare Equations (5.28) and (5.37). If Equation (5.37) is more negative than Equation (5.28), then, because of concavity, the retailer's optimal private standard with side payments will be further away from the government's optimal public standard than the retailer's optimal private standard without side payments, i.e. $s^G < s^R < s^{RP}$; and vice versa. Comparing these equations is not straightforward since they are evaluated at different levels of the standard. However, in general Equation (5.37) will be less negative than Equation (5.28) (or even positive) if producer profits are marginally decreasing at s^R; and vice versa. To understand why this is the case, take the example where producer profits are marginally decreasing at s^R, and assume for simplicity that $u_s = c_s$ for any value of s. Then Equation (5.28) is negative and $s^R > s^G$. If producer profits are marginally decreasing at s^R, it also follows that $s^{RP} < s^R$ because of the producers' side payments to the retailer. Since s^{RP} is necessarily closer to the producers' preferred level of the standard than s^R, it follows from the concavity of the producers' profit function that the marginal decrease in producer profits is less negative at s^{RP} than at s^R. Hence part (2) of Equation (5.37) is less negative than part (2) of Equation (5.28). Moreover, the weight attached to part (2) is lower in Equation (5.37) than in Equation (5.28), i.e. $\alpha^P - \alpha^R < \alpha^P$, which reinforces the previous effect. Additionally, because $s^{RP} < s^R$, it follows from the concavity of the retailer's profit function that the standard's marginal impact on retailer profits is positive at s^{RP}, and thus that part (1) of Equation (5.37) is positive. Together these factors render Equation (5.37) less negative than Equation (5.28), such that, because of concavity, s^{RP} is closer to s^G than s^R to s^G. In the extreme, if these effects render Equation (5.37) positive, s^{RP} would be lower than s^G and thus the private standard would not be imposed if side payments are allowed. In contrast, if no side payments are possible, the private standard is set at a higher level than the public standard $\left(s^R > s^G\right)$.

The intuition behind the previous result is that if producer profits are marginally decreasing at the retailer's optimal private standard without side payments, and if this private standard is more stringent than the public standard $\left(s^R > s^G\right)$, producers have an incentive to make side payments to the retailer to lower its private standard. These side payments reduce the level of the private standard set by the retailer $\left(s^{RP} < s^R\right)$ and the private standard is set closer to the government's optimal public standard. If these side payments are sufficiently large, they may even withhold the retailer from setting a private standard. In that case, the standard that governs the market is the public standard, s^G, and retailers receive side payments equal to $\Pi^P\left(s^G\right)-\Pi^P\left(s^R\right)$. If side payments would not be allowed, the standard that governs the market would be s^R since $s^R > s^G$.

Vice versa, if producer profits are marginally increasing at the retailer's optimal private standard without side payments, producers have an incentive to make side payments such that the retailer sets a higher private standard $\left(s^{RP} > s^R\right)$. If $s^R > s^G$, then Equation (5.37) is more negative than Equation (5.28) and the private standard with side payments is further away from the public standard $\left(s^G < s^R < s^{RP}\right)$. Moreover, if $s^R < s^G$ (Equation (5.28) positive), i.e. the retailer does not impose a private standard without side payments, producers' side payments may induce the retailer to set a private standard at a higher level than the public one (Equation (5.37) negative), i.e. $s^R < s^G < s^{RP}$

In summary, side payments may affect the comparison between the government's optimal public standard and the retailer's optimal private standard in either way, depending on how producers' interests are affected by the standard at the retailer's optimal private standard without side payments.

5.7. Conclusions

It is well documented that retailers' private standards are increasingly important in the global economy. Empirical evidence shows that these private standards are frequently more stringent than their public counterparts. Several explanations have been offered to explain this stylized fact, and this chapter adds an additional potential explanation by taking a political-economic perspective.

In the model, we assume three market players, namely consumers, producers, and a monopolist retailer. The retailer is a necessary intermediary agent that transfers goods from producers to consumers. A standard is assumed to positively affect consumer utility, while it also entails implementation costs. Private and public standards are assumed to have the same effect on consumer utility, and on production costs, ceteris paribus. We assume that the government sets a public standard to maximize, in line with Grossman and Helpman (1994), an objective function that is the weighted sum of interest group contributions and social welfare. Additionally, the retailer may set a private standard that regulates the same characteristics as the government's public standard.

Under these assumptions, we first show that all three market players may gain or lose from (a change in) a standard, and that this change involves rent transfer between the different market players. Likewise, social welfare may either increase or decrease with a change in the standard, depending on the relative size of the efficiency gain, implementation cost, and different rent transfers.

Second, we show that only under very specific circumstances the retailer's optimal private standard is also optimal from both the consumers' and producers' perspective. In any other case, the market players' interests differ.

Third, our analysis demonstrates that the retailer's optimal private standard only maximizes social welfare if the standard's direct welfare effects on consumers and producers cancel out. The reason is that the retailer only cares about the standard's net rent transfer effects, not about the direct welfare effects which the welfare calculus does take into account. However, even if the socially optimal standard and the private one are equal, this does not imply that this level of the standard is optimal for consumers and/or producers, since even the standard that maximizes social welfare involves rent transfers.

Fourth, by comparing the retailer's optimal private standard to the government's optimal public standard, we show that several factors may cause the private standard to be more stringent than the public one. We demonstrate that a retailer is more likely to set a more stringent private standard if (a) the rent transfer from the retailer to producers is smaller such that producers bear a larger share of the standard's implementation cost; (b) the producers' interest group has a larger political power when producers' interests are opposite to those of the retailer; (c) the standard creates a smaller efficiency gain for consumers; and (d) the standard entails larger implementation costs for producers. We also show that retailers' market power is crucial in this argument: if retailers have no market power, private standards are never set at higher levels than public standards. Hence when producers use their political power to obtain lower public standards, retailers may apply their market power to set higher private standards. In combination these factors may contribute to explaining why industry-wide private standards may be more stringent than their public counterparts.

Fifth, we illustrate our model with an application to developing countries' high-value crop exports to developed countries and show how our model may contribute to explaining why in these sectors private standards are more stringent than public standards, both imposed by the developing (exporting) and the developed (importing) country.

Sixth, we extend our model to allow producers to influence the retailer's private standard-setting behavior by making side payments, which may induce the retailer to set a private standard that is more aligned with producers' interest. Depending on how the producers' interests are affected by the standard at the retailer's optimal private standard without side payments, these side payments may affect the comparison between the government's optimal public standard and the private standard in either way.

Figures

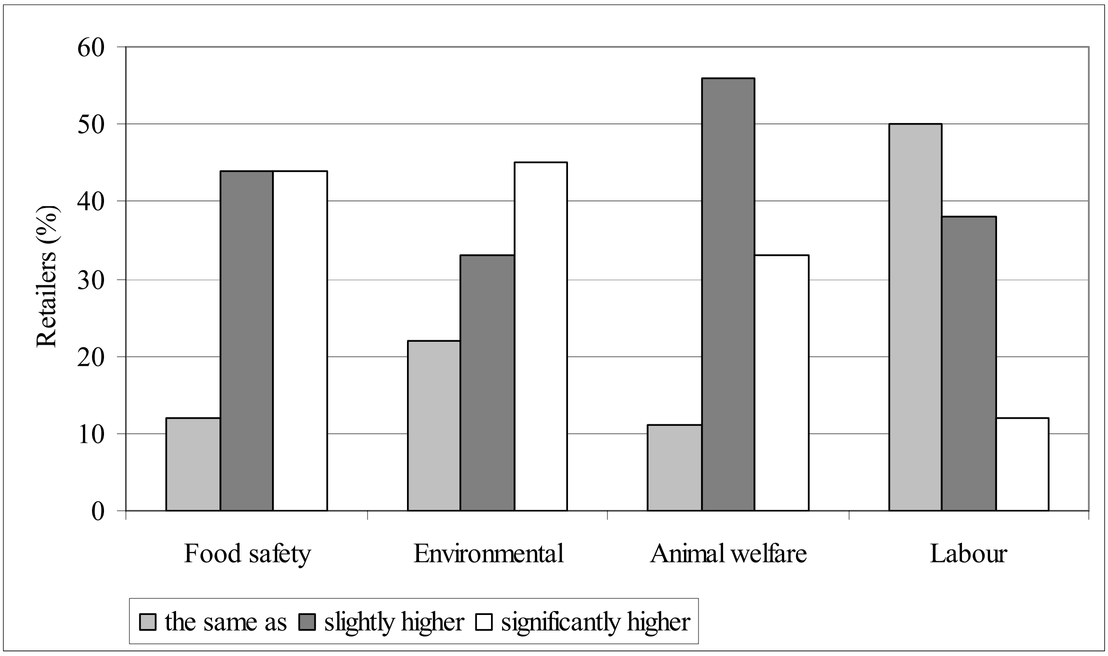

Figure 5.1: Retailers' Self-Assessed Standards Compared to Those of Government

(Source: Fulponi 2007)

Chapter 6. Quality and Inclusion of Producers in Value Chains

6.1. Introduction[69]

Recent technological developments and globalization are transforming the industrial organization and international location of production. One of the most important mechanisms underlying the globalization process lies in the transfer of advanced production capabilities to low-wage economies. These capabilities comprise both an increase in productivity and in product quality (Goldberg and Pavcnik 2007; Eswaran and Kotwal 1985). Sutton (2001) argues that the quality aspect is far the more important element: poor productivity can be offset by low wage rates, but until firms attain some threshold level of quality, they cannot achieve any sales in global markets, however low the local wage level.

These quality requirements affect poorer countries through several channels.[70] First, increasing public quality requirements in richer countries are also imposed on imports and consequently have an impact on producers and traders in exporting nations (Jaffee and Henson 2005; Unnevehr 2000). Second, global supply chains are playing an increasingly important role in world food markets and the growth of these vertically coordinated marketing channels is facilitated by increasing quality standards (Swinnen 2005; 2007). For example, modern retailing companies increasingly dominate

[69] This chapter is based on joint research with Johan F.M. Swinnen, Scott Rozelle, and Tao Xiang (see Vandemoortele *et al*. 2009).

[70] This chapter focuses on the development implications of changes in the demand for high quality products. There are several related areas in the literature on product quality standards, including a) analyses of asymmetric information problems which may be one of the reasons for companies or public regulators to introduce standards (Fulton and Giannakas 2004; Gardner 2003); b) studies on the role of standards in reducing consumption externalities (Copeland and Taylor 1995; Besley and Ghatak 2007); c) the role of standards in providing non-tariff trade protection (Anderson *et al*. 2004; Fischer and Serra 2000); and d) the political economy of standards (Swinnen and Vandemoortele 2008; 2009; 2011a).

international and local markets in fruits and vegetables, including those in many poorer countries, and have begun to set standards for food quality and safety in this sector wherever they are doing business (Dolan and Humphrey 2000; Henson *et al*. 2000). Third, rising investment in processing and retailing in developing countries also has begun to be translated into higher quality standards, as buyers are making new demands on local producers in order to serve the high-end income consumers in the domestic economy or to minimize transaction costs in their regional distribution and supply chains (Dries and Swinnen 2004; Dries *et al*. 2004; Reardon *et al*. 2003).

Importantly, the early literature posited that the rise of quality standards could have sharp negative influences on equity and poverty. Several of the studies argued that modern supply chains in developing countries would systematically exclude the poor and negatively affect the incomes of small farmers; in other words, it was being suggested that unlike other waves of rising economic activity, the poor would suffer from this process (Farina and Reardon 2000). The predictions from these studies included the poorest parts of the world. For example, several studies of farm communities in Latin America and Africa argued that small farmers were being left behind in the supermarket-driven horticultural marketing and trade (Dolan and Humphrey 2000; Humphrey *et al*. 2004; Key and Runsten 1999; Reardon *et al*. 2003; Weatherspoon *et al*. 2001). In a study on Kenya, Minot and Ngigi (2004) demonstrated that modern supply chains put intense pressure on smallholders (although smallholders were still participating). Even more extreme, in the case of Côte d'Ivoire, almost all of the fruit and vegetables being produced for exports were being cultivated on large industrial estates. Likewise, Weatherspoon and Reardon (2003) argued that the rise of supermarkets in Southern

Africa failed to help small producers who were almost completely excluded from dynamic urban markets due to quality and safety requirements.

Recent research suggests a more nuanced picture of the effect on poverty and its overall development implications. Dries and Swinnen (2004) find that high standards lead to increased vertical coordination in supply chains that is realized in their study area by the emergence of extensive contracting between processing companies and farmers. The rise of contracting, far from leading to the exclusion of poorer farmers, is shown to improve access to credit, technology and quality inputs for poor, small farmers that heretofore were faced with binding liquidity and information constraints due to poorly developed input markets. Minten *et al*. (2009) and Maertens and Swinnen (2009) also find increased vertical coordination in newly emerging supply chains between buyers and poor, small farmers in African countries, such as Madagascar and Senegal. According to their work, poor rural households experienced measurable gains from supplying high standard horticulture commodities to global retail chains. In China Wang *et al*. (2009) found that while rising urban incomes and emergence of a relatively wealthy middle class were associated with an enormous rise in the demand for fruits and vegetables, almost all of the increased supply was being produced by small, relatively poor farmers that sell to small, relatively poor traders. Despite sharp shifts in the downstream segment of the food chain towards modern retailing (e.g., there has been a rapid increase in the share of food purchased by urban consumers in supermarkets, convenience stores and restaurants), modern marketing chains have almost zero penetration to the farm level.

These conflicting empirical findings are puzzling. Why would one observe such different outcomes? To understand better why different outcomes may emerge, this chapter is the first[71] to develop a formal theory of the process where modern supply chains and demand signals are directing producers to grow and sell high quality and safe foods. We use this theory to analyze whether this process may result in different outcomes when economies are characterized by different structural conditions. In particular, we analyze which producers are most likely to be included in these modern supply chains, and how the inclusion process is affected by factors such as the productivity distribution of producers and the nature of the transaction costs involved. In the last part of the chapter we analyze the impact of contracting between processors and producers.

The chapter is organized as follows. In Section 6.2, we present a formal model to analyze the endogenous process of the introduction of high quality products in developing countries. We discuss the structural factors of the market equilibrium resulting from this model. Sections 6.3 and 6.4 analyze how the inclusivity of this process towards producers is influenced by respectively the production structure and the nature of transaction costs. Section 6.5 discusses the impact of contracting between processors and producers on this process and its inclusivity. Section 6.6 concludes.

6.2. The Model

Our basic model has the following main properties: (a) all consumers value high-quality products more than low-quality products but are heterogeneous in their willingness to pay for this quality difference; (b) producers can only supply a high-quality product by

[71] Exceptions are some recent studies on the relationships between the local suppliers and modern processors/retailers in developing countries focusing on vertical coordination and rent distribution (Marcoul and Veysierre 2010; Swinnen and Vandeplas 2010). However these studies do not seek to explain the variations in the structure of the modern supply chains that one observes.

undertaking a production process that is costlier than the one required to produce a low-quality product; (c) a high-quality product needs processing by a third-party (processor) to transfer the product from producers to consumers; and (d) both producers and processors operate in a competitive industry with free entry and exit.

6.2.1. Demand

To model the demand side, we draw upon the vertical differentiation literature.[72] We consider the unit-demand version of the standard vertical product differentiation model whereby each consumer buys at most one unit of the good. The model is adjusted for a limited number of product types and relates income directly to the preferences for quality, following Tirole (1988).[73]

Assume that there are only two types of products with different qualities in this market, a basic *low quality* (ϕ_L) product and a *high quality* ($\phi_H > \phi_L$) product. When both qualities are available, consumers choose among three options:

$$U = \begin{cases} i\phi_H - P_H & \text{if the high quality good is bought;} \\ i\phi_L - P_L & \text{if the low quality good is bought;} \\ 0 & \text{otherwise;} \end{cases} \tag{6.1}$$

[72] The literature started with papers explaining the emergence of endogenous quality outcomes in monopolized markets (Spence 1975; Mussa and Rosen 1978) and in monopolistic competition and oligopolistic markets (Gabszewicz and Thisse 1979; Shaked and Sutton 1982; 1983; Tirole 1988). Ellickson (2006) examines vertical differentiation in the context of grocery retailing and Roe and Sheldon (2007) examine labeling and credence features of products using a vertical differentiation model.

[73] Our approach implicitly assumes that the introduction of high quality reflects consumer preferences. Another reason why a company may want to introduce certain quality or process standards is to reduce transaction costs in sourcing and selling (Henson 2006; McCluskey and Winfree 2009; Fulponi 2007). Since the introduction of quality or process standards for these purposes would also require specific investments by suppliers (hence higher production costs) and (increased) transaction costs for the processors, most of such effects would be similar to thsoe analyzed in this chapter.

where ϕ_H and ϕ_L are the qualities and P_H and P_L are the unit consumer prices of respectively the high and low standards product; the index $i \in (I-1, I) \subseteq R_+$ represents consumer income. Consumers with higher incomes are assumed to have higher preferences for quality. The distribution of income, $F(i)$, is uniform between $I-1$ and I, where the latter is the highest income among consumers. We assume that the distribution of income does not change when income grows so that an increase of aggregate income can be represented by an increase of I.

When both high quality (HQ) and low quality (LQ) products are bought by some consumers when available and some consumers buy nothing (i.e. there is an 'uncovered' market), the aggregate market demand functions Q_H^D and Q_L^D are:

$$Q_H^D = M\left(I - \frac{P_H - P_L}{\phi}\right); \tag{6.2}$$

$$Q_L^D = M\left(\frac{P_H - P_L}{\phi} - \frac{P_L}{\phi_L}\right); \tag{6.3}$$

subject to $\frac{P_L}{\phi_L} + 1 > I > \frac{P_H - P_L}{\phi}$, where M is the total number of consumers in this economy and $\phi \equiv \phi_H - \phi_L$ represents the quality difference. If $I < \frac{P_H - P_L}{\phi}$ there is no demand for high quality products $\left(Q_H^D = 0\right)$.[74]

[74] See Gabszewicz and Thisse (1979) and Tirole (1988) for formal derivations of these conclusions.

6.2.2. Supply

On the supply side, we assume a standard competitive industry populated by numerous producers who behave as price takers. In our model all producers are able to produce either the high quality or the low quality product. To start, we assume that producers are identical. Later in the chapter we relax this assumption and analyze how producer differences affect their integration into the high quality economy.

We assume further that producers have a production technology that requires a unit cost c_H and c_L, for the high and low quality product respectively, and that $c_H = c_L + k$, where k is the per unit additional capital cost for producing the high quality product.[75] Finally, for simplicity, we assume that the other costs remain the same and that producers can produce the same number of units of the commodity regardless of whether they produce low quality or high quality commodities.[76]

6.2.3. Marketing and Trade

Once the products are produced in response to consumer demand, our model needs to account for the transfer of the commodities from farm to plate. For simplicity we assume that one unit of production is identical to one unit at retail (consumer) level for both high and low quality. We use different marketing assumptions for the LQ products and the HQ products. We assume that producers sell their LQ commodity in villages and city markets

[75] We thus assume that there are no fixed costs of switching to high quality production. For an analysis of how fixed compliance costs affect market structure, we refer to Rau and van Tongeren (2007). We ignore quality uncertainty, so each farm can meet the processor's quality threshold with certainty if it makes a predetermined capital investment. We also ignore issues of contracting and contract enforcement in the HQ chain. For more details about this, see Swinnen and Vandeplas (2010) who show that the premium itself depends on the contract enforcement conditions.

[76] This assumption is consistent with, for example, a farmer who may produce 100 liters of non-cooled, high-bacteria milk if operating in the low quality market or, after an investment in a cooling tank is made, 100 liters of cooled, low-bacteria milk if operating in the high quality market.

at price P_L under perfect competition. For the HQ supply chain, we assume that 'processors' (which may represent any company involved in processing, marketing or retailing) purchase the HQ commodity from producers at price p_H and resell this commodity to consumers at price P_H. We consider that these companies incur a unit transaction cost τ in sourcing from producers. Under perfect competition and free entry and exit for processors, it follows that the consumer price of the commodity is the sum of the producer price and the transaction cost, such that $P_H = p_H + \tau$.[77]

6.2.4. Structural Factors and the Market Equilibrium

With producers' supply of low and high quality products determined by their respective marginal costs c_L and c_H and the demand functions (6.2) and (6.3) we can derive the market equilibrium level of LQ products $\left(X_L^*\right)$ and HQ products $\left(X_H^*\right)$ as follows:

$$X_L^* = M\left(\frac{k+\tau}{\phi} - \frac{c_L}{\phi_L}\right); \tag{6.4}$$

$$X_H^* = M\left(I - \frac{k+\tau}{\phi}\right). \tag{6.5}$$

Equations (6.4) and (6.5) incorporate the relationship between a series of structural variables and the relative importance of the high and low quality economies. For each of the key variables $\left(I, k, \tau, \phi\right)$ one can identify threshold levels (either minima or maxima)

[77] We ignore 'processing costs' because they do not affect the conclusions. We also considered an alternative model with a monopolistic market structure in processing. Again, this vastly complicated the model without yielding substantial differences in the key results regarding the issues where this chapter focuses on. See Swinnen and Vandeplas (2010) for an analysis of the role and effects of competition in the emergence and growth of a high quality economy.

for the high quality economy (HQE) to exist, i.e. for $X_H^* > 0$. For positive levels of X_H^*, one can use comparative statics to show how the variables affect the size of the HQE.

Income (I). The size of the HQE is directly related to the level of income in the economy. A minimum level of income is required for a HQE to emerge. Formally, the condition is: $I > \frac{k+\tau}{\phi}$. Hence, one of the basic results that falls out of our model is consistent with the observation that HQ markets are more likely found in countries with higher incomes than in countries with lower incomes. Additionally, once income is above this threshold, the model shows that the HQE becomes larger when income increases $\left(\frac{\partial X_H^*}{\partial I} = M > 0\right)$. The positive effect of I on X_H^* is also consistent with the observation that HQ production systems tend to emerge first in export sectors in developing countries. For example in many African economies HQ production is limited to supply chains targeted to (high income) EU consumer markets while production for domestic markets is limited to LQ production.

Capital costs (k). In many developing countries capital constraints are important and the real cost of capital is high. According to our model this is another reason that HQ markets are less likely to emerge in developing countries. If capital costs of producing HQ are too high, i.e. if $k > \phi I - \tau$, then no HQE emerges. Moreover, given that a HQE exists, the size of the HQE is smaller if capital costs are higher, as $\frac{\partial X_H^*}{\partial k} = -\frac{M}{\phi} < 0$.

Quality difference (ϕ): An additional condition for the emergence of a HQE is that the high quality level is sufficiently larger than the low quality level, given the extra cost of that quality difference. Formally, the quality difference ϕ must be such that $\phi > \frac{k+\tau}{I}$ holds. Given that this condition is fulfilled, the HQE is larger for larger quality differences $\left(\frac{\partial X_H^*}{\partial \phi} = \frac{M\left(k+\tau\right)}{\phi^2} > 0 \right)$.

However, as we show in the next sections, these conclusions need to be nuanced when one allows explicitly for details on the production structure as well as on the nature of transaction costs in the model.

6.3. Production Structure

In addition to being able to predict the factors that underlie the emergence of the HQE, our model can be used to gain insights on what types of producers are most likely to join the HQE (when it emerges) and what types of producers are likely to be left out. As discussed in the introduction, this issue has attracted a lot of policy attention and academic debate. Some studies have argued that smallholders are excluded from HQE due to scale diseconomies and higher transaction costs; others have argued that this is not (necessarily) the case.

The arguments used in the literature are often quite simplistic. In fact, they may also be *too* simplistic. For example, the impact of scale economies is not as trivial as often argued.[78] Scale economies can differ strongly between activities (e.g. extensive

[78] There is an extensive literature showing how farm productivity, and in particular the relationship between size and productivity, tends to differ importantly by commodity (e.g. Allen and Lueck 1998; Pollak 1985). For example, while large producers may have scale advantages in land intensive commodities, such as wheat or corn, this is typically much less the case in labor intensive commodities, such as fruits and vegetables. In fact, there are cases in which small-scale producers may have advantages over larger farmers. In the production of some HQ commodities, small farmers may have an advantage over larger farmers because of the importance of labor governance and the quality of the labor input. This implies that the inclusion or exclusion of small farms is likely to depend on the type of the commodity. This is

grain farming compared to intensive vegetable or dairy production). Scale economies may also be influenced by local institutions and market constraints.

While scale economies can be important, in our analysis here we focus on two other factors, the initial production structure of the economy and the nature of the transaction costs. We show that both factors have an important impact on the size of the HQE and on who is included in the HQE.

One of our key arguments is that initial conditions matter. One might expect different outcomes from the emergence of the HQE in rural settings that have highly unequal distributions of land resources (such as, in some nations in Latin America and parts of the former Soviet Union – which have some individuals holding massive estates and many smaller, relatively poor farmers), compared to rural societies characterized by more egalitarian distributions of cultivated land (e.g., China, Vietnam, and Poland). In the rest of the analysis we call this the *production structure* of the rural economy. In this section we formally show that the initial production structure indeed matters: the share of smallholders in the production system – and the existence of large holdings amongst the smallholders – affects both the size of the HQE and the integration of smallholders into the HQE. To analyze this we relax the assumption of a homogenous producer structure. This means that k is not necessarily identical for all producers. In line with our general model, we introduce producer heterogeneity by varying the capital cost k.

We assume that capital cost k_j of producers j is uniformly distributed across N producers with $k_j \in [k-\gamma_k, k+\gamma_k]$ $\forall j = \{1,...,N\}$ and $\gamma_k \in [0,k]$ with $k \geq 0$. For

consistent with findings from Wang *et al*. (2009) on China and Minten *et al*. (2009) on Madagascar who find that smallholders are extensively included in labor intensive fruits and vegetable production.

simplicity, we assume that individual producers only produce one unit of the high standards product when they are involved in the HQE.[79, 80] Producers with lower capital costs are more efficient.

We can now consider variation in the production structure by considering changes in γ_k. Specifically, the extreme case of homogeneous producers – which was the assumption in the first part of the chapter – is represented by $\gamma_k = 0$. The efficiency distribution is increasingly unequal as γ_k increases. With any given distribution, the average efficiency is represented by capital cost k (as in the general model).

The supply curves for heterogeneous and homogeneous production structures are shown in Figure 6.1. In this graphical representation $X_H^S\left(\gamma_k = 0\right)$ represents the supply function for homogeneous producers. Likewise, $X_H^S\left(\gamma_k > 0\right)$ is the supply function for heterogeneous producers.

When producers choose to produce the HQ products, under the assumption that one producer produces only one unit of output in the HQE, their profits are $p_H - c_H$, with $c_H = c_L + \tilde{k}$ where $\tilde{k}$ is the capital cost of the producer that is indifferent between producing for the HQE and the LQE. Using this, we can then derive the aggregate supply of HQ products as:

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[79] This assumption is sufficient to guarantee that production capacities of producers are limited, which is necessary to allow for co-existence of free entry/exit and heterogeneous farmers. Otherwise, if production capacities were unlimited, the most productive producers would dominate the market and drive out all other producers. Alternatively, one could fix the inputs and consider variation in output, or consider variations in input and/or output size. Our specification is closer to the basic model specification and allows deriving the key results.

[80] This assumption rules out scale economies. It can be relaxed, although at the cost of additional complexity, without affecting our basic results. The results in this section are driven by producer heterogeneity, but not by the source of producer heterogeneity. Therefore any assumption that leads to producer heterogeneity would qualitatively yield the same results.

$$X_H^S = \frac{N}{2\gamma_k} \int_{k-\gamma_k}^{\tilde{k}} dk_j = \frac{N\left(\tilde{k} + \gamma_k - k\right)}{2\gamma_k}.\text{[81]} \tag{6.6}$$

This, in turn, leads to a new expression for the equilibrium quantity in the HQ market:

$$X_H^* = M\left(I - \frac{\left(k - \gamma_k + \tau\right)}{\phi}\right)\left(\frac{1}{1 + \dfrac{M/\phi}{N/2\gamma_k}}\right). \tag{6.7}$$

Comparing (6.5) and (6.7) yields some important insights. The second term of the right hand side (RHS) of condition (6.7) shows that the HQE emerges at lower income levels with a heterogeneous production structure than with a more homogeneous structure. Specifically, $I > \dfrac{k - \gamma_k + \tau}{\phi}$ is the condition for the HQE to emerge. With $\gamma_k > 0$ the required income level is lower than when $\gamma_k = 0$. In addition, the required income level (for the emergence of a HQE) declines when the distribution is more unequal (that is, when γ_k is higher). The intuitive reason for this finding is that when an economy faces a more heterogeneous production structure, this implies that there are more efficient producers among the entire set of producers, ceteris paribus. As a result of this, these producers are able to produce HQ products when it is not possible in an economy characterized by a homogeneous production structure.

However, the third term of the RHS of condition (6.7) implies that the expansion of HQ production – once it exists – proceeds more gradually when there is a heterogeneous distribution of producers. To see this, define $B = 2M\gamma_k / N\phi$. The third

[81] When $\gamma_k = 0$, the HQ output X_H^S is completely determined by demand in the equilibrium (perfectly elastic supply) and Equation (6.6) is irrelevant.

term then equals $1/(1+B)$, which is less than 1 with $B>0$. Formally, $\partial X_H^* / \partial I = \dfrac{M}{1+B}$.
With $B=0$ when $\gamma_k = 0$, and $\partial B / \partial \gamma_k > 0$, it follows that the growth in X_H^* with increasing income is more gradual when there is a more heterogeneous set of producers – given that $X_H^* > 0$. These results are illustrated in Figure 6.1.

In Figure 6.1 $X_H^S(\gamma_k = 0)$ represents the supply function for homogeneous producers and $X_H^S(\gamma_k > 0)$ the supply function for heterogeneous producers. For low income, represented by demand function Q_{H1}^D for high standards products, the equilibrium output in the high standards market is zero with homogeneously distributed producers i.e. $X_{H1}^*(\gamma_k = 0) = 0$. In contrast, under a heterogeneous producer structure, the HQE does emerge and the equilibrium is at point A. HQ output is equal to $X_{H1}^*(\gamma_k > 0)$. For higher income levels, represented by demand curves Q_{H2}^D and Q_{H3}^D, the market equilibrium with the heterogeneous structure shifts to points B and C, respectively. For the homogeneous production structure, there is also positive HQ output at Q_{H2}^D and Q_{H3}^D, represented by points D and E, respectively.

Figure 6.1 thus illustrates that HQ production emerges at lower levels of income for heterogeneous structure (represented by point A). However, once the HQ emerges in an economy characterized by a more homogeneous structure, the growth of the HQE is more rapid as income grows. In Figure 6.1, the growth in production represented by the shift from point D to E (homogenous structure) is larger than for the shift from B to C (heterogeneous structure).

These results are further illustrated in Figure 6.2. When income is too low $\left(I < \frac{k+\tau-\gamma_k}{\phi}\right)$, for example in point G, there is no HQE under either the heterogeneous or homogeneous structure. As income increases, however, the HQE emerges first in the economy characterized by a heterogeneous production structure for $I > \frac{k+\tau-\gamma_k}{\phi}$. Under the assumption that a nation's production structure is more homogeneous, the minimum income requirement for the emergence of a HQE is higher $\left(I > \frac{k+\tau}{\phi}\right)$. When income is low $\left(\frac{k+\tau-\gamma_k}{\phi} < I < \frac{k+\tau}{\phi}\right)$, a HQE exists under the heterogeneous structure (point A), but does not (yet) exist under the homogeneous structure (point F). At higher incomes, HQ production is also positive for the homogeneous structure, but output remains higher for heterogeneous production structure, as long as income does not reach the level $I = \frac{k+\tau}{\phi} + \frac{N}{2M}$ (point H). At higher incomes, the homogeneous producer structure produces higher output. Finally, when income is larger than $\frac{k+\tau}{\phi} + \frac{N}{M}$ but lower than $\frac{k+\tau+\gamma_k}{\phi} + \frac{N}{M}$, the HQE includes all producers under the homogeneous structure in contrast to the heterogeneous structure, shown by respectively points K and J.

This approach also allows us to analyze *who is included in the HQE*. With a heterogeneous production structure, the most productive producers start producing HQ at low income levels. However, given the same set of incomes and other factors, the less productive producers are excluded. When the production structure of an economy is more homogeneous, HQ production only starts at higher income levels. Although beginning later in the development process, once started the process is more inclusive. More producers are included. This insight can be seen graphically in Figure 6.3. The line that divides the graph between the LQE and the HQE is characterized by $\frac{k-\gamma_k+\tau}{\phi}$, which is the minimum income level required for a HQE to emerge under given producer heterogeneity γ_k. It illustrates again that when producers are more heterogeneous, there is a more rapid emergence of the HQE – given certain levels of income growth. In addition, under our assumption that more efficient producers have lower capital costs k_j, Figure 6.3 also illustrates that when income increases, a homogeneous producer structure is more inclusive. At high levels of income, all producers are included under any distribution.

6.4. Transaction Costs

The nature of transaction costs is another fundamental feature of an economy that may affect the HQE. First, transaction costs affect the overall size of HQ production. Equation (6.5) shows that higher transaction costs constrain the size of the HQE $\left(\frac{\partial X_H^*}{\partial \tau} = -\frac{M}{\phi} < 0\right)$. It makes sourcing from suppliers more costly and therefore increases the relative cost of the HQ products.

Second, transaction costs also affect *who is included*. In the literature, a standard argument is that there are fixed transaction costs per supplier for processors. This implies that transaction costs per unit of output are lower for large producers and hence small producers are excluded. However, such conclusion is overly simplistic and depends on the specific (often implicit) assumptions on the nature of the transaction costs. In reality there are different types of transaction costs that might be important when processors source HQ commodities from producers. For example, one common type of transaction costs might include costs of search (by company procurement agents that are looking for producers that are willing to supply to the HQE), supervision costs, quality and process control costs, and the costs of enforcement of agreements. As an illustration, consider the following example from Minten *et al*. (2009, p. 1733), which studies processor-farmer interactions in a HQ vegetable production region which produce horticultural exports in Madagascar for the European Union:

> *"To monitor the correct implementation of the [HQ] conditions, the [processor] has ...around 300 extension agents who are permanently on the payroll of the company. Every extension agent is responsible for about thirty farmers. To supervise these, (s)he coordinates [another] five or six extension assistants ... that live in the village itself. During the cultivation period of the [HQ] vegetables, the farmer is visited on average more than once a week ...to ensure correct production management as well as to avoid 'side-selling'. ...99% of the farmers say that the firm knows the exact location of the plot; 92% of the farmers say that the firm even knows ...the number of plants on the plot. For crucial aspects of the production process, such as pesticide application, representatives of the company will even intervene in the production management to ensure it is rightly done. [One-third] of the farmers report that representatives of the firm will themselves put the pesticides on the crops to ensure that it is rightly done."*

This example clearly illustrates that the notion of fixed transaction costs per supplier is not (necessarily) consistent with reality. For conceptual purposes, one may distinguish three types of transaction costs: those which are fixed per supplier (e.g. contract negotiation costs), those which are fixed per unit of output (e.g. output control costs) and those which are fixed per unit of production input (e.g. monitoring of plots and production activities).

To show that these different types of transaction costs have different effects on the emergence, size and composition of the HQE, we compare two types of transaction costs. Specifically, we assume that τ_j is a producer specific transaction cost. It is uniformly distributed over the interval $[\tau-\gamma_\tau, \tau+\gamma_\tau]$ with $\gamma_\tau \in [0, \tau]$ and $\tau \geq 0$. With transaction costs defined in this way, we first consider the case when transaction costs are fixed per producer. This means that transaction costs are identical for all producers (or, $\gamma_\tau = 0$ and $\tau_j = \tau$). In the second case, we consider transaction costs which are fixed per unit of input. This implies that transaction costs are negatively related to producer efficiency, i.e. $\partial\tau_j/\partial k_j > 0$ and therefore $\gamma_\tau > 0$.

It is immediately clear that these different types of transaction costs have fundamentally different implications for which producers are included in the HQE. In one case, the transaction costs are 'neutral' regarding productivity heterogeneity; in the other case, they reinforce the productivity-bias. Formally this can be seen from the new condition for the equilibrium output of HQ products with producer specific transaction costs:

$$X_H^* = M\left[I - \frac{(k-\gamma_k)+(\tau-\gamma_\tau)}{\phi}\right]\left(\frac{1}{1+\dfrac{M/\phi}{N/2(\gamma_k+\gamma_\tau)}}\right). \tag{6.8}$$

It follows from Equation (6.8) that the structure with heterogeneous transaction costs, i.e. $\gamma_\tau \neq 0$, induces earlier emergence of HQE for increasing income levels. The HQE arises when $I > \frac{\tau+k-\gamma_k-\gamma_\tau}{\phi}$, which is less restrictive for higher γ_τ (more heterogeneity in transaction costs).

Figure 6.4 illustrates this effect. The HQ supply function with fixed transaction costs $(\gamma_\tau = 0)$ per supplier is identical to that of Figure 6.1 with heterogeneous suppliers.[82] It follows from Equation (6.8) that with heterogeneous transaction costs, the HQ supply function pivots around point H. This implies more HQ supply at lower levels of income (represented by Q_{H1}^D) but less supply at higher levels of income (represented by Q_{H3}^D). As is illustrated in Figure 6.4, the negative relation of transaction costs with productivity reinforces the productivity effect by the pivot of the supply function.

The impact on which producers are included when considering the nature of transaction costs is analogous to the discussion on the impact of the economy's production structure. Low productivity suppliers are less likely to be included with transaction costs fixed per unit of input, and vice versa. In this way, transaction costs reinforce the productivity effect, in the sense that they reduce the purchasing costs for processors from more productive producers. Producers with higher productivity have even more cost advantages because the per unit transaction costs are lower. However, this result depends on the nature of transaction costs. If transaction costs are fixed per producers, this is not the case.

Notice that one should be careful in interpreting these findings. Our specific findings are conditional on our model specification, which assumes that there is a fixed output per producer. However, our main result, i.e. that the impact on inclusion in the HQE depends on the nature of the transaction costs, holds in general. In reality, some transaction costs are fixed per producer, such as those for bargaining and search. Other

[82] Note that in case of homogeneous suppliers, there is no effect of the nature of transaction costs on producer inclusion since all suppliers (and thus their transaction costs) are identical.

costs however, such as product or process control costs, at least have a component that is better modeled as a per unit of output or input cost. To the extent that these variable transaction costs are more important, the cost advantage of large and more productive producers changes. Another issue is the distribution of the profits because of low transaction costs. Generally, this depends on the bargaining power of the market players involved (Swinnen and Vandeplas 2010).

6.5. Contracting

In developing countries, processing firms or large traders are often less capital constrained than producers. As a consequence of this asymmetric capital market imperfection, processors and producers may start a process of vertical coordination or contracting by which processors supply producers with the capital necessary to produce the high quality product. This is consistent with empirical observations that the introduction of higher quality requirements in transition and developing countries has coincided with the growth of contracting (Swinnen 2007). Empirical studies show that local producers in developing countries are engaging in complex contracting with processors selling into high quality markets. These contracts not only specify conditions for delivery and production processes but also include the provision of inputs, credit, technology, management advice etc. (Minten *et al*. 2009; World Bank 2005b). The latter are particularly important for local producers who face important local factor market imperfections. If the institutional environment is such that producers and processors have the possibility to contract the production of high quality products, this may have important implications for the emergence, growth, size, and inclusivity of the HQE.

To analyze the impact of contracting in our framework, we use a simplified version of the contract model that is typically used to study these problems.[83] We assume that all processors face the same capital cost k_p. When processors contract producers, we further assume that processors can provide the capital necessary to produce the high quality product to producers at the cost k_p (instead of the producer's individual capital cost k_j).

Processors and producers only participate in this type of contracting if the processors' capital cost k_p is smaller than the producer's individual capital cost k_j. As before, we assume that the individual capital cost k_j differs among producers and is uniformly distributed, but for simplicity we assume identical transaction costs τ (i.e. transaction costs are fixed per producer).

The impact of (the possibility of) contracting on the emergence, growth, size, and inclusivity of the HQE strongly depends on the relative capital cost of processors $\left(k_p\right)$ with respect to the capital cost $\tilde{k}$ of the producer who is indifferent between producing for the HQE and the LQE if the option of contracting is not available. In other words, the latter is the equilibrium capital cost in the case without contracting, and can be derived from combining Equations (6.2) and (6.6) with, as before, $P_H = c_L + \tilde{k} + \tau$ and $P_L = c_L$. Formally, the capital cost of the indifferent producer is equal to:

$$\tilde{k} = \frac{\phi I - \tau}{1 + 1/B} + \frac{k - \gamma_k}{1 + B}, \tag{6.9}$$

[83] See Swinnen and Vandeplas (2010) for an extensive analysis of such models and the impact of competition and imperfect enforcement on (the efficiency of) contracting between processors and producers.

with $B = \frac{2M\gamma_k}{N\phi}$ as before. Whether contracting has an impact on the market equilibrium in the HQE depends on whether $k_p \geq \tilde{k}$ or $k_p < \tilde{k}$.

First, consider the situation where $k_p \geq \tilde{k}$, i.e. where the capital cost of processors is larger than the capital cost of the indifferent producer in the equilibrium without contracting (Equation (6.7)). In this case the possibility of contracting does not impact on the HQE as contracting does not occur. Only producers with $k_j \leq \tilde{k}$ participate in the HQE, but only producers with $k_j \geq k_p$ would benefit from contracting with a processor. However, as $k_p \geq \tilde{k}$, no producer involved in the HQE contracts with a processor. Because the capital that processors may provide with is more costly than the capital of the indifferent producer, contracting is not desirable.

Second, when $k_p < \tilde{k}$, contracting does have an impact on the emergence, size, and inclusivity of the HQE. In Figure 6.5, the equilibrium without contracting is depicted by point $\left(X_H^*, \tilde{k} + \tau\right)$ and the contracting equilibrium by $\left(X_H^{c*}, k_p + \tau\right)$, where X_H^{c*} is the equilibrium HQ output under contracting. As before, X_H^* is determined by (6.7) while the equilibrium HQ output under contracting is determined by:

$$X_H^{c*} = M\left(I - \frac{k_p + \tau}{\phi}\right). \qquad (6.10)$$

Contracting has an impact on the emergence of the HQE when $k_p < k - \gamma_k < \tilde{k}$. This case is illustrated in Figure 6.5 by k_p'. In an analysis similar to the one in Figure 6.1, for sufficiently low levels of income I and a subsequent low level of demand Q_H^D, there is a positive equilibrium in the HQE with contracting (supply function $X_H^S\left(k_p';\gamma_k>0\right)$) while there is no HQE without contracting (supply function $X_H^S\left(\gamma_k>0\right)$). With contracting the threshold income for a HQE to emerge is $\frac{k_p'+\tau}{\phi}$ which is lower than the income threshold without contracting $\left(I>\frac{k-\gamma_k+\tau}{\phi}\right)$, as $k_p'\le k-\gamma_k$.

Next, consider the case where $k-\gamma_k\le k_p<\tilde{k}$. The HQE emerges when income is above the same threshold, namely when $I>\frac{k-\gamma_k+\tau}{\phi}$, with and without contracting (see Figure 6.5). Therefore contracting does not have an impact on the emergence of the HQE for $k_p\ge k-\gamma_k$. However, comparing (6.7) and (6.10), it follows that for $k_p<\tilde{k}$ contracting has an impact on the size of the HQE and on its suppliers.

First, the HQE is larger with the possibility of contracting, i.e. $X_H^{c*}>X_H^*$, which is clear from Figure 6.5. By supplying cheaper capital to producers with $k_j>k_p$, contracting enlarges the set of producers who are able to produce the high quality product at a given equilibrium price. As a consequence, for the same level of income and willingness to pay for high quality by consumers (demand function Q_H^D), the HQE is larger when contracting is feasible. Formally, given that we derived that $\frac{\partial X_H^*}{\partial k}<0$ and that $k_p<\tilde{k}$ (the equilibrium capital cost in the respective situations), it must be that $X_H^{c*}>X_H^*$.

Second, for levels of income I such that $k_p < \frac{\phi I - \tau}{1+1/B} + \frac{k-\gamma_k}{1+B} = \tilde{k}$, the expansion of HQ production proceeds faster under the possibility of contracting. This can be seen in Figure 6.5 by shifting the demand function Q_H^D to the right, which represents an increase in consumers' income. The increase in X_H^{c*} is larger than the increase in X_H^*, ceteris paribus, which is analogous to our earlier comparison between homogeneous and heterogeneous production structures (see Figure 6.1). By providing capital to producers at the same cost – irrespective of the producers' different individual capital costs – processors create homogeneity in the production structure, at least for producers in the range for which $k_j > k_p$ holds.

Third, contracting between processors and producers induces the HQE to become more inclusive towards less productive producers, for two reasons. The HQE is larger under contracting and thus more producers are included, which implies also less productive ones. In addition, processors are indifferent towards contracting with producers j with $k_j \in \left[k_p, k+\gamma_k\right]$. As before, the possibility of contracting creates homogeneity in the production structure for $k_j > k_p$, and as we already analyzed a homogeneous production structure creates higher inclusivity (see Figure 6.3). Therefore contracting creates more inclusivity towards less productive producers.

In conclusion, if processors can relax credit constraints of producers, contracting improves the size, growth, and inclusivity of the HQE, and in extreme cases it may even lead to an earlier emergence of the HQE. This linkage between the cost of capital, contracting, and the emergence of the HQE offers an explanation for the empirical observation foreign direct investment (FDI) play an important role in the emergence of

HQEs (e.g. Dries and Swinnen 2004). Processors have developed vertical coordination (VC) arrangements with supplying producers to provide capital inputs to producers who are capital constrained, either because of the collapse of the financial system (e.g., in transition countries – see Gow and Swinnen 1998; World Bank 2005a) or because of general credit constraints of producers in developing countries (e.g., Minten *et al*. 2009; Maertens and Swinnen 2009). To set up such VC arrangements, processors themselves need sufficient access to capital. This is why FDI – or other institutional arrangements which enhance the access of processors to capital markets have played an important role. While FDI may have more than one effect on the emergence of a HQE, a crucial element is that, with capital market imperfections in developing countries, foreign companies frequently have lower capital costs (or face less restrictive credit constraints) than domestic companies in developing countries. Because of this, foreign firms may therefore be able to invest, using lower cost capital when it is not possible for domestic companies to do so.[84] Through VC this, in turn, leads to reduced capital costs for producers with FDI. This section clearly demonstrated the beneficial impact of contracting on the emergence of the HQE in line with the empirical observations.

6.6. Conclusions

In this chapter we have developed a formal theory of the process of the endogenous introduction of high quality products in developing countries. We use our theoretical model to analyze how different structural conditions of the economy affect the emergence and size of the high quality economy (HQE). Differences in the form of the level of

[84] In some cases, access to capital has also come from (domestic) company investments which have other sources of capital (such as the case of Russia where energy firms are willing to invest in domestic firms) or through supply contracts with international traders (as in cotton markets in Central Asia – Swinnen 2007).

income, the relative cost of capital, the extent and nature of transaction costs and whether the production structure is homogeneous or heterogeneous affects the timing of the emergence and the size of the HQE. These results can be used to gain insights on how institutional reforms, including macro-economic stabilization, liberalization of trade and foreign investment regulations can have important impacts on the growth of the HQE. In particular, these and other policy changes that reduce the cost of capital, according to our model, play an important role in stimulating the growth of the HQE.

We also examine which factors affect which producers are able to participate in the HQE as it is emerging. Not surprisingly, we find that the most efficient producers switch first to producing for the HQ market. Importantly, our analysis shows how the nature of the initial production structure can affect both the size and distributional effects of the HQE. In countries with a mixed production structure, combining large and medium size commercial farms with small-scale household farms, such as in Latin America and parts of Eastern Europe and the former Soviet Union, the process is more likely to lead to an initial exclusion of smallholders from the HQE. In contrast, in countries such as China and Vietnam, India and parts of Africa, Eastern Europe and Central Asia, where the farm sector is more uniform and dominated by small farms, the emergence of the HQE, although delayed, can be expected to be more inclusive.

Transaction costs also play an important role as they may or may not reinforce the disadvantaged position of less productive producers – depending on the nature of the transaction costs. Reducing these transaction costs, for example by investments in infrastructure, producer associations, third party quality control and monitoring institutions, could also play a role in reducing the bias against small and less efficient producers and speed their integration into the HQE.

Additionally, we show that contracting between producers and processors may induce the HQE to be more inclusive towards less efficient producers through increased access to capital. We also explain how foreign direct investment may play an important role in this way.

While this chapter is the first attempt to model the introduction of HQ products in developing countries, we realize that our analysis is only the first step. Several issues in this process require more analysis. First, the producer heterogeneity issue and its relation with the HQE which has been the subject of extensive empirical analysis and debate, requires more extensive analysis. Second, the interactions between processors and producers in the HQE are either modeled as spot market transactions or as simple contracts in which processors provide producers with capital at a lower cost. However, there is substantial empirical evidence that this relationship is often more complicated, taking the form of complex contracts or other forms of vertical integration. These different governance forms that are observed in the HQ supply chain affect both the emergence and size of the HQ chain.

While policies and institutions are not explicitly in our model, they do affect the equilibrium indirectly through their effect on the various factors which we have discussed. A few examples may indicate how an extended version of our model could be used to capture such policy effects. For example, if foreign investment rules were liberalized, they could stimulate the HQE through their effect on the inflow of FDI and reduced capital costs for producers. Public investments in infrastructure and institutions that promote quality control and food safety institutions could stimulate the HQE by reducing transaction costs in the HQ market. Economic and institutional reforms could also have non-linear dynamic effects on the HQE if they initially increase the cost of capital because of disruptions (as they did during the early years of the transition in Eastern Europe). In the longer run, however, institutional reform reduces the cost of capital as the more efficient, post-liberalization economic system develops. More generally, policies which affect macro-economic uncertainty and the security of property rights for investors are likely to affect the emergence and size of the HQE through their effects on the cost of capital for producers, either directly or through the profitability of vertical coordination arrangements.

Finally, to further complete the analysis one should also look at the interaction with labor markets. HQ investments affect labor markets as the new investments create off-farm employment both inside the processing facility, as well as in the service sector (e.g., in the areas of extension, packaging, supervision, controlling, marketing and transport). Some – or most – of these jobs are low skilled and may be taken by the poorest of the poor. Empirical studies indicate that if HQ production takes place through vertically integrated company-owned farms, this may have different effects on rural households than when they can start producing HQ commodities themselves (see e.g. Maertens and Swinnen 2009; Maertens *et al*. 2011).

In summary, all these factors should be considered when attempting to analyze the effect of the emergence of HQ markets on households in developing and transition countries. These combined effects are likely to be complex. These and other issues should be the focus of future research and we hope that such models can build upon the theoretical framework that is developed in this chapter.

Figures

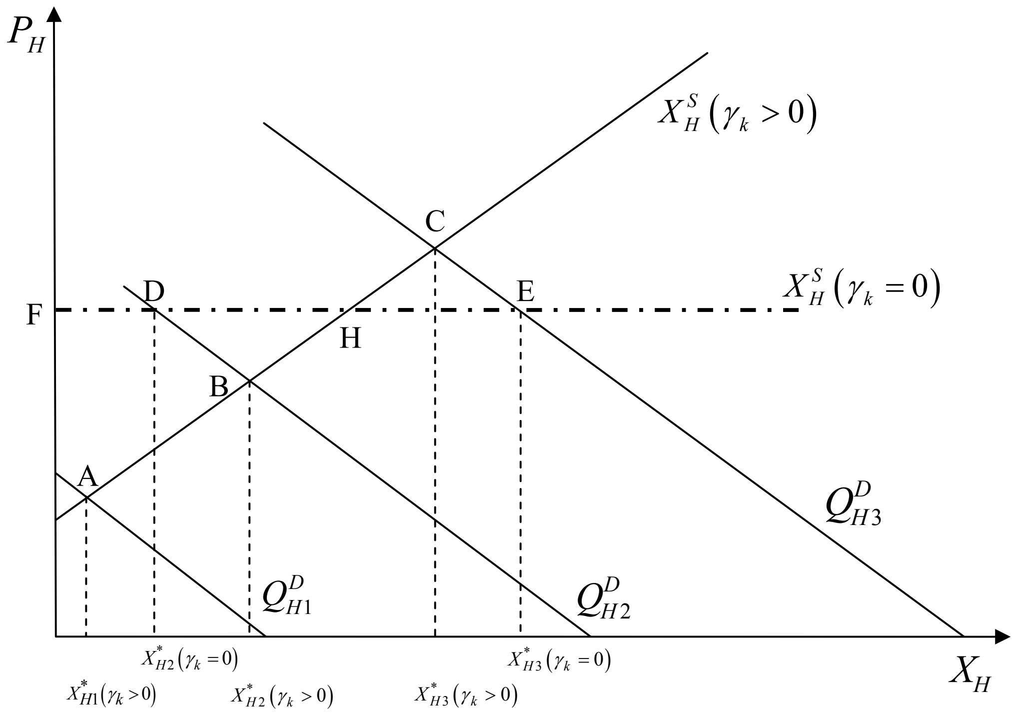

Figure 6.1: HQ Production under Different Production Structures

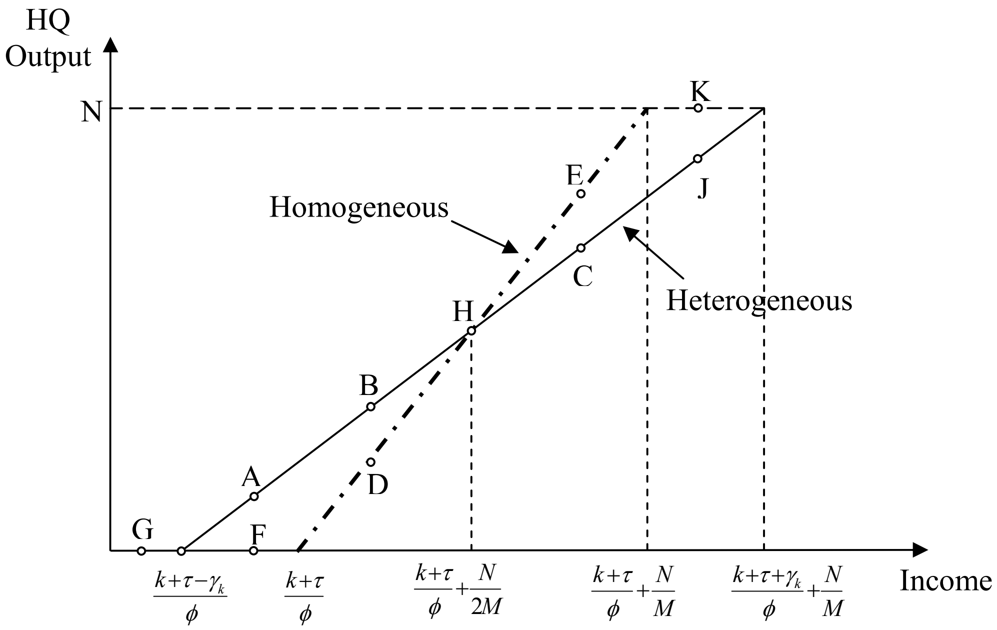

Figure 6.2: Size of the HQE under Different Production Structures

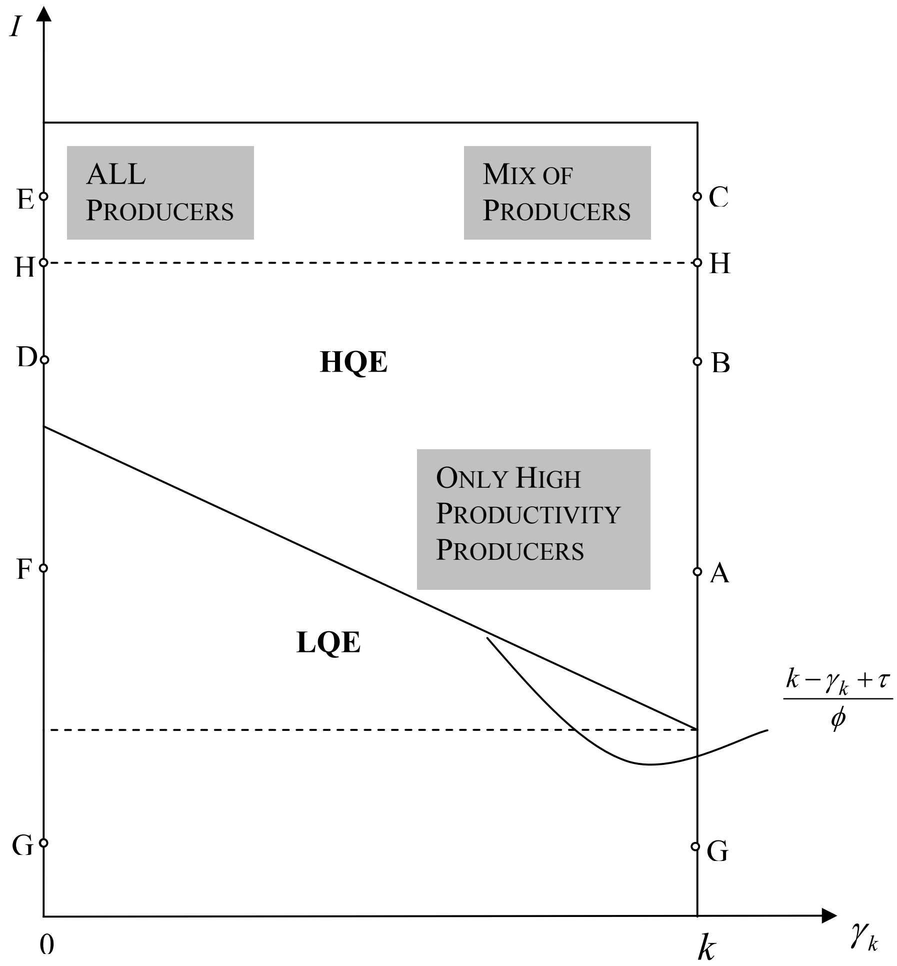

Figure 6.3: Combined Impact of Production Structure and Income on HQE

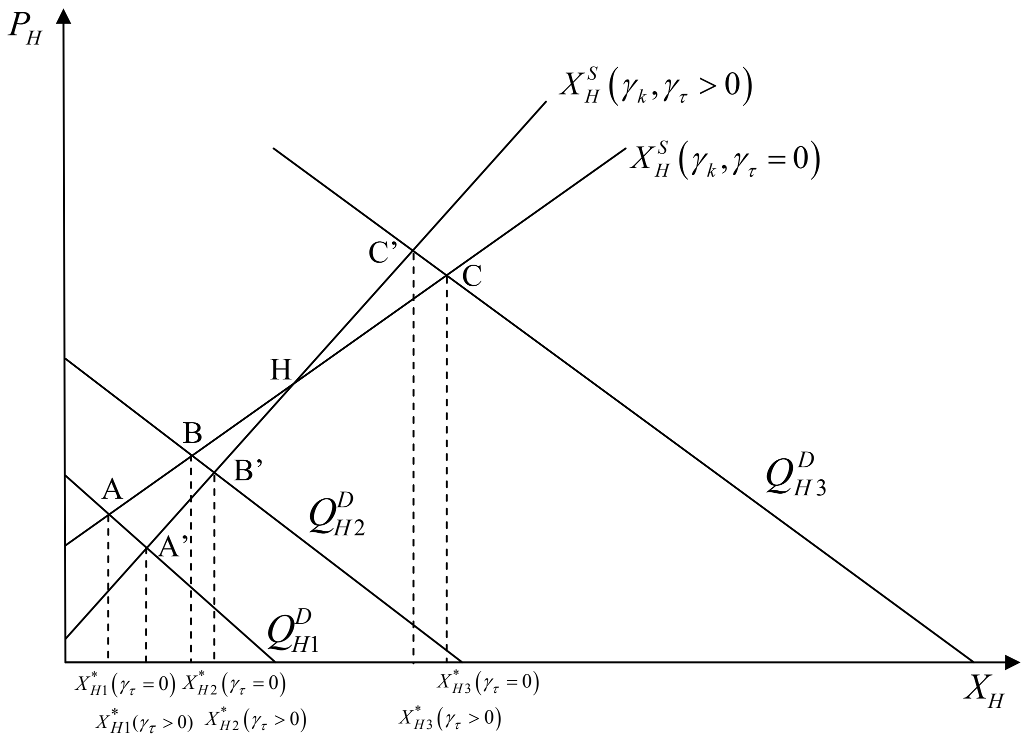

Figure 6.4: HQ Production under Different Types of Transaction Costs

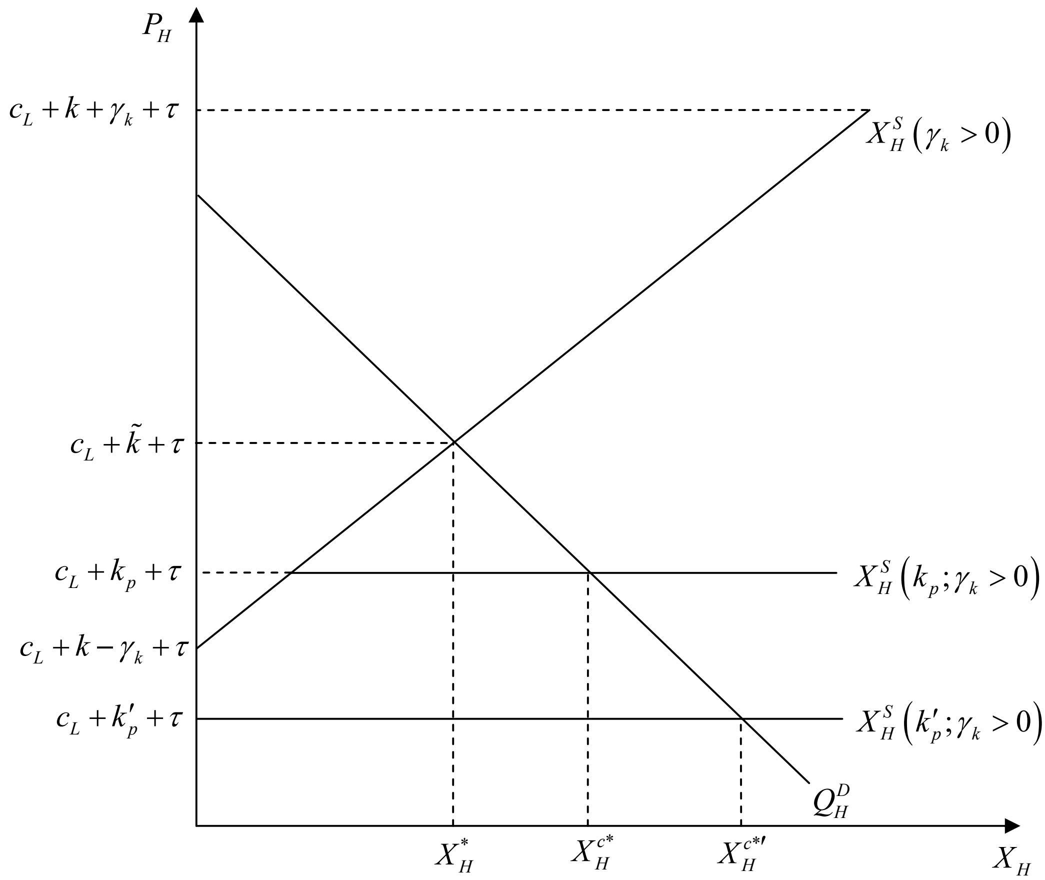

Figure 6.5: Impact of Contracting on the HQE Equilibrium

Chapter 7. General Conclusions

Standards are progressively more important in the global market system. Consumers increasingly rely on public standards (set by governments) as well as private standards (set by firms) to make their consumption decisions. Standards allow taking into account additional product characteristics, besides prices, such as amongst others safety features, quality requirements, environmental friendliness, and social issues. Similarly producers rely heavily on standards to gear their production systems to one another and to increase transparency and traceability throughout the supply chain.

While the above examples illustrate some of the potential benefits of standards, their implementation also entails costs and affects prices. Chapter 2 illustrated that standards may therefore have different – positive or negative – welfare impacts on different actors in the market. Additionally, standards may increase or decrease social welfare. These potentially different impacts on various groups in society have caused suspicion that standards may be captured by lobby groups to serve their individual interests instead of the public. Despite standards' potential benefits, fears have arisen (a) that these public regulations may be used as strategic trade-protectionist tools to shelter domestic producers; (b) that private standards may be introduced by retailers as devices to extract rents from other agents in the supply chain; and (c) that certain (groups of) producers in developing countries may be excluded from these production systems governed by high standards and high quality. Each chapter in this dissertation addressed one of these concerns.

In response to the first concern that standards may serve as protectionist instruments, Chapter 3 developed a political economy model of public standards in which both consumers and producers try to influence the government's standard-setting behavior through lobbying. The model showed that public standards nearly always affect imports and can be either 'catalysts' or 'barriers' to trade, even if standards are optimal from a social welfare perspective. Hence a public standard's impact on trade cannot be directly linked to protectionism since the change in imports may be optimal from a (domestic) social welfare perspective. Additionally, even if public standards deviate from the social optimum, this does not necessarily amount to producer protectionism as producers may be hurt by suboptimal public standards as well. Importantly, the model does not refute the possibility that public standards may serve protectionist intentions, but it nuances the argument that all standards are pure protectionism. Hence an important implication of this chapter is that one should be careful in categorizing standards as protectionist instruments or not, and that standards may be welfare optimal while negatively affecting trade. Additionally, we have demonstrated how our model may contribute to explaining the observed positive correlation between standards and development, and that this relation not necessarily implies that protectionism through standards rises with development as well.

Chapter 4 addressed the same concern of standards-as-protectionism but from a strategic and dynamic perspective. The chapter advanced a dynamic political economy model of technology regulation in which two countries' governments strategically decide which of two technologies to allow by setting a public standard. We showed that a temporary difference in consumer preferences between those countries may trigger differences in initial technology regulations, and thus different investments by producers. Due to these technology-specific investments, producer interests in both countries shift in favor of maintaining the regulatory status quo which excludes foreign imports, although producers were initially indifferent towards the technology choice. Consequently, if governments are responsive to domestic producers' pressures, regulatory differences may be long-lasting even if consumer preferences are identical between countries in the long run. Hence producer lobbying may create hysteresis in (differences in) technology regulation. These results fit well the differences in biotechnology regulation between the EU and the US, and illustrate that both consumer preferences and protectionist motives play a crucial role in explaining these differences. The main factor that causes producer lobbying and thus regulatory persistence is the cost related to switching between different technologies. If producers would be able to adjust their production technology without losing profits to foreign producers, their incentives to lobby in favor of a regulatory status quo would disappear and hence the hysteresis in technology regulation as well. This holds the important policy implication that to overcome the status quo bias, adjustment costs need to be reduced. This would effectively reduce the capture of public standards and technology regulation by interest groups that aim at protecting their home markets from foreign imports.

Chapter 5 tackled the second issue, namely that retailers may employ private standards to extract rents from other agents in the supply chain. The model showed that several factors may cause retailers to set their private standards at more stringent levels than public standards. Retailers are more likely to set relatively more stringent and rent-extracting private standards if (a) the rent transfer from the retailer to producers is smaller such that producers bear a larger share of the standard's implementation cost; (b) the producers' interest group has a larger political power when producers' interests are opposite to those of the retailer; (c) the standard creates a smaller efficiency gain for consumers; and (d) the standard entails larger implementation costs for producers. We also show that retailers' market power is crucial in this argument: if retailers have no market power, private standards are never set at higher levels than public standards. Hence when producers use their political power to obtain lower public standards, retailers may apply their market power to set higher private standards. In combination these factors may contribute to explaining why industry-wide private standards may be more stringent than their public counterparts. Importantly, the model also demonstrated that, in general, the optimal private standard differs from the socially optimal one. This sub-optimality generates additional profits for retailers at the expense of consumer and/or producer welfare. Therefore government intervention that regulates the use of private standards could be warranted. However, doubts might be cast on the optimality of government intervention in the domain of private standards because, as demonstrated in Chapter 3, also politically optimal public standards may differ from their social optimum due to interest group lobbying.

Finally, Chapter 6 addressed the issue that certain (groups of) producers may be excluded from a high-quality economy (HQE) and supply chains governed by high standards. The partial equilibrium model developed in Chapter 6 showed that the initial production structure (in terms of productivity heterogeneity) affects who is able to participate in the HQE and who is not. The most productive producers switch first to the HQE, and in countries with a more heterogeneous production structure this process is more likely to lead to an initial exclusion of producers, although the emergence of the HQE occurs faster in terms of rising incomes. In countries with a more uniform production structure, the emergence of the HQE, although delayed, can be expected to be more inclusive. We also demonstrated that, depending on their nature, transaction costs may or may not reinforce the disadvantaged position of less productive producers. Additionally, our model showed that contracting between producers and processors – i.e. processors supplying credit to producers – may induce the HQE to be more inclusive towards less efficient producers. The model thus lays out three different mechanisms by which a HQE can be made more inclusive towards different groups of producers, namely (a) by reducing heterogeneity in the initial production structure through raising productivity of the least productive producers; (b) by reducing transaction costs in general and especially those transaction costs that reinforce productivity disadvantages; and (c) by creating an institutional environment that is favorable to contracting between producers and processors or that facilitates producers' access to credit.

The analyses in this dissertation are all theoretical in nature. While these models and their results have not been empirically tested yet, they confirm and explain several important empirical observations and provide with a number of additional testable hypotheses. Hence the empirical assessment of the validity of these theoretical analyses is definitely worth pursuing.

Unfortunately, there is a considerable lack of precise information on standards which allows comparing standards between different countries, and between governments and the private sector. While in principle all information on standards is publicly available, these data have yet to be brought together in a comprehensive dataset that presents an overview of the (number of) different types of standards, at which regulatory levels they are imposed, their relative stringency, their scope of application, etc. The main reason for this lacking overview is that standards are inherently difficult to quantify. First, standards can be categorized in a number of different ways, e.g. according to their scope of application, according to the regulatory level that imposed the standard, according to which products the standard applies, etc. (see e.g. Henson and Humphrey 2008). Additionally one standard may belong to different categories, e.g. a standard may regulate both safety and environmental issues, or a product may be regulated by several related but different standards. Second, while certain issues such as carbon dioxide emissions are easy to quantify and compare, many other types of issues and the standards that regulate them are not. Countries may choose to regulate the same issue through different types of standards. For example to reduce pesticide residues on fruit, a government may restrict the use of a certain type of pesticide (process standard) while another government may prefer imposing a maximum residue level on the final product (product standard), leaving the choice of how not to reach this maximum level to the individual producers. Additionally, countries may choose to regulate issues at different regulatory levels (e.g. at an international, national, or regional level) which further complicates the assessment of which standard regulates which concern or product.

Additional to this issue of quantifying and comparing standards, empirically testing these models imposes substantial data requirements. Take for example the data required to test the model in Chapter 3. To measure the impact of a specific standard on consumer welfare, experiments that measure consumers' willingness to pay for specific standards need to be executed (see e.g. Loureiro and Umberger 2007). Data needs to be gathered on the standard's implementation costs both for domestic and foreign producers. In an ideal situation, one would measure and compare production costs before and after the introduction of the standard while controlling for other factors. Frequently this information is not available and implementation costs have to be estimated (see e.g. Aloui and Kenny 2005). Additionally, to calculate socially optimal standards one needs to be able to measure consumers' willingness to pay and producers' implementation costs *per unit* of the standard.

Provided that sufficient comparable information on a specific standard is available for different countries, and that data on consumers' willingness to pay and domestic and foreign implementation costs for that same specific standard have been gathered in these countries, one can test the model in Chapter 3 and estimate the political power coefficients. By comparing these estimated coefficients, and under the assumptions of our model, one would be able to make inferences on the protectionist nature of that specific standard in these countries.

Although these final paragraphs may seem to challenge the testability of these theoretical models, they should only be interpreted as an indication of the complexities that are likely to arise when empirically testing these models.

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