European Commission

Sustainability standards: Voluntary versus mandatory regulation

Their role in facilitating transition to sustainable agri-food systems

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Contents

Abstract[1]

This report presents a review of economic and managerial literature about mandatory and voluntary sustainability standards. The review addresses the study question: *"Do mandatory standards or voluntary standards do better job in stimulating the transition to sustainable agri-food system?*". A bibliometric review identified four main branches in the academic literature on sustainability standards: Fairness and farmer welfare, Governance, Management and Consumption. The review concluded that sustainability standards can promote the transition toward a more sustainable food system, provide profit opportunity for farmers, improve vertical coordination, but they can be used to increase large firms' bargaining power. The review found also that only a very limited number of papers compared mandatory and voluntary sustainability standards. To address the research question, an illustrative model was developed based on existing literature on safety and quality standards. The model found that the relative performance of voluntary and mandatory standards depends on market conditions (including demand and cost variables and competition) and the policy objectives. If the main objective of the policy action is helping efficient firms to be even more sustainable, voluntary standards may be preferable. Instead, if the main objective is to lead all firms (and the least efficient ones in particular) to ensure at least a minimum level of sustainability, mandatory standards may be preferable.

[1] The authors are solely responsible for the content of the report. The views expressed are purely those of the authors and may not in any circumstances be regarded as stating an official position of the European Commission.

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Executive summary

Objective of the literature review and study question

This report presents the results of an extensive review of economics and managerial literature comparing voluntary and mandatory sustainability standards. The review was written in fulfillment of the requirement of an expert contract that the Joint Research Centre of the EU Commission awarded to the authors.

The goal of the review is to provide organized knowledge in the context of the EU Commission's objectives to improve sustainability standards in the agri-food system, as outlined in the Farm to Fork Strategy (COM(2020) 381 final). Specifically, the contract asked to **compare the efficiency of voluntary vs. mandatory sustainability-related standards in stimulating firms adopting strategies facilitating their transition to sustainable agri-food system**. The overarching study question is:

> ***Do mandatory standards or voluntary standards do better job in stimulating the transition to sustainable agri-food system?***

The following four research questions specified the content of the overarching question:

- Do mandatory standards generate better outcomes in terms of increasing production and supply of sustainable of food than voluntary standards?
- Voluntary vs. mandatory standards: which is the more efficient in stimulating firms to shift towards production and supply of sustainable food?
- Under which conditions voluntary vs. mandatory standards are more effective in promoting transition to sustainable food system?
- What are advantages and drawbacks of voluntary and mandatory standards from firms' behaviour and strategic choice perspectives relevant for the transition to sustainable agri-food system?

To address the study question, the literature review was organized into two steps: (i) a bibliometric review of the literature on marketing standards (Chapter 2 of this report), and (ii) the development of illustrative model comparing voluntary and mandatory sustainability standards (Chapter 3 of this report). The illustrative model expanded existing industrial organization literature on vertical quality and minimum quality standards to incorporate the distinctive characteristics of sustainability standards. Chapter 4 summarizes the findings into direct answers to the four study questions.

Key findings from the bibliometric literature review (Chapter 2)

In the first step, a bibliometric approach was followed to identify major trends in the academic debate about sustainability standards. Three keywords "sustainability", "standards", "food" were selected and searched for in the fields *Economics, Management, Business, Agricultural Economics Policy and Agriculture Multidisciplinary* of the dataset *Web of Science*. 335 papers were identified from this procedure.

A co-word analysis was run on the 335 papers and **four main branches of literature were identified: (i) Fairness & welfare, (ii) Governance, (iii) Management, and (iv) Consumption.** The 30 most cited papers *that had standards as main topic of research* out of the 335 have been selected and reviewed.

- Papers in *Fairness & farmer welfare* branch addressed the effects of standards (mainly organic and fairtrade) on value distribution and farmers' income. Cost and benefits for small and/or developing country farmers were debated in this branch, including unintended consequences as the exclusion of inefficient producers from the market. **Results are mixed and depend on the market characteristics**. This finding suggests that **a sectoral approach to the revision of marketing standards may be advisable to take specific market features into consideration**.
- Literature in the *Governance* branch investigated the design process of voluntary and mandatory standards. They are the result of a complex interaction between multiple stakeholders with divergent objectives and the outcome is shaped by narratives and distribution of bargaining power. Because of heterogeneous goals, moral hazard is possible in the implementation of sustainability standards. **Revision of marketing standards must reconcile divergent interests and consider appropriate monitoring to prevent opportunism.**
- Contributions in the *Management* branch debated the managerial implications of sustainable initiatives in agri-food supply chains, with a special focus on private voluntary initiatives. A Key finding is **that sustainability standards can improve vertical coordination and the sustainability of the agri-food**

system, but at the same time private standards can be used by lead firms in the supply chain to extract profits and build up bargaining power.

- The *Consumption* branch debates the role of standards in eliciting demand for sustainable food. According to these studies, sustainability is a credence attribute and certified standards can be a credible tool to solve asymmetric information problems. **The literature found a circular relationship between the implementation of sustainability standards and the demand for sustainable food.** On the one hand, standards solve the asymmetric information problem and elicit demand. On the other hand, the demand for sustainable food is a key incentive to develop certification schemes and labeling for firms.

Key findings from the illustrative model (Chapter 3)

Because the results of the bibliometric review did not provide a clear answer to the research questions, an illustrative model was developed to address them. **An illustrative model is not intended as a simulation providing a quantitative assessment of cost and benefits of voluntary and mandatory standards. Instead, it is a tool providing a general discussion the key trade-offs and economic variables that a regulator may want to consider in policy design.**

The theoretical foundations of the illustrative model are contributions in industrial organization literature about vertical quality models, minimum quality standards and moral hazard. Mostly, these contributions concerned quality and safety standards and the illustrative model was modified to incorporate the unique characteristics of sustainability standards (from the bibliometric review).

The illustrative model found that:

- Sustainable standards can:
  - Solve asymmetric information problems due to the credence nature of sustainability attributes, supporting the production of sustainable food.
  - Promote positive externalities from sustainable food production.
- Sustainability standards may be needed when one or more of the following conditions hold:
  - Private incentives are low (consumers' willingness to pay for sustainable food is low and/or cost of producing sustainable food is high),
  - Sustainable food production delivers valuable social and environmental externalities,
  - Implementing private standards is too costly (for example, high coordination costs).
- Both voluntary and mandatory standards are vulnerable to opportunism (moral hazard). Firms may increase profits by claiming to sell sustainable food while producing conventional goods. A monitoring system is required to prevent moral hazard.
- Voluntary standards:
  - May be preferable when the policy goal is to support firms in delivering consumers the sustainability attributes that they are willing to pay for (focus on solving information asymmetry and market opportunities for sustainable firms).
  - **Are beneficial for adopting firms and** – in principle – **do not harm other firms.** However, a reduction in price for conventional products may be possible.
  - **The value of externalities that are generated by voluntary standards depends on the share of firms that adopt them**. This share is negatively correlated with (i) cost of producing sustainable food, (ii) the level of sustainability requirements (high requirements lead to low share of adoption)
- Mandatory standards:
  - **may be preferable when the policy goal is to promote the production of externalities** by a large number of firms (focus on allocating production to firms that meet minimum sustainability standards only)
  - **Are beneficial for firms that have low cost of production of sustainable food** if they are a credible signal to consumers, solving asymmetric information problems.
  - **Harm firms with high cost of production of sustainable food.** They may incur in a profit loss and may be forced to leave the market if the sustainable requirements are high (exclusion effect). **In the absence of compensation, mandatory standards are not expected to be Pareto efficient**.
  - **The value of externalities that are generated by mandatory standards depends on the share of firms that must exit the market.** The share is positively correlated with (i) cost of producing sustainable food, (ii) the level of sustainability requirements.
- Combining mandatory and voluntary standards may be efficient if firms are heterogeneous. In this case:

    - Mandatory standards focus on firms with high cost of production of sustainable food and force them to increase the sustainability of their production processes.
    - Voluntary standards focus on firms with low cost of production of sustainable food and support them in capturing consumers' willingness to pay for sustainable food.
    - Illustrative model suggests that exclusion effect of inefficient firms may be attenuated when mandatory standards are combined with voluntary ones because the optimal sustainability requirements may be lower.
- Sustainability standards may be supported with subsidies.
    - **Compensative subsidies can be paid to firms incurring in losses when mandatory standards are implemented.** These payments may attenuate the exclusion effect and may lead to Pareto efficiency. Subsidies may be able to support high sustainability requirements in mandatory standards.
    - **Incentive subsidies are paid to firms adopting voluntary standards.** The objective is to increase the share of adopting firms and to use higher sustainability requirements.
    - Using subsidies to support sustainability standards may increase the benefits of the regulation and facilitate the transition to sustainable food production. However, three main limitations must be considered:
        - **Distribution effects**. Efficient compensative/incentive subsidies are proportional to production costs. If costs are heterogeneous and unobservable or if firm cannot be discriminated (i.e., all firms must receive the same amount of subsidy), distribution effects are possible. Efficient (low cost) firms may be over-compensated and inefficient firms may be under-compensated.
        - Opportunism. Subsidies may exacerbate the moral hazard problem. The combination of standards and subsidies may require a strict monitoring system to prevent frauds.
        - **Barrier to trade.** If subsidies are paid to domestic producers only, the exclusion effect can be severe for international firms.

Answering the research questions (Chapter 4)

The results from the bibliometric review and the illustrative models were used to answer the four research questions.

Do mandatory standards generate better outcomes in terms of increasing production and supply of sustainable food than voluntary standards?

The answer to the question must consider two main warnings.

- **If firms are heterogeneous, mandatory and voluntary standards may be complementary measures instead of substitutes.** Using the two types of standards may: (i) achieve a more efficient allocation, (ii) reduce the cost for firms, and (iii) favor the production of positive externalities than using only one.
    - When voluntary standards are in place, mandatory ones may set lower sustainability requirements, therefore exclusion effect and profit losses are attenuated.
    - When mandatory standards are in place, voluntary standards may focus on a smaller set of firms and high sustainability requirements can be implemented. In this way, the profits of adopting firms increase.
- **The preference between mandatory and voluntary standards may depend on the use of subsidies**. It is possible that mandatory standards require more expensive subsidies than voluntary ones.

Assuming that (i) complementarity cannot be exploited, and (ii) subsidy are not paid, the choice between the two types of standards depends on the objective of the policy. **If the main objective of the policy action is helping efficient firms to be even more sustainable, voluntary standards may be preferable. Instead, if the main objective is to lead all firms (and the least efficient ones in particular) to ensure at least a minimum level of sustainability, mandatory standards may be preferable.**

Voluntary vs. mandatory standards: which is the more efficient in stimulating firms to shift towards production and supply of sustainable food?

The relative efficiency depends on the actual characteristics of the market. Voluntary standards may be more efficient when the main goal is to solve asymmetric information and mandatory standards may be more efficient when the objective is to promote the production of positive externalities when market incentives are not sufficient to achieve the social optimum.

The relative efficiency of the two types of standards may depend on the distribution of (i) the cost of producing sustainable food and (ii) consumer willingness to pay for sustainable food. If the share of production of firms with low cost of production and/or the share of consumer with high willingness to pay is high, voluntary standards may be efficient. Instead, if the share of production of firms with high cost of production is high and/or consumer willingness to pay is low, mandatory standards may be preferable.

As noted in the previous point, the combined use of mandatory and voluntary standards may grant a more efficient shift toward sustainable food production than each type alone, especially if firms or consumers are heterogeneous. Also, subsidies may affect the relative efficiency of the two types of standards.

Under which conditions voluntary vs. mandatory standards are more effective in promoting transition to a sustainable food system?

The choice between mandatory and voluntary standards depends on many variables and market characteristics that can be categorized into three main groups:

- Cost factors defining the cost increase of sustainable production with respect to conventional production.
- Demand factors, including the willingness to pay for sustainable food, and other demand characteristics.
- Competition factors (such as collusion, price vs. quantity competition, time of entry) defining firms' strategic reaction to regulation.

Although a complete characterization of the conditions for relative efficiency is not possible, four key variables were found:

- **Profit margin on sustainable food,** defined as the difference between the willingness to pay of a perfectly informed consumer minus the average cost of production of sustainable food. If the margin is "high" voluntary standards may be preferable. If it is "low" mandatory standards may be preferable.
- **Value of the social and environmental externalities**. If the value is "high" mandatory standards may be preferable. Voluntary standards are preferable otherwise.
- **Share of firms with "high" cost of production of sustainable food on total food production**. If the share is "high" mandatory standards are preferable, voluntary standards are preferable otherwise.
- **Share of consumers with high willingness to pay for sustainable food.** If the market for sustainable food is thin, voluntary standards may be ineffective and mandatory standards are preferable.

What are the advantages and drawbacks of voluntary and mandatory standards from firms' behaviour and strategic choice perspectives relevant for the transition to sustainable agri-food system?

- The industrial organization literature identifies a key trade-off between sustainability requirements and the actual implementation of standards. High requirements imply that participation is low. In this regard, differences exist between mandatory and voluntary standards. **Mandatory standards are more effective in promoting sustainable food production in inefficient firms than voluntary ones, but their cost may be high. Voluntary standards promote sustainability in efficient firms only, the ones that are more likely to adopt private standards if available. However, their impact on inefficient firms is limited.**
- Opportunism is possible when standards are introduced. A key difference was found between mandatory and voluntary standards. Under mandatory standards, inefficient firms may have incentive to opportunism to avoid profit loss. Instead, the opportunistic behavior of firms facing voluntary standards is driven by the extra-profits that the label or certification may give. This difference may affect the public perception of standards and monitoring activities.
- **Mandatory standards may reduce the degree of quality differentiation in the market**. This may result in an unintended price effect. If all producers in the market comply with the mandatory standards, certified sustainable production may be perceived as a prerequisite for market access. Consumers and intermediaries may not be willing to pay a premium in this case.

Introduction

This report summarizes the results of a literature review on the relative efficiency of voluntary and mandatory marketing standards the transition to sustainable agri-food system. The main objective of the research is to answer the following overarching research question:

Do mandatory standards or voluntary standards do better job in stimulating the transition to sustainable agri-food system?

The research goal was detailed **into four sub-questions**:

a) Do mandatory standards generate better outcomes in terms of increasing production and supply of sustainable of food than voluntary standards?
b) Voluntary vs. mandatory standards: which is the more efficient in stimulating firms to shift towards production and supply of sustainable food?
c) Under which conditions voluntary vs. mandatory standards are more effective in promoting transition to sustainable food system?
d) What are advantages and drawbacks of voluntary and mandatory standards from firms' behavior and strategic choice perspectives relevant for the transition to sustainable agri-food system?

These questions were specified in the funding contract and were taken as given by the research team. The research is expected to contribute to the drafting of a revision of the EU regulation on marketing standards following the input of the Farm to Fork strategy.

In order to address the study questions, **a two-step approach was followed**. In the first step, **a bibliometric review of the most influential (most cited) economic and managerial literature** identified the main topics in the academic debate about sustainability standard in food production. The review was used to identify the distinctive characteristics of sustainability standards compared to other standards. Results are reported in Chapter 2. The review concluded that the comparison between mandatory and voluntary standards *was not* among the most debated topics and contributions in this regard were very sparse. A more sensible approach to answer the study questions was to research related fields. In particular, industrial organization models about food quality and safety standards were considered.

In the second step, an illustrative model was developed to illustrate the results of the analysis of industrial organization literature about quality and safety standards. This was a practical and concise way to present the findings from the review of a literature that was indirectly related to the study questions. In fact, conclusions and results literature must be considered in the light of the distinctive features and characteristics of sustainability standards. For this reason, the simple summary of paper would not be sufficient to address the study questions and additional interpretation is needed. The illustrative model is presented in Chapter 3.

Finally in Chapter 4, the conclusions of the research model are presented. In this section each study question is addressed specifically.

Bibliometric and bibliographic analysis of the literature on sustainability standards in the agri-food sector

Marcello Sansone, Annarita Colamatteo, Maria Anna Pagnanelli

This Chapter reports the finding of an analysis of the reference literature on the role of sustainability standards (both mandatory and voluntary) in the agri-food sector. The scope of the review is purposely broad and general keywords were used. The objective of the analysis is to provide a general summary of the main fields of academic literature about sustainability standards, while the study questions are addressed specifically in Chapter 3.

The bibliometric and bibliographic analysis in this Chapter is organized into two steps:

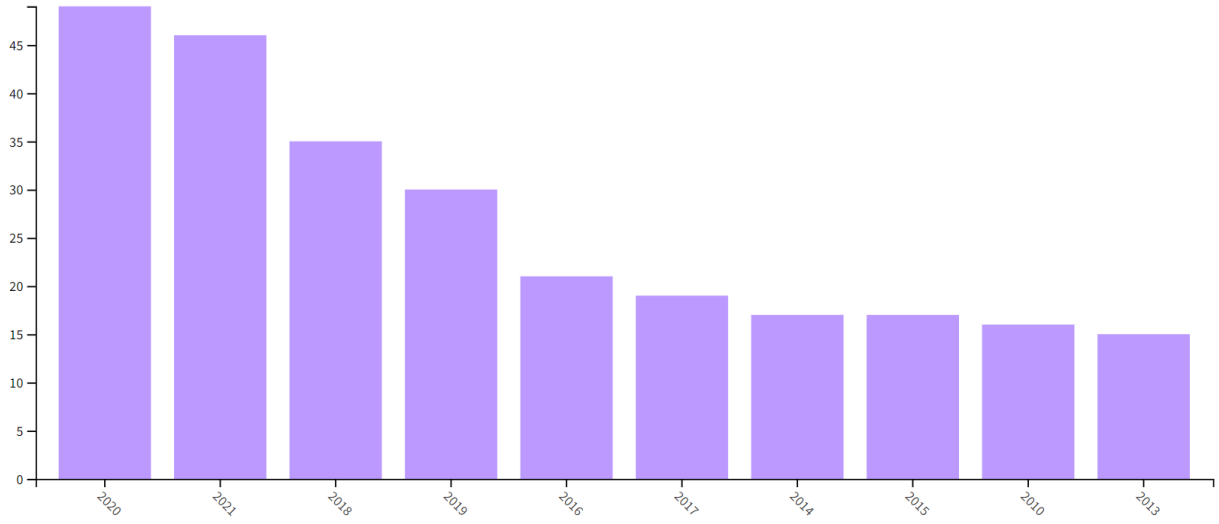
- Literature mapping, where the main research topics (branches) in the academic literature are identified.
- Literature review, where the most influential papers in each branch are reviewed in the context of the research objective.

1.1 Mapping literature

Mandatory and voluntary sustainability standards and their effects are debated by a wide and diverse literature. For this reason, a systematic approach to the review was chosen, instead on focusing on key selected papers. The goal of the first step is to give readers a general perspective of the main topics in the debate.

To this purpose, general keywords were selected to identify the papers to be included in the analysis. The keyword "**standards**" (without adjectives, to include all types), together with "**sustainability**" (in line with the purpose) and "**food**" (to define the sector) were used. This first search of the *Web of Science* dataset yielded 1,863 papers. Among these, however, many are far from our research field (e.g., Environmental Sciences or Environmental Engineering). Therefore, the research has refined the selection using the **disciplinary categories**: Economics, Management, Business, Agricultural Economics Policy and Agriculture Multidisciplinary.

Figure 2-1: Publication years of the 335 selected papers for the bibliometric analysis.



This process led to the selection of 335 papers on the subject of "standards", "sustainability" and "food", which are the starting point for the bibliometric and bibliographic analysis. The distribution of the papers by publication years is reported Figure 2-1.

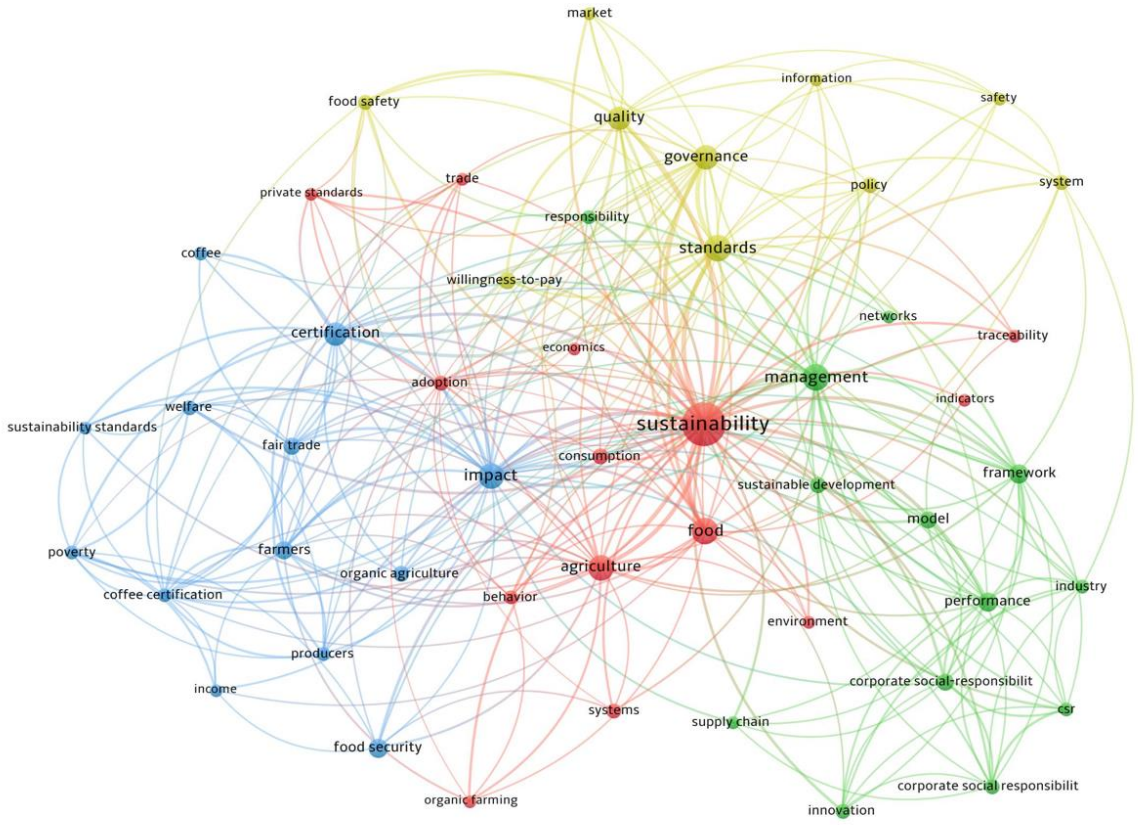
The dataset of 335 selected papers was analyzed through *VosViewer* - one of the main software for the construction of maps and bibliographic networks - for the definition of research maps according to the methodology of co-word analysis of papers' keywords, title or abstract. These maps illustrate the content of the studies and the cognitive structure relating to a specific scientific field (Courtial & Callon 1984). In fact, they provide information on core topics

- *active research fronts in a specific scientific field and emerging topics* - and are useful for understanding the network of correlations between primary, secondary, and emerging topics, going beyond the simple analysis of the content of research contributions. From the application of this methodology, it was possible i) to map the co-occurrences of keywords and the frequency with which they occurred within the most relevant papers on the topic, and ii) to identify the research branches and which the most debated topics.

A map built on co-occurrences of terms (co-word analysis) provides a better presentation of the knowledge structure than other science maps. The co-occurrences that emerge with this method refer to the keywords or words contained in the titles, in the abstract or in their text. The co-word frequency matrix is used to construct a map that represents the intellectual content of a scientific field using ensemble analysis and network analysis.

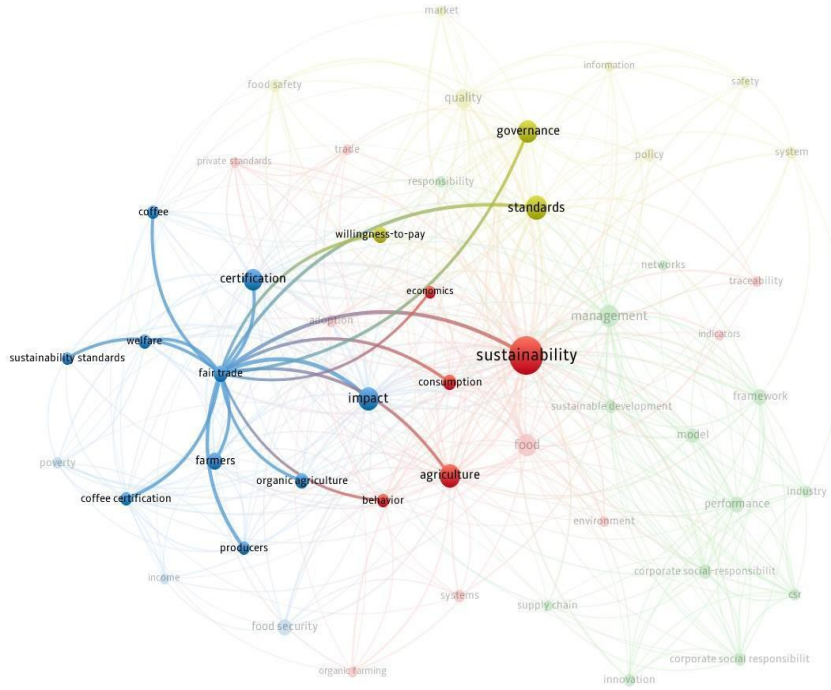
Figure 2-2 shows the results of the co-word analysis for the 335 selected papers, graphically highlighting 4 main research branches on the subject: 1) Fairness and welfare (blue), 2) Governance (yellow), 3) Management (green) and 4) Consumption (red).

Figure 2-2: Bibliometric map from co-word analysis



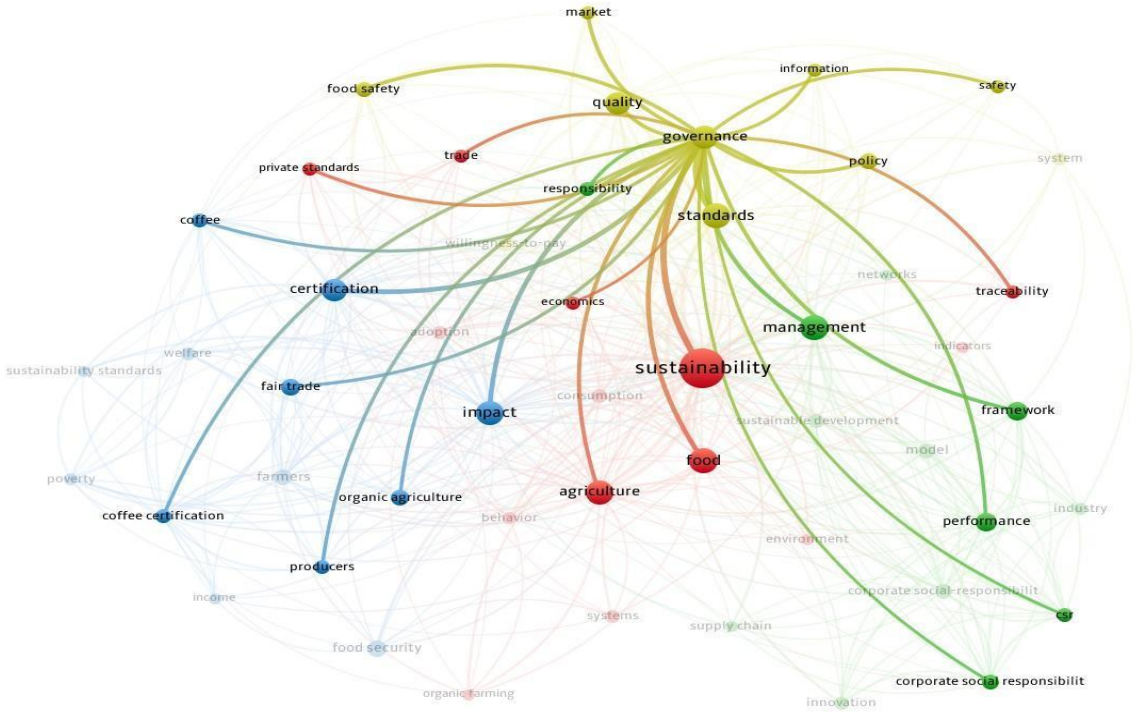
The first branch of research (blue) was linked to the theme of fairness and welfare. **Contributions focus on the social dimension of sustainability**. This area of the map links the concepts of standards and sustainability to those of fair trade, well-being of farmers and producers, and welfare. Furthermore, these issues are linked to governance, consumers' willingness to pay, purchasing and consumption behavior (Figure 2-3).

Figure 2-3: Branch "fairness and welfare" of the literature on sustainability standards



The second branch of the co-word map was related to governance, regulatory policies, quality standards (yellow). The contributions in this area focus on **the institutional issues of sustainability standards**. Important links emerged with the management area and fairness related certification (Figure 2-4).

Figure 2-4: Branch "governance" of the literature on sustainability standards



The third (green) branch was about firm management, supply chain management, performance, corporate social responsibility, and innovation, from a managerial perspective. It covered topics related to **managerial issues and**

efficiency of firms adopting sustainability standards. Figure 2-5 highlights the connections with the other research areas.

Figure 2-5: Branch "management" of the literature on sustainability standards

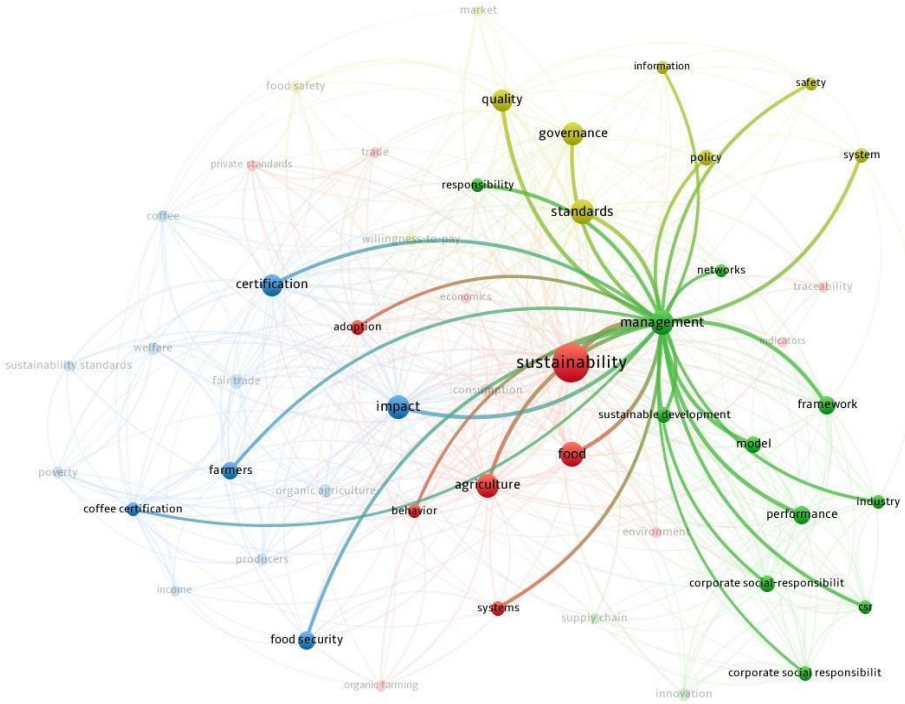
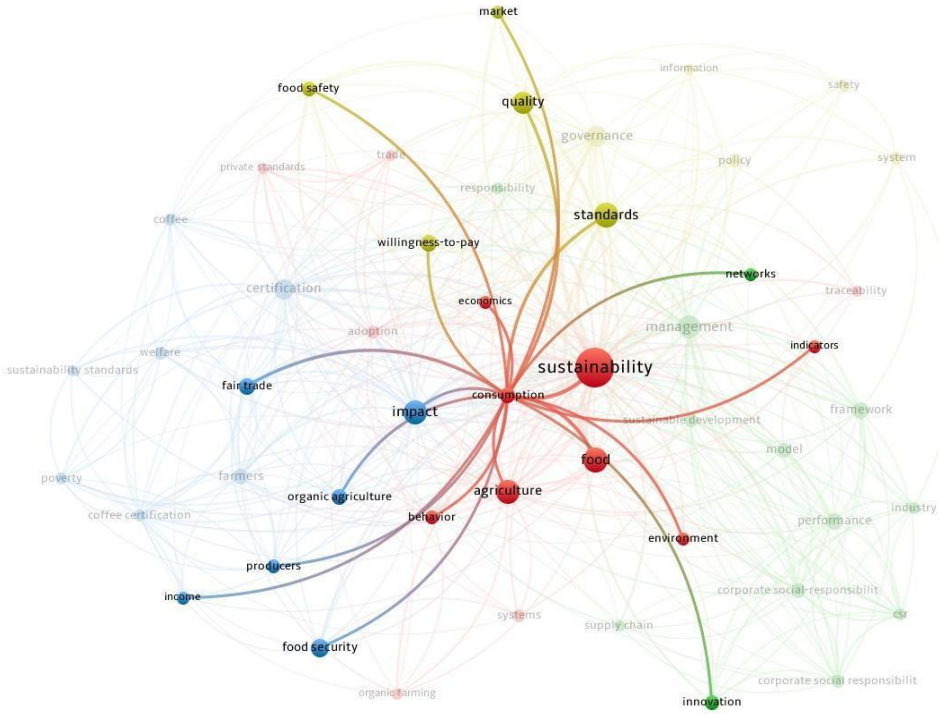


Figure 2-6: Branch "consumption" of the literature on sustainability standards



The fourth area of research was about **consumption** (red). Contributions are linked to consumer behavior, organic products, and agricultural systems. Figure 2-6 highlights the connection between this area and the willingness to pay, the concept of quality, the fair trade, food safety and security.

The bibliometric mapping of the literature brought two main conclusions:

- Sustainability standards are a transversal topic that is debated in the academic literature from many different points of views.
- There are remarkable connections between studies from different disciplines and from different branches of the literature.

The analysis concludes that sustainability standards are a multidisciplinary research field, with a variety of studies approaching managerial, social, policy, and environmental implications of the regulations. In the next Section 2.2 a brief survey of the most influential papers in the literature is reported.

1.2 Analysis of literature by research branch

The 335 papers selected and subject to bibliometric analysis, were sorted by highest citation number. The top 30 papers that had sustainability standards as main topic were classified and placed in the 4 research branches in Section 2.1 based on an analysis of the contents.[2] Furthermore, for each paper, it was indicated whether they referred to Mandatory Standards (MS), Voluntary Standards (VS), Standards (S) in general, or Sustainable initiatives (SI). In the next section the key findings from the papers are summarized.

1.2.1 Fairness and welfare

The branch of literature identified as *fairness and welfare* includes all studies that focus on the effects of sustainability standards on fair trade, welfare distribution, and well-being of farmers, workers, and local communities. Table 2-1 reports the papers with the highest number of citations that were found in the search of the database Web of Science with the keywords described in Section 2.1.

Table 2-1: Most influential papers in the "fairness & welfare" literature branch by number of citations

Reference	Title		N. Cit.
Lotter, (2003).	Organic agriculture	VS	169
Chiputwa, Spielman & Qaim, (2015).	Food Standards, Certification, and Poverty among Coffee Farmers in Uganda	VS	115
Belton, Haque, Little & Sinh, (2011).	Certifying catfish in Vietnam and Bangladesh: Who will make the grade and will it matter?	VS	82
Shreck, Getz & Feenstra, (2006).	Social sustainability, farm labour, and organic agriculture: Findings from an exploratory analysis	VS	82
Pacini, Wossink, Giesen & Huirne, (2004).	Ecological-economic modelling to support multi-objective policy making: a farming systems approach implemented for Tuscany	MS	68
Chiputwa & Qaim, (2016).	Sustainability Standards, Gender, and Nutrition among Smallholder Farmers in Uganda	VS	45
Krumbiegel, Maertens & Wollni, (2018).	The Role of Fairtrade Certification for Wages and Job Satisfaction of Plantation Workers	VS	27
Minten, Dereje, Engida & Tamru, (2018).	Tracking the Quality Premium of Certified Coffee: Evidence from Ethiopia	VS	26

A group of studies in this branch focus on the role of standards in organic agriculture and other voluntary schemes and their appealing for farmers. Pacini et al. (2004) provide a comprehensive analysis of the agroecological benefits

[2] In the process, 18 papers were discarded because they did not addressed standards as a main topic even if the word was mentioned in the abstract, text or keywords.

of organic farming in Tuscany, finding significant improvements in sustainability of food production when the standards are adopted.

Lotter (2003) provides a general analysis of organic agriculture (with focus on the US markets), consumer demand for organic products, and illustrates the benefits from adoption of the voluntary organic standards. It concludes that organic standards were profitable and were particularly appealing for farmers who that have significantly greater concern for long-term farm sustainability, greater willingness to incur present risk for possible future benefits, greater awareness of and concern for environmental problems associated with agriculture. **This finding suggests that farmers may be heterogeneous regarding the cost of implementing sustainability standards or their willingness to adopt them**, depending on their operations and their intertemporal preferences.

Shreck et al.(2006) in a survey of California farmers about the possibility of incorporating social standards (working conditions) into organic standards certification criteria noted that "*nonetheless, the broader international organic community is moving ever closer to formally addressing the needs and rights of farmworkers and attempting to ensure that organic agriculture meets the ''ambitious goal'' of being socially as well as environmentally and economically sustainable",* there was only lukewarm support for social certification in organic farming among certified organic farmers in California. **The key finding is that farmers may have a heterogeneous perception of costs and returns from each dimension of the standards and may have different willingness to accept regulations in the different dimensions. Thus, it should not be assumed that farmers already adopting sustainable standards would necessarily support an extension of the regulations.**

Chiputwa et al. (2015), in a study about coffee production, consider three distinct sustainability standards: Fairtrade, Utz, and Organic. They compared trade volumes, number of certified farmers and the impact on household income. **A key topic in the paper is standard heterogeneity and the impact on farmer welfare**. All three standards have social and environmental objectives, but they pursue them in different ways, measuring and weighting the dimensions differently. Fairtrade focuses on transparency, democracy and guaranteed prices that ensure acceptable living standards. Utz standards on traceability and sustainable production processes as specified by GlobalGAP. Organic certification follows the specific regulation. Author found that Fairtrade certification increases household living standards by 30% and reduces poverty. The other two certification schemes had no significant impacts. **This result implies that the nature of the sustainability requirements that are imposed by the standards may affect farmer income greatly**. In a subsequent study, Chiputwa & Quaim (2016) by using survey data from smallholder coffee farmers in Uganda who participate in Fairtrade, Organic, and Utz certification schemes, analyzed the impacts of smallholder farmers' participation in terms of household nutrition. They argue that sustainability standards in the coffee market have positive impacts on the food security and diet quality of smallholder farmers in Uganda. In fact, sustainability certification improves household income, nutrition, and gender equity.

Krumbiegel et al. (2018) investigated the implications of Fairtrade certification for hired labor on large-scale pineapple plantations in Ghana. The authors explored the impacts on workers' hourly wages and job satisfaction in eight different export-oriented companies. Research results show that both the hourly wage and job satisfaction are in fact higher on Fairtrade certified plantations. The reasons for greater job satisfaction are probably related to higher wages, long-term employment contracts, educational opportunities, company facilities such as medical care and paid holidays, and consolidated trade unions on Fairtrade certified plantations.

The benefits for farmers from voluntary standards may depend on the organization of the supply chain and transaction costs. A survey on the Certification of Voluntary Sustainability Standards (Fairtrade and organic) in Ethiopia coffee industry (Minten et al. 2018) found that there was a significant price premium for certifications at the export level, but farmers receive only one-third of it. A part of a quality premium is used by producers to finance communal investment - such as higher school enrolment rates - but a significantly larger part of the premiums is spent on general expenses and management.

Developing general standards that may be applied to diverse ecosystems can be difficult. Belton et al. (2011), referring to certification standards about Vietnamese and Bangladeshi pangasius industries, question whether standards can increase the sustainability of production. Specifically, analyzing two different areas in Bangladesh and Vietnam, the authors highlight the inherent difficulties in defining standards with an environmental component that can effectively regulate more than one production system simultaneously. The authors noted that the process of setting environmental standards is an arbitrary process, based on the experience of certifiers in developing standards for all forms of aquaculture and not on the analysis of the ecosystems in which the standards will have an effect. This generality may reduce the effectiveness of the standards in managing ecosystems and ultimately the benefits for farm workers.

Contributions in the branch "fairness and welfare" focus on voluntary standard such as organic and Fairtrade and do not include comparative research measuring the effects of mandatory vs voluntary standards. The review of the

literature highlights mixed results. Voluntary standards may have a positive effect in stimulating firms to adopt sustainable behavior and promoting the transition to a sustainable agri-food system, but the evidence about the magnitude of benefits is not conclusive, with some studies finding limited effects. In fact, results may vary greatly depending on the structure of the value chain, country or sector.

1.2.2 Governance

The branch of literature concerning *governance* collects studies focusing on the effects of sustainable standards on public and private governance of the supply chain. Contributions investigate vertical coordination and design of standards. Table 2-2 reports the list of papers with the highest number of citations in the branch.

Nelson & Tallontire in 2014, discussed the role of private voluntary sustainability standards and related multi-stakeholder processes. **The main results of the paper concern the complexity in designing and adopting standards and the role of power in defining norms and objectives**. The analysis investigated the value chains of horticulture and floriculture linking Kenya and the UK and examined labor and good agricultural practices. The focus of the study was the decision to adopt private standards and multi-stakeholder initiatives since the late 1990s. In particular, the authors analyzed the political dynamics to understand how and to what end private standards are used by groups with varying levels of power. To this purpose, they studied the involvement of multiple stakeholders across the different aspects of standards governance: legislative governance, judicial governance, and executive governance. For each type of governance, they also distinguish those related to four different forms of narrative (global sourcing narrative, pragmatic development narrative, broader development narrative and potentially transformative) with the aim to identify the dominant ones and the interactions. **Authors observed that influential stakeholders may impose their narrative and influence the design of standards to their advantage.**

Table 2-2: Most influential papers in the "governance" literature branch by number of citations

Reference	Title		N. Cit.
Wilhelm, Blome, Bhakoo & Paulraj, (2016).	Sustainability in multi-tier supply chains: Understanding the double agency role of the first-tier supplier	S	244
Giovannucci & Ponte, (2005).	Standards as a new form of social contract? Sustainability initiatives in the coffee industry	VS	196
DuPuis & Gillon, (2008).	Alternative modes of governance: organic as civic engagement.	S	61
Nelson & Tallontire, (2014)	Battlefields of ideas: changing narratives and power dynamics in private standards in global agricultural value chains	VS	42
Jespersen, Kelling, Ponte & Kruijssen, (2014).	What shapes food value chains? Lessons from aquaculture in Asia	VS & MS	34
Pant, Prakash & Farooquie, (2015).	A Framework for Traceability and Transparency in the Dairy Supply Chain Networks	MS	31

A study on organic agriculture underlines the interactions between public governance and introduction of sustainable standards (DuPuis and Gillon 2008). The authors argued that government involvement in standards revision within organic agriculture is subject to more public scrutiny and debate than private firms. The results are not necessarily higher standards or consistent benefit flows to producers. An increased focus on standard-setting through a system

of micro-politics analysis of the organic system may lead to an increased importance of organic as a mode of governance.

Giovannucci and Ponte (2005) in their analysis of coffee industry argued that sustainable standards are new forms of social contract in which the government, rather than being directly involved, provides a basic form of guarantee. NGOs and non-governmental organizations are the ones signing the agreements. The certification systems and private initiatives on sustainability can facilitate more direct relationships between producers and consumers and a better knowledge of information on markets, prices, and customer demand for sustainability content. **The key message is the complementarity between public and private action in promoting sustainable food production.**

Whilem et al., 2016 investigated the implementations of private sustainability standards that are designed by a lead firm in a multi-tier supply chain. A multiple agency model was applied to discuss three case-studies. The authors found that three factors were of importance in ensuring successful implementation of sustainability standards: (i) the actual reduction of information asymmetries, (ii) the provision of tailored incentives to each participant to the supply chain, and (iii) and the lead firm's "internal alignment" with sustainability objectives. The key message of the paper is that **voluntary sustainability standards are effective only if they are incentive-compatible, that is if they are consistent with the maximization of the objective function of all firms involved in the production process.**

Pan et al. (2015) investigated the role of sustainable standards in improving quality, safety, transparency, traceability, and information flow in the Indian dairy industry. The authors stressed **the importance of strict monitoring of new standards by the law enforcing agencies in order to avoid opportunistic behavior and promote consumer trust. The necessity of allocating enough financial resources for an effective monitoring is considered in the paper as well**.

The role of sustainability standards in facilitating international trade is addressed by Jespersen et al. (2014). They investigated the role of international and domestic regulations in shaping value chains using data from selected aquaculture industries from four Asian countries. They considered a multiplicity of standards such as ISO, BRC, HACCP, GAA-BAP, ASC, GlobalGAP, IFS, SSOP, pollution free and green food certification (for the domestic market), Fairtrade, ThaiGAP and organic Thai certification. They found that domestic regulation in exporting countries provide key features such as internationally acceptable traceability and testing systems and offer a firm basis on which third-party certification can be built, **confirming the complementarity between public and private roles**. In doing so, the reputation of the exporting country is raised in international trade of aquaculture products, bringing both financial and non-financial benefits.

Literature in the governance branch investigated how voluntary and mandatory standards are designed, in a positive and normative approach. Standards are the result of a complex interaction between multiple stakeholders with divergent objectives where narratives and power shape the outcome. Even after standards are defined, their adoption and implementation depend on the incentives of the participants to the supply chains and opportunistic behavior is possible. For this reason, public monitoring and incentive contracts may be necessary to ensure that standards result in a transition towards sustainable food production.

1.2.3 Management

Papers in the *Management* branch investigated the coordination issues and proposed solutions for efficient implementation of sustainability standards (Table 2-3). Three key topics are developed: (i) factors supporting the adoption of voluntary standards and (ii) consequences of standards on the organization of the supply chain (iii) effects on the performance of the value chain.

Understanding and measuring the factors affecting the decision to adopt voluntary sustainable initiatives was a key field of study. In 2009, Kaufmann et al. investigated the choices of Latvia and Estonia farmers about organic farmers to identify social and economic factors supporting adoption. Social influence alone appears to make little difference. Instead, economic factors are influential. The combination of the two drivers is effective and have a greater impact than the sum of the effect of each one alone. Authors argued that policies are more effective if they are sensitive to specific contexts and the social structure of the community (such as farm structures, the social composition of the farming community, local infrastructure, the way organic farming is perceived) because they shape the attitudes and decisions of entrepreneurs.

Table 2-3: Most influential papers in the "management" literature branch by number of citations

Reference	Title		N° Cit.
Touboulic, Chicksand, Walker, (2014).	Managing Imbalanced Supply Chain Relationships for Sustainability: A Power Perspective	SI	152
Milestad, Darnhofer, (2013).	Building farm resilience: The prospects and challenges of organic farming	S	105
Gerbens-Leenes, Moll, Schoot Uiterkamp, (2003).	Design and development of a measuring method for environmental sustainability in food production systems	SI	100
Kaufmann, Stagl, Franks, (2009).	Simulating the diffusion of organic farming practices in two New EU Member States	SI	72
Fischer, Hartmann, Reynolds, Leat, Revoredo-Giha, Henchion, Gracia, (2009).	Factors influencing contractual choice and sustainable relationships in European agri-food supply chains	VS	59
Fuchs, Kalfagianni, Arentsen, (2009).	Retail Power, Private Standards, and Sustainability in the Global Food System	VS	50
Kleemann, Abdulai, (2013).	Organic certification, agro-ecological practices and return on investment: Evidence from pineapple producers in Ghana	VS	36
Banterle, Cereda, Fritz, (2013).	Labelling and sustainability in food supply networks	S	30
Stubbs, (2019).	Strategies, practices, and tensions in managing business model innovation for sustainability: The case of an Australian BCorp. Corporate Social Responsibility and Environmental Management	SI	28
Stranieri, Orsi, Banterle, Ricci (2018).	Sustainable development and supply chain coordination: The impact of corporate social responsibility rules in the European Union food industry	VS	23

Touboulic et al. (2014) used the theory of power to investigate the implementation of sustainability standards. The analysis focused on the power relationships between retailers and manufacturers in the UK. They found that **commercial dependence can force compliance and leading firms can use power to impose sustainability standards** by inflicting additional costs on the weaker party. By doing so, lead firms capture the largest share of the gains. **Power-based coordination and rent extraction are expected to be resisted by the weak parties in the supply chain**. This may result, albeit indirectly, in a slower transition to a sustainable supply chain and in further conflicts. However, the authors argued that imbalance of power is not necessarily detrimental to sustainability.

Power theory was used to investigate the effects of standards on the **organization of the supply chain** as well. Fuchs et al. (2009) pointed out that large-scale distribution invested considerable resources in the adoption of sustainable private standards that ensure food quality and safety. The introduction of sustainable standards (such as GlobalGap) enables retailers to impose their contractual terms upon producers because of the increased horizontal and vertical integration of value chains. **This might lead to the exclusion of smallholders from production for large scale distribution because of the high costs of compliance and certification**. The authors argue that the adoption of private standard by retailer determine the power of retailers to control the production and processing chain; this is expressed in their ability to exclude certain producers, based on their agro-practices, and in the remodeling of local production structure and resources use in accordance with the demands of global food networks.

Research conducted by Stranieri et al. (2018) focuses on the role of voluntary standards in coordinating the supply chain, through a content analysis on the Global Reporting Initiative reports of European companies operating in the food and beverages sector. The authors found that voluntary *sourcing* standards have the greatest impact on sustainable supply chain management and on the coordination between companies.

Banterle et al., 2013 investigated the effects of sustainability certification on the vertical organization of the supply chains. They discussed 17 cases of large retailers in Italy and in Germany. The results of the analysis show that **eco-certification led to a reorganization of supply chain relationships, with increased bilateral dependence between supply chain actors, a reduction in product uncertainty and a higher degree of vertical coordination**.

Proliferation of standards may attenuate the coordination effects of voluntary initiatives. Fischer et. al (2009) analyze business-to-business relationships in European pork, beef, and cereal supply chains, using data from a survey of 1,442 farmers, processors and retailers in six countries. They found that the adoption of voluntary traceability schemes has not significantly affected vertical relationships in the supply chain, especially where mandatory schemes or standards are already present. Even if from a theoretical point of view, the implementation of traceability schemes is expected to favor vertical collaboration and therefore relations between companies, there are no significant impacts of the additional voluntary schemes. However, they stressed that **the effects of the standards, the choice of the type of contract and the management of relationships is influenced by country-specific factors**.

A third field of research investigated **the effect of sustainability standards on business performance**. In particular, Kleeman & Abdulai in 2013, studying the organic pineapple sector of Ghana, found that organic certification contributes to higher profitability in the small farm sector. They argued organic sustainable certification for small African farmers can provide two types of economic benefits, if properly managed: (i) it can reduce rural poverty by ensuring market access, higher prices, and higher yields, and (ii) it can provide ecological benefits for the local economy in the long run.

Stubbs 2019 addressed the role of business models in the sustainable innovation process. The author found that certification is effective in reconciling economic, environmental, and social priorities. It supports business in codifying practices, reporting to stakeholders, increasing the credibility of the organization economic and social motivations, and attracting the "right" employees in terms of sharing the company's objectives. This ultimately results in better business performances.

Milestad & Darnhofer (2013) found that adopting organic standards increase farmers' resilience[3]. To this purpose, the benefits are not from definition of the standards, but from the ownership of the development process and the management of the standards already defined.

It must be noted that measuring the impact of standards on performance is not an easy task. Gerbens et al. (2004) pointed out the problem of measuring sustainability within the food supply chain. They noted that companies measure the impact of their actions on the environment through a large number of indicators, generating information that are difficult to compare.

Contributions in the research branch *management* addressed the managerial implications of sustainable initiatives in the supply chain. Key findings suggest that private **sustainability initiatives, while improving vertical coordination and the sustainability of the agri-food system, can also be used by strong players in the**

[3] Resilience was defined by "three [...] characteristics: the amount of change the system can undergo while maintaining its functions and structures, the degree of self-organization, and the capacity for learning and adaptation" (Milestad, Darnhofer 2013).

supply chain to extract profits and build bargaining power. Results of the studies vary greatly depending on the empirical setting that is considered. This outcome suggests that **the impact of standards on the supply chain may be sector-specific and country-specific**.

1.2.4 Consumption

The *consumption* branch of literature addresses issues related to consumer demand for certified and labeled sustainable food. The studies investigate consumer preferences and purchasing behavior, consumer perception of sustainable food and the factors affecting sustainable food consumption. Table 2-4 reports the papers that are included in the review.

Thøgersen (2010) states that sustainable consumption depends on individual consumer choices. Yet, individual choices are constrained by a range of macro and structural factors that are determined by political decisions (e.g., standards) and market forces. These factors play a key role in the level of organic (and therefore also sustainable) consumption in a country. This finding implies that **the outcome of regulation may vary with market (or social) conditions.** For example, the implementation of the National Organic Program and the United States Department of Agriculture (USDA) label in the United States in 2002 resulted in a boost to the organic sector. Instead, introduction of the German national logo in 2001 did not seem to benefit the sector particularly, at least in the short run. So, each case appears unique, and the effects of a specific policy' intervention, such as a national organic label, may be reduced or amplified by the intervention of others market's dynamics**.**

The relationship between consumer demand for sustainability and sustainability standards is bi-directional. On the one hand, consumer demand motivates the adoption of standards. For example, Biao et al. 2003 states that an increasing number of critical consumers (who are willing to pay premium prices) enabled the farmers to cover the high costs of sustainable production and obtain a profit.

Table 2-4: Most influential papers in the "consumption" literature branch by number of citations

Reference	Title		N° Cit.
Thøgersen, (2010).	Country Differences in Sustainable Consumption: The Case of Organic Food	S	175
Adams & Salois, (2010).	Local versus organic: A turn in consumer preferences and willingness-to-pay	VS	162
Ricci, Banterle & Stranieri, (2018).	Trust to Go Green: An Exploration of Consumer Intentions for Eco-friendly Convenience Food	S	76
Dixon & Isaacs, (2013).	Why sustainable and "nutritionally correct" food is not on the agenda: Western Sydney, the moral arts of everyday life and public policy	MS	40
Biao, Xiaorong, Zhuhong & Yaping, (2003).	Critical impact assessment of organic agriculture	VS	32
Brayden, Noblet, Evans & Rickard, (2018).	Consumer preferences for seafood attributes of wild-harvested and farm-raised products	S	27
Miller, Tait, Saunders, Dalziel, Rutherford, & Abell, W. (2017).	Estimation of consumer willingness-to-pay for social responsibility in fruit and vegetable products: A cross-country comparison using a choice experiment.	S	23

On the other hand, the introduction of standards may stimulate demand, although sometimes in unpredictable ways. Ricci et al. (2018) investigated the role of trust in promoting consumer eco-friendly behavior and evaluating credence goods. The study found that, among other variables, sustainability standards positively affect trust and ultimately purchase intentions. Similarly, Brayden et al. (2018) investigated consumer preferences for product attributes of shellfish and seaweed salad focusing on certification status (organic, sustainably harvested, non-certified) and product origin (home state, U.S., imported). The study concluded that certification standards (such as Monterey Bay Aquarium's Seafood Watch list) were informative and increased consumer interest in local food.

Mandatory standards may stimulate demand as well. A survey of Australian consumers confirmed the connection between food safety, sustainability and quality standards and increased consumer confidence. This survey also confirmed that consumers are comforted by the high number of mandatory food-related standards in Australia (Dixon and Isaacs, 2013).

An interesting example of unpredicted consumer reaction is Adams and Salois (2010). The paper investigated the effects of the introduction of organic standards within the US food market and found that it stimulated consumers demand for local food. The reason was consumers' response to large corporations' investments in organic food. This study shows that local food production is perceived by consumers as more eco-friendly than organic production from industrialized farming. Because standards allowed large corporations to enter the organic market segment, consumer reacted by shifting to local food.

Many studies in the literature measured consumer preferences in terms of willingness to pay for sustainable food, with mixed evidence. This bibliometric review includes a paper on this topic by Miller et al. (2017), comparing consumer's willingness to pay for social responsibility in fruit and vegetables markets in developed (UK and Japan) and developing countries (India and Indonesia). They reported a willingness to pay for it and debated the importance of certifications and standards to capture the premium.

Studies in the consumption branch of the literature stressed the role of standards in eliciting demand for sustainable food. The key driver of this result is that sustainability is a credence attribute and certified standards can be a credible tool to solve the asymmetric information problem.

1.3 Summary of findings

In this Chapters the results of a bibliometric review on sustainability standards were reported. A list of 335 papers were obtained by searching the *Web of Science* dataset using the keywords: *Sustainability, Standards* and *Food*. The search was restricted to the disciplinary fields: Economics, Management, Business, Agricultural Economics Policy and Agriculture Multidisciplinary. The papers were organized in four branches using co-word analysis: Fairness & welfare, Governance, Management, Consumption. Among the 335 papers, the 30 most cited articles were selected for a review.

The review found that most papers focused on voluntary standards (mostly organic agriculture, GlobaGap, Fairtrade, etc.). The comparison between mandatory and voluntary *sustainability* standards is a neglected topic, and it is almost ignored in the literature. Few papers compare public and private standards.

This finding brought us to the conclusion that the study questions must be addressed with an indirect approach. Instead of searching the literature about sustainability standards for answers, it is more appropriate to build on contributions in related fields. A survey of existing literature suggested that the industrial organization models about *Minimum quality standards*, *Vertical quality*, *Optimal regulation,* and *Monitoring of compliance to regulation* can provide useful insights into the study questions. This literature mostly refers to food quality and safety standards and results must be adapted to take into consideration the distinctive characteristics of sustainability standards. In Chapter 3 we use an illustrative model to summarize the results of this process.

The review of the literature in this Chapter was used to identify the key features that must be considered in the discussion of industrial organization literature. Figure 2-7 reports a synopsis of the main points.

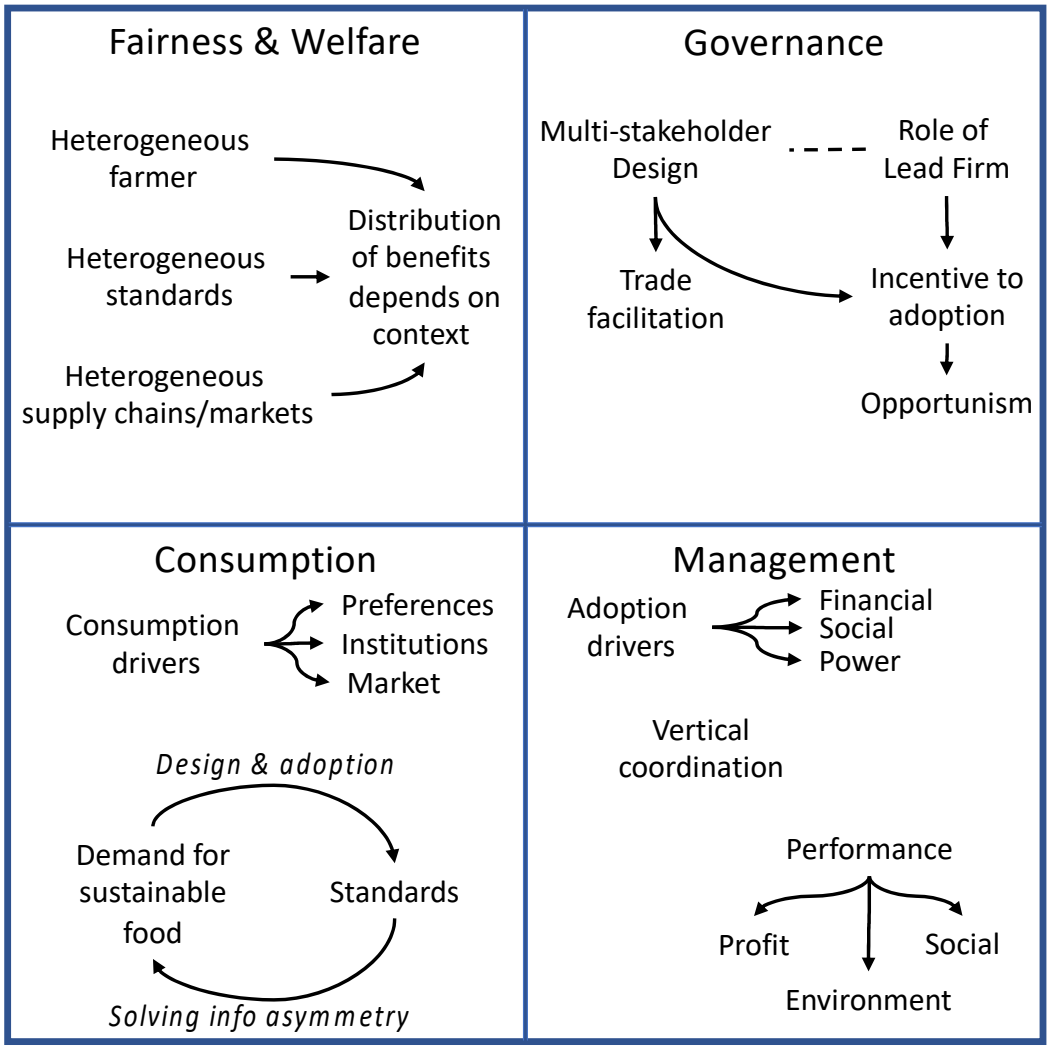
- From the literature from the *Fairness & welfare* branch we found that the issue of **heterogeneity** is a key topic. It involves three main dimensions:
    - farmers have heterogeneous characteristics (such as cost functions, structure, social norms),
    - sustainability standards are heterogeneous because they may weight different dimensions of sustainability in a different way,
    - markets are heterogeneous with respect to the demand for sustainability (such as willingness to pay), structure (for example, concentration, vertical relationships) and firm conduct (e.g., collusion, competition).

The heterogeneity affects the distribution of the benefits from the use of standards among the stakeholders. For example, farmers with different characteristics may benefit to a different degree and some of them may even be

excluded from the market, if standards are too restrictive. The outcome of the policy depends on the actual realization of the many possible combinations of the variables measuring the heterogeneity, i.e., on the actual market conditions.

- The literature from the *Governance* branch suggests that the design of sustainability standards is a multi-stakeholder process, where lead firms (i.e., firms holding bargaining power in the supply chain) can play an important role and impose private standards to their advantage. Each stakeholder has their own objective function, and this diversity implies that models of interest must:
    - Allow for heterogeneous objective functions of stakeholders (including at least regulators, lead firms and weak firms)
    - Consider that opportunism may be possible if the multi-stakeholder process leads to the adoption of standards that are not incentive compatible with the objective function of a group of stakeholders.

Figure 2-7: Synopsis of main findings from bibliometric review



- The literature from the *Management* branch investigated the adoption of voluntary standards finding three key drivers: Financial, social, and power factors. It also found that the performance of sustainability standards must be investigated in a multidimensional setting, including financial (profits), environmental, and social dimensions. It must be noted that industrial organization literature about the topic captures financial and environmental dimensions, while the social dimension is often described in a stylized way (if any).
- The literature from *consumption* branch points out that demand for sustainable goods depends on many factors and it is not just a matter of individual preferences. Institutions and market drivers play a role too.
    - In this process there is a circular relationship between demand for sustainable foods and sustainability standards. Standards may solve asymmetric information problems, and, in this way, they elicit demand.

- At the same time, high demand for sustainable good (and a high willingness to pay) give firms a strong incentive to create and adopt standards.

These findings from the bibliometric review are used to modify industrial organization models that were originally developed to address other issues so that they can provide answers (or insights in) to the study questions.

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An industrial organization perspective

Carlo Russo

Sustainability standards are instruments (such as regulations, procedures, contractual agreements) to improve social and environmental practices in supply chains and to communicate these sustainable sourcing practices to customers (Lambin & Thorlackson 2018, p. 370). In this Chapter we report the findings from a review of the industrial organization literature that were obtained by applying models investigating quality and safety standards to the discussion of sustainability standards.

1.5 Literature of reference and organization of the Chapter

To the best of our knowledge, the industrial organization literature comparing voluntary and mandatory sustainability standards is sparse. Studies from several disciplines point to a complementarity between private voluntary initiatives and public mandatory regulations in promoting sustainability (e.g., Santacoloma 2014, Marx 2018, Lambin & Thorlakson 2018). Yet, few studies provide direct and comprehensive comparisons of costs and benefits of mandatory versus voluntary standards from the perspective of industrial organization (Macedoni 2021, with a focus on trade issues). Nevertheless, an abundance of industrial organization contributions provides useful insights on specific issues related with the study question of this report.

A vast literature on minimum quality standards has been developing since the late 1970s (e.g., Leland 1979) with mixed conclusions about the welfare consequences (for example, Bockstael 1984 found that minimum quality standards reduce welfare and Ronnen 1991 argued that they improve social welfare, especially when they create positive externalities). In general, contributions in this area build on vertical quality models to investigate the effect of a constraint on firms' choice of quality (a typical example is Valletti 2000). To the purpose of this study, applications of interests concern safety standards (e.g., Hobbs 2010), marketing boards, collective standards and collusion (Ecchia & Lambertini 1997, Saitone & Sexton 2011), geographical indications (Moschini et al. 2010), and consumer information (Garella & Petrakis 2008).

Another area of interest relates with the role of standards as a tool to solve moral hazard problem in agri-food supply chains when quality (or, in this case, sustainability) cannot be observed. Building monitoring systems is one of the possible solutions to the problem (e.g., Milgrom & Roberts 1992). In this regard, codification of procedures (such as standards) enables effective monitoring and promotes efficient governance of global value chains (Gereffi et al. 2005) at the same time. This field of study is relevant to the study question because it investigates the behavioral consequences after marketing standards are implemented in the market (Hirschauer et al. 2012). The effectiveness of marketing standards in promoting sustainability depends on firms' compliance to the requirements but firms may have incentive to deviate from the standards, if profitable. This area of study addresses questions such as how many firms adopts voluntary standards, and how many of them comply with mandatory standards or commit frauds.

The survey of the literature concludes that studies in this area are highly heterogeneous (see for example Nes & Ciaian 2021, 2022) and address the study question indirectly only. For these reasons, a presentation of the results based on summaries of a set of papers does not provide concise and applicable information for policy decision. For a concise and meaningful presentations of the conclusions from the industrial organization literature, an illustrative example is used instead.

An illustrative model is a simple mathematical or numerical representation that is used to provide an intuitive discussion of the relationships between economics variables, without the burden of advanced mathematical tools (Meade 1974). This technique is used for general assessment of policy alternatives and simple illustration of how institutional choices may affect market outcome (Gallopìn 1980). The emphasis of illustrative models is in the presentation of issues and trade-offs, without the pretense of being an actual ex-ante assessment of policy measures. The solution of the model can be considered as an illustrative example only.

In this chapter, a simple industrial organization model is developed to explain the key trade-offs that regulators must consider when evaluating the consequences of the implementation of voluntary or mandatory standards. **The illustrative model is not intended as a normative tool. The objective is not to give specific policy advice. Instead, the goal is to identify what are the key variables at play and the possible unintended outcomes.** In this example, mandatory and voluntary public standards are compared in the light of industrial organization theory, and key policy implications are identified. In particular, the following topics are discussed:

- **Differences in the definition and objectives of mandatory vs. voluntary and private vs. public standards** (Section 3.2.2), based on the contributions of Henson & Reardon (2005), Meybeck & Redfern (2014), Lambin & Thorlakson (2018)
- **Optimal mandatory or voluntary standards: computing marginal costs and benefits.** (Section 3.3). *The section is a concise discussion the basic trade-offs between consumer willingness to pay, value of the externalities and cost of implementing the standards that a regulator may face when considering introducing sustainable standard*. The key differences between voluntary and mandatory standards are outlined in this section. The material is derived from the contribution by Segerson 1999, Swinnen & Vandemoortele (2008, 2011), Saitone & Sexton (2010).
- **Distributive effects and firm heterogeneity** (Section 3.4). Introducing firm heterogeneity allows *a discussion of the distributive effects of marketing standards among producers*. The example illustrates the effect of firm heterogeneity on optimal standard design. It extends the results from a theoretical and empirical literature on safety standards to sustainability (e.g., Cho & Hooker 2007, Rau & van Tongeren 2009, Pouliot 2014, Rouvière 2016).
- **Compliance, frauds, and monitoring** (Section 3.5). In this section, we consider possible food frauds (i.e., selling products claiming that they comply with the standards when they do not). *The setting of the example is a typical moral hazard framework* that has been applied widely to food safety standards (Starbird 2005, Hirschauer et al. 2012) and environmental control (e.g., Merel & Carter 2008).
- **Combination of mandatory and voluntary standards** (Section 3.6.1). Several contributions point out a complementarity between different kinds of standards. *The section explores the use of more than one type of standards to improve sustainability of food production*. The discussion is derived from an extremely simplified version of the model by Fischer & Lyon (2019).
- **Regulating market when private standards are already in place** (Section 3.6.2). The model in Section 3.6.1 is extended to allow for different times of implementation of the standards. In particular, the case of the design of mandatory public standards with pre-existing private voluntary standards is considered. The section is a simple derivation of entry models in vertically differentiated markets (e.g., Donnenfeld & Weber 1992, Aoki & Prusa 1997).

The illustrative example provides a concise, simple, and organized presentation of the material, at the cost of generality. It must be clearly noted that the specific results are conditional to the assumptions and the calibration of the model, which are described and discussed extensively during the presentation. In the discussion of the results, explicit consideration is given to the sensitivity of results to changes in calibration.

To simplify the presentation, the technical details of the model and calculation are reported in the technical appendix to this Chapter. The discussion focuses on results and implications.

1.6 Structure of the illustrative model

1.6.1 Assumptions of the model

In order to simplify the discussion, the illustrative model assumes that sustainability can be measured with a scalar θx. The higher the value of θx, the more sustainable food production is. This is a common assumption in modeling (e.g., Arora & Gangopadhyay 1995) even if sustainability is a multidimensional concept and using one-dimension measures is a rough approximation.

In a one-dimension setting, sustainability standards can be defined as rules ensuring that the level of sustainability of food production $\boldsymbol{\theta x}$ is equal or greater than the sustainability requirements $\boldsymbol{\Theta_h}$. If the standards are in place, the firm maximizes profits under the constraint $\theta x \geq \Theta_h$.

The illustrative model gives a stylized description of the interactions between the main economic variables at work in a market that is regulated with sustainability standards. According to the industrial organization literature assumptions about the variables can be grouped into four categories:

- **Assumption about consumers**, explaining the demand for sustainable food production.
    - *Sustainability as product attribute*. The model setting is based on Lancaster (1966) theory and sustainability is considered as a product attribute contributing to consumer utility.
    - *Imperfect information*. It is assumed that sustainability is a credence attribute and cannot be observed by consumers even after consumption (Darby & Karni 1973). This implies that consumers take their purchasing decisions based on *their expectations* about θx ($\widehat{\theta x}$). Expectations are built on firms' claims about sustainability. If firms claim that they are using sustainability standards h, $\widehat{\theta x} = \Theta_h$ otherwise consumers expect that the sustainability level is at the lowest level θmin.[4]
    - *Linear willingness to pay*. Utility functions are used to rank preferences for different values of θx or to establish how much consumers are willing to pay for sustainability. Following a common simplification in industrial organization models, we assume that consumers' willingness to pay for sustainability $wtp(\widehat{\theta x})$ is a linear function of the expectations $\widehat{\theta x}$, with $wtp(\widehat{\theta x}) = R \cdot \widehat{\theta x}$ and consumer surplus is equal to the willingness to pay minus price (p) (Mussa & Rosen 1974). The parameter R is the consumers' marginal willingness to pay for sustainability and it can be adjusted to low values if consumers give limited value to firms' claims.
    - *Infinite demand, equilibrium prices and frauds.* Unlike Mussa & Rosen (1974), we assume that demand is infinite (or at least it is larger than production) and consumers are willing to buy any quantity of product for a price $p \leq wtp(\widehat{\theta x})$. Competition among consumers leads to an equilibrium price $p = wtp(\widehat{\theta x})$, meaning that *if expectations are correct* (the firm claims are true) consumers achieve zero surplus. Surplus is negative if firms claim to use the standards, but they do not (i.e., firms commit frauds).
- **Assumptions about costs.** These variables define the cost of sustainable food production for firms. Typically, they are defined with cost functions. The model predictions about policy outcome or market equilibrium can vary remarkably, depending on the assumptions about cost functions (Ronnen 1991). The issue has been studied extensively in the literature about vertical quality models (e.g., Tirole 1988). In the illustrative model, a simplified version of Ronnen's (1991) cost function is considered. It is assumed that an infinite number of firms produces a fixed infinitesimal quantity for a cost $C_i(\theta x)$ that is a convex function of the sustainability attribute. In particular, it is assumed that $C_i(\theta x) = c_i \cdot \theta x^2$, where c_i is an individual and unobservable cost parameter that is homogenously distributed between a minimum and a maximum value ($cmin$ and $cmax$, respectively) with $c_i \sim U[cmin, cmax]$. It must be noted that because sustainable production is a credence attribute, firms may have incentive to opportunistic behavior (see the discussion in Section 3.5).
- **Assumptions about competition.** The nature of competition (for example price vs quantity competition or simultaneous vs. sequential entry) plays an important role in determining the outcome of quality model (Motta 1993). In the illustrative model it is assumed that firms are price takers, there is not strategic interaction and that their only decision is the value of θx they offer. In this way, the illustrative model is suited to describe

[4] Several contributions in the literature point out that consumers have limited trust in firms' claim about sustainability (Atkinson & Rosenthal 2014, Tonkin et al. 2015, Nuttavuthisit & Thøgersen 2017). This evidence conflicts with the assumption that consumers build expectations based on firms' claims. The issue is considered in a following assumption because the value of marginal willingness to pay for sustainability (R) can be lowered in order to account for consumers' mistrust.

the behavior of an infinite number of very small producers, such as the European or even international farmers. Market power models could be used if the goal was to describe the behavior of large firms in processing or retailing industries.

- **Assumptions about externalities.** Sustainable food production creates positive externalities for society, for example reducing environmental impact or promoting social inclusion. The magnitude of the externalities affects the benefits of marketing standards in terms of social welfare (Ronnen 1991). In this illustrative model, it is assumed that the economic value of externalities from sustainable food production $\mathrm{A}(\theta x)$ is an increasing and concave function of θx, with $\mathrm{A}(\theta x) = a \cdot \ln(\theta x)$. Concavity of $\mathrm{A}(\theta x)$ and convexity of $C_i(\theta x)$ ensure that the model has an interior solution in θx.

For the reader's convenience, we report the list of the model variables and the specification of the functional forms in the following Table 3-1 and Table 3-2. Table 3-1 reports the numerical values that are chosen for the illustrative example as well. A detailed discussion of the variables and the functional forms is reported in the technical appendix to this Chapter.

Table 3-1: List of the variables in the illustrative numerical example and numerical values

	Variables and Parameters	**Definitions/ Numerical values**
θx	Level of the sustainability attribute in a unit of product	$\theta x \in [\theta min, \theta max]$
θc	Firm's claim about θx (the claim can be false)	$\theta c \in [\theta min, \theta max]$
θmin	Minimum technical level of t θx	$\theta min = 1$
θmax	Maximum technical level of θx	$\theta max = 2$
Θ_h	Sustainability requirements in standard h (requiring $\theta x \geq \Theta_h$)	$\Theta_h \in [\theta min, \theta max]$
θx_i	Level of the sustainability attribute provided by firm *i*	$\theta x_i \in [\theta min, \theta max]$
$\widehat{\theta x}$	Consumer expectations regarding θx (credence attribute)	$\widehat{\theta x} = \theta c$
$wtp(\widehat{\theta x})$	Consumer willingness to pay for a product with θx	$R \cdot \widehat{\theta x}$
R	Constant and homogeneous marginal $wtp(\theta x)$	$R = 4$
p	Exogenous market price for a unit of product with θx	$p = wtp(\widehat{\theta x})$
a	Parameter measuring externality value	$a = 5$
c_i	Heterogeneous and unobservable cost parameter	$c_i \sim U[cmin, cmax]$
$cmin$	Minimum value of c_i	$cmin = 1$
$cmax$	Maximum value of c_i	$cmax = 4$
$\mathrm{K}_{X,Y}$	Value of c_i making a firm indifferent between alternatives X and Y	$\mathrm{K}_{X,Y} \in [cmin, cmax]$
g	Parameter measuring the cost of monitoring	$g = 0.1$
F	Expected penalty if a fraud is committed	$F \in [0, \infty]$
M	Total quantity in the market	$\int_{cmin}^{cmax} 1 dc_i$

Table 3-2: Specification of functional forms

Function	Definition
Consumer surplus from a unit consumption	$CS(\theta x) = R \cdot \theta x - p(\widehat{\theta x})$
Firm *i*'s profit function (unit production)	$\pi_i(\theta c, \theta x) = R \cdot \widehat{\theta x} - c_i \cdot \theta x^2$
Monetary value of externality from a unit	$\alpha(\theta x) = a \cdot \ln(\theta x)$
Cost of monitoring a unit production	$\gamma(F) = g \cdot F$
Social welfare from a unit trade	$\omega(\theta x) = \pi(\theta x) + \alpha(\theta x) + CS(\theta x) - \gamma(F) + F$

1.6.2 Taxonomy of sustainability standards

For modeling purpose, sustainability standards can be grouped into four categories based on the combinations of two binary characteristics: their public or private source, and their voluntary or mandatory nature (see Meybeck & Redfern 2014). Table 3-3 illustrates the differences between the types.

Table 3-3: Types of sustainability standards

Nature	**Source**	
	Public	Private
Voluntary	*Objective*: Max social welfare *Available alternatives to adoption*: Conventional production Fraud Exit	*Objective*: Profit Max *Available alternatives to adoption*: Conventional production Fraud Exit
Mandatory	*Objective*: Max social welfare *Available alternatives to compliance*: Fraud Exit	*Objective*: Profit Max *Available alternatives to compliance*: Fraud Exit

The source of the standards defines their objectives and efficiency criterion. We assume that public standards aim at maximizing social welfare while private standards maximize producer surplus only.

The nature of the standards defines the strategic alternatives that are available firms. *Under mandatory standards*, the available alternatives are:

- Complying with the mandatory rules (setting $\theta x = \Theta_h$)
- Leaving the market (exit)
- Committing a fraud (falsely claiming $\theta x = \Theta_h$ while setting $\theta x = \theta min$).

Under voluntary standards, the available alternatives are:

- Adopting the voluntary rules (setting $\theta x = \Theta_h$)
- Conventional production (setting and claiming $\theta x = \theta min$)
- Leaving the market (exit)
- Committing a fraud (falsely claiming $\theta x = \Theta_h$ while setting $\theta x = \theta min$).

In order to avoid ambiguity in jargon, the terms *compliance* (or *to comply*) refers to the firms' implementation of mandatory standards, *adoption* (or to *adopt*) refers to firms' implementation of voluntary standards, and *implementation* is used to refer to mandatory and voluntary standards alike.

Firms choose the profit-maximizing alternative. Profits $\pi_i(\theta c, \theta x)$ are function of two decision variables: the level of sustainability firms achieve in their production (θx) and their claims to consumers about sustainability (θc). If a firm chooses to commit a fraud the following inequality holds $\theta c > \theta x$. For all other alternatives, $\theta c = \theta x$. The payoffs of each alternative are reported in Table 3-4 (all parameter and values are defined in Table 3-1).

Table 3-4: Payoff of firm's alternatives given a sustainability standard

	Alternative	Payoff	Payoff Specifications
C	Comply with mandatory standards (requirements Θ_m)	$\pi_i\{\Theta_m, \Theta_m\}$	$R \cdot \Theta_m - c_i \cdot \Theta_m^2$
A	Adopt voluntary standards (requirements Θ_v)	$\pi_i\{\Theta_v, \Theta_v\}$	$R \cdot \Theta_v - c_i \cdot \Theta_v^2$
N	Conventional production	$\pi_i\{\theta min, \theta min\}$	$R \cdot \theta min - c_i \cdot \theta min^2$
F	Fraud (falsely claiming to use standards Θ_f)	$\pi_i\{\Theta_f, \theta min\}$	$R \cdot \Theta_f - c_i \cdot \theta min^2 - F$
E	Exit	$\pi_i\{0,0\}$	0

The payoffs in Table 3-4 depends on the value of the individual cost-efficiency parameter c_i. If c_i varies, firms may choose different alternatives depending on their specific cost-efficiency. The parameter $\mathrm{K}_{X,Y}$ is the value of c_i making firm i indifferent between alternative X and alternative Y, with X, Y = C, A, N, F, E from Table 3-4. All values of are constrained to be $\mathrm{K}_{X,Y} \in [cmin, cmax]$. For example, $\mathrm{K}_{C,E}$ is the value of c_i identifying the firm that is indifferent between comply with mandatory standards or exiting the market ($\pi_i\{\Theta_m, \Theta_m | c_i = \mathrm{K}_{C,E}\} = \pi_i\{0,0\}$). All firms with $c_i \leq \mathrm{K}_{C,E}$ choose to comply, all firms with $c_i > \mathrm{K}_{C,E}$ choose to exit. The values of $\mathrm{K}_{X,Y}$ are reported in Table 3-12 in the appendix.

1.6.3 Aggregation and objective functions.

The functions in Table 3-2 refer to a single transaction that is the sale of one infinitesimal unit of product. In order calculate aggregate values, it is sufficient to compute a definite integral over an interval defined by the appropriate indifference conditions.

For example, consider a public mandatory standard such that compliance or exit are the only alternative (perfect monitoring). In this case, aggregate profits are defined as: $\Pi(\theta x) = \int_{cmin}^{\kappa_{C,E}} \pi_i\,(\Theta_h, \Theta_h) dc_i$. Other aggregate quantities are defined in a similar way.

1.6.4 Presentation of results from the illustrative example.

In the following sections, the results of the illustrative example are reported. For clarity of presentation, we use an incremental approach. We discuss simpler models first and build up to more complex representations.

In Section 3.3, the simplest model is presented, where firms are homogenous (i.e., all firms share the same value of c_i), and standards are perfectly monitored. The example introduces the trade-off between strict standards (i.e., imposing high Θ_h) and implementation by firms. The main conclusion is that strict standards may have limited impact on sustainability if few firms use them. Less strict standards (i.e., low Θ_h), but with higher implementation rate may be more beneficial than strict standards, under specific conditions.

Section 3.4 introduces firm heterogeneity (i.e., c_i is a random variable that is uniformly distributed between two extreme values $cmin$ and $cmax$). The purpose of this model is to illustrate the distributive effects of sustainability standards. Because the cost of implementation varies between firms, we observe the coexistence of different choices in the market. This setting is of particular importance when regulators must consider the effects of a revision of marketing standards on groups of firms with different values of the parameter cost (for example, domestic vs. international producers or firms in remote areas).

Moral hazard is introduced in Section 3.5. In this model, monitor is imperfect and costly, and firms are allowed to commit frauds (i.e., claiming that standards are implemented when the firm uses conventional production processes).

The example illustrates the role trade-off between strict standards and incentives to fraud and the behavioral consequences of regulation.

Finally, Section 3.6 illustrates the issues related to the coexistence of multiple standards in the market. Two cases are discussed: (i) the coexistence of mandatory and voluntary public standards, and (ii) the introduction of public mandatory standards when private voluntary standards are already in place. The analysis provides insights into private-public regulation and illustrates how a combination of measures can be used to obtain greater sustainability objectives when firms are heterogeneous.

In the examples, the discussion focuses on the welfare effects of each type of standards. The conditions for efficiency of standards are derived using sensitivity analysis and comparative statics.

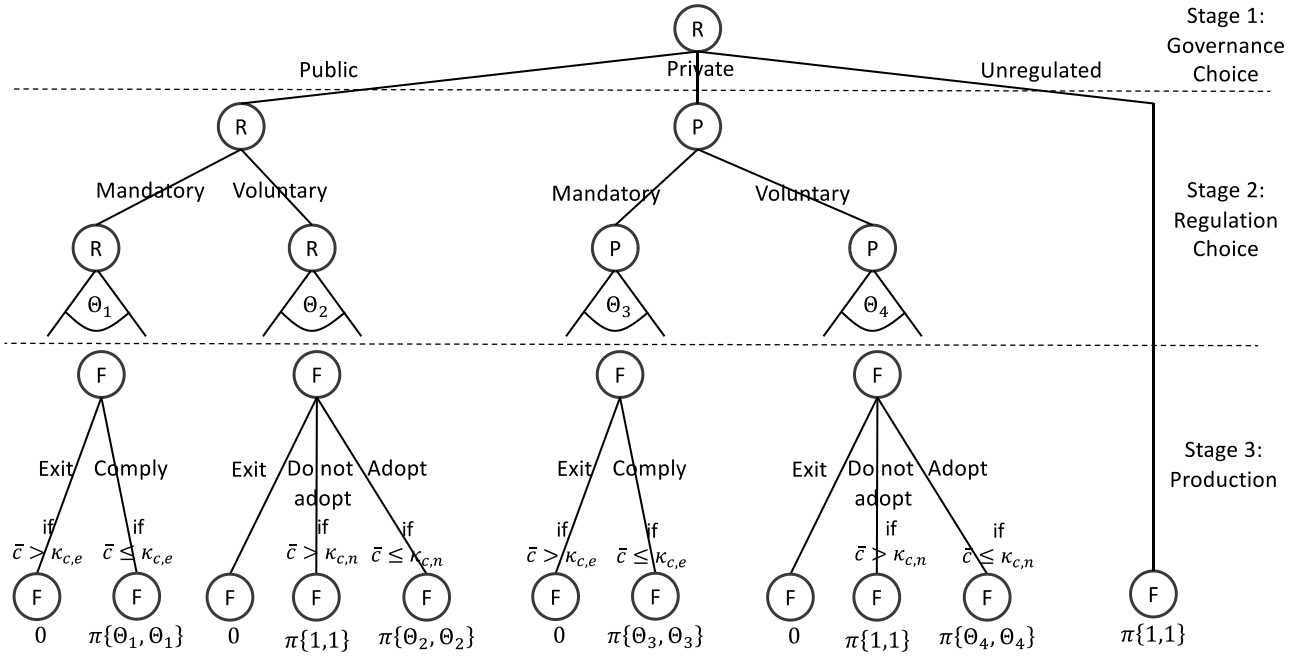
1.7 Homogeneous firms and perfect costless monitoring.

In the first example, we assume that all firms are homogeneous, sharing the same $c_i = \bar{c} \in [cmin, cmax] \forall i$. Also, monitoring is perfect and costless so that committing fraud is not a viable alternative. In this setting, if mandatory standards are imposed, the only available alternatives are either comply or exit the market. If voluntary standards are proposed, the alternatives are adopting the standards, conventional production, or exit.

The comparison of voluntary vs. mandatory or public vs. private standards can be illustrated as a three-stage game (Figure 3-1). In stage 1, a public regulator (R) chooses a form of governance that is the public or private nature of the standards. The standards can be defined by the regulator themselves (maximizing social welfare), by a private entity (P) who maximize firm profits, or an unregulated market can be chosen.

In the unregulated market, no standards are defined, and consumers assume $\theta x = \theta min = 1$ (Section 3.2.1) and firms maximize profits delivering $\theta x = \theta min = 1$. As a result, firm payoff is $\pi\{1,1\}$, externalities are $\alpha(1) = 0$ and consumer surplus is zero (Table 3-2). The unregulated market is used as a benchmark to assess the benefit of regulation.

Figure 3-1: Representation of the three-stage game for determining optimal regulation with homogeneous firms and costless perfect monitoring



R: public regulator; P: private entity; F: homogeneous firms with $c_i = \bar{c}\ \forall i$; definitions of $\kappa_{c,e}$, $\kappa_{c,n}$ are in Table 3-12

1.7.1 Solution of stage 3: firm choices.

The game can be solved by backward induction (e.g., Gibbons 1992). In stage 3, firms must decide whether to comply with mandatory standards or to exit or whether to adopt voluntary standards or not, taking the regulation choice in Stage 2 as given.

Under mandatory standards, firms choose to comply if the payoff from compliance is greater than the exit payoff (equal to zero by assumption). From Table 3-12 in the appendix, the condition for compliance is:

$$\bar{c} \leq \frac{R}{\Theta_m} = \mathrm{K}_{C,E}$$

where $\Theta_m = \Theta_1, \Theta_3$ is the level of the sustainability attribute that is required by public and private mandatory standards, respectively. Note that **high values of Θ_m require that firms are cost-efficient in producing the sustainable attribute (low $\bar{c}$) to ensure compliance to mandatory standards and avoid exit.**

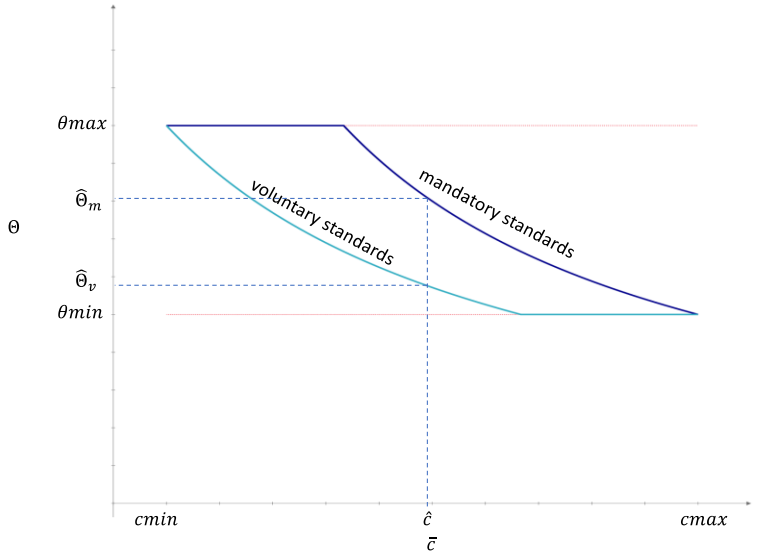
In the case of voluntary standards, given the values of parameters from Table 3-1, there is no incentive to exit, because not-adoption choices lead to non-negative profits for any value of $\bar{c}$ in the selected range. In fact, firms exiting the market under voluntary standards would not produce in the unregulated market either. Thus, the exit option is never chosen. The condition for adoption (Table 3-12 in the appendix) is:

$$\bar{c} \leq \frac{R}{(\Theta_v + 1)} = \mathrm{K}_{c,n}$$

where $\Theta_v = \Theta_2, \Theta_4$ is the level of the sustainability attribute that is required by public and private voluntary standards, respectively. In the case of voluntary standards too, high levels of Θ_v require cost-efficiency (low $\bar{c}$).

The specifications of $\kappa_{c,e}$ and $\kappa_{c,n}$ suggests that **mandatory standards may force firms to comply with stricter sustainability standards than voluntary standards**. Figure 3-2 illustrates this conclusion. Let $\widehat{\Theta}_m$ and $\widehat{\Theta}_v$ be values of Θ_m and Θ_v such that $\mathrm{K}_{C,E} = \mathrm{K}_{C,N} = \hat{c}$ for any $\hat{c} \in [cmin, cmax]$. Then, $\widehat{\Theta}_m$ and $\widehat{\Theta}_v$ make firms indifferent between comply and exit and adopt or not adopt, respectively. They are the maximum provisions that firms are willing to comply with under mandatory and voluntary standards. Figure 3-2 shows that $\widehat{\Theta}_m \geq \widehat{\Theta}_v$ for all $\hat{c}$, with the equal sign holding only when the technical constraints θmin and θmax are binding.

Figure 3-2: Maximum values of $\boldsymbol{\theta_m}$ and $\boldsymbol{\theta_m}$ that firms are willing to comply with under mandatory and voluntary standards, respectively.



The conclusion is general and holds if payoff from not adopting the voluntary standards ($\boldsymbol{\pi}\{\mathbf{1}, \mathbf{1}\}$) is more profitable than the payoff from exiting the market ($\boldsymbol{\pi}\{\mathbf{0}, \mathbf{0}\} = \mathbf{0}$). Under voluntary standards, firms do not adopt costly sustainability standards because they can stay in the market profitably using conventional production. Instead, firms decide to comply with costly standards even they incur in a loss in profits as long as profits are not negative because the alternative is closing down operations. It must be noted that the high standards under the mandatory regulation are achieve at the expenses of firm profits. Imposing high mandatory standards may result in a profit loss compared to the unregulated market. Instead, voluntary standards prevent losses by letting firm choose to keep the most profitable sustainability level.

Firms' strategy in stage 3 is completely defined by the parameters $K_{C,E}$ and $K_{C,N}$. If the firms' cost parameter $\hat{c}$ is lower or equal to the parameters, firms comply with the mandatory standards or adopt the voluntary ones, respectively. It must be noted that in this setting the firm choice does not depend on the source of the standards. Firm behavioral rule is the same regardless the standards being public or private.

1.7.2 Finding optimal provisions for public/private, voluntary/mandatory sustainability standards.

In stage 2, a public regulator and a private entity choose the optimal provisions of the sustainability standards (the optimal value of the variable Θ). The difference between the two agents is in their objective function. A public regulator chooses the optimal provisions of mandatory or voluntary standards to maximize an aggregate social welfare function

$\Omega(\theta x)$ that is the sum of aggregate profits $\Pi(\theta c, \theta x)$ and aggregate externalities $\mathrm{A}(\theta x)$.[5] The private entity's objective function is maximization of $\Pi(\theta c, \theta x)$ alone.

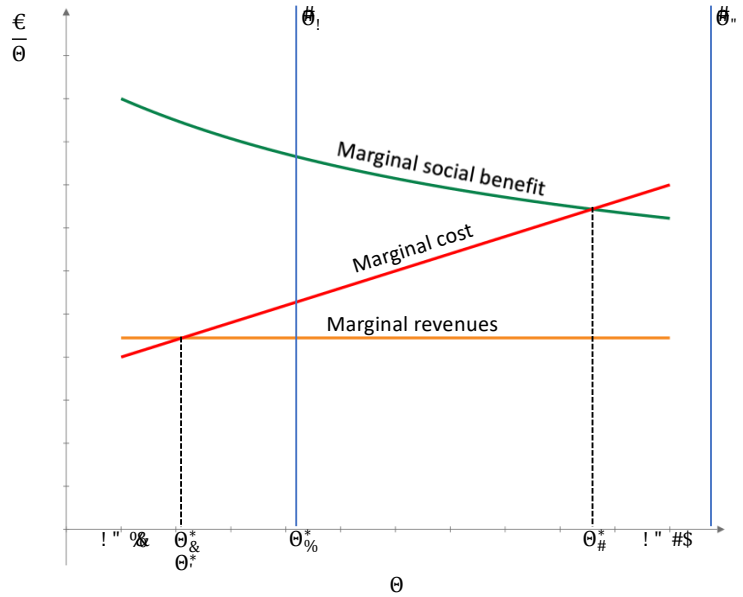
Both agents are subjected to constraints derived from the solution of stage 3. They must set a value of Θ_h such that firms choose to adopt voluntary standards or prefer to comply with mandatory standards. Table 3-5 summarizes the optimization problems for the four types of standards.

Table 3-5: Definitions of the optimization problems for the case of homogenous firms and costless perfect monitoring

Nature	Source	
	Public	Private
Voluntary	$\max_{\Theta_2} \Pi(\theta c, \theta x) + \mathrm{A}(\theta x)$ $\mathrm{s.t.}\ \Theta_2 \in [\theta min, \widehat{\Theta}_v]$	$\max_{\Theta_4} \Pi(\theta c, \theta x)$ $\mathrm{s.t.}\ \Theta_4 \in [\theta min, \widehat{\Theta}_v]$
Mandatory	$\max_{\Theta_1} \Pi(\theta x \theta c, \theta x) + \mathrm{A}(\theta x)$ $\mathrm{s.t.}\ \Theta_1 \in [\theta min, \widehat{\Theta}_m]$	$\max_{\Theta_3} \Pi(\theta c, \theta x)$ $\mathrm{s.t.}\ \Theta_3 \in [\theta min, \widehat{\Theta}_m]$

Figure 3-3 illustrates the solutions of the optimization problems. Both the public regulator and the private entity equates marginal costs and marginal benefits of the respective objective functions for an infinitesimal change in Θ_h, given the constraints.

Figure 3-3: Solutions of the optimization problems for the case of homogenous firms and costless perfect monitoring (*)



(*) Numerical values from Table 3-1, $\hat{c} = 1.8$

Marginal costs are the same for both agents. They are the marginal production cost of firms, which are linear in θx by assumption (Table 3-2). If firms implement the standards, they set $\theta x = \Theta_h$ and the cost function is computed accordingly. Marginal costs are represented by the red solid line in Figure 3-3.

[5] Consumer welfare is assumed to be equal to zero because price is equal to their willingness to pay (Section 1.6.1).

Marginal benefits differ between public regulator and private entity. The latter considers firm profits only. Therefore, the marginal benefit of increasing Θ is the increase in market price only (firms' marginal revenue). By assumption, this increase is constant and equal to R (Table 3-2). Marginal revenues are represented by the yellow solid line in Figure 3-3.

Public regulator adds to marginal revenues the marginal increase in the positive externality because the objective function considers the social effects of the standards in addition to profits. The marginal social benefit of an increase of Θ_h is represented by the green solid line in Figure 3-3.

Figure 3-3 illustrates the constraints from Table 3-5. Provisions for voluntary standards are constrained to be on the left of the vertical blue line $\widehat{\Theta}_v$ and provisions for mandatory standards must be on the left of the vertical blue line $\widehat{\Theta}_m$. In the presented numerical example, the constraint for mandatory standards is not binding because the value of $\widehat{\Theta}_m$ is greater than the upper bound θmax.

The public regulator maximizes social welfare at the intersection of the marginal social benefit and marginal costs. The intersection is feasible for mandatory standards (because $\Theta_1^* < \widehat{\Theta}_m$) and it is not feasible for voluntary standards (because $\Theta_1^* > \widehat{\Theta}_v$). Firms do not adopt the voluntary standards unless they achieve at least the same profits as in conventional production. The constraint $\widehat{\Theta}_v$ is binding and the constrained optimum is $\Theta_2^* = \widehat{\Theta}_v$.

The private entity maximizes aggregate profits at the intersection of marginal costs and marginal revenues curves. In the example, the value is feasible for both mandatory and voluntary standards and the solution is $\Theta = \Theta_3^*$=Θ_4^* in Figure 3-3. The equality between Θ_3^* and Θ_4^* is because constraint $\widehat{\Theta}_v$ is not binding for the private entity, therefore both mandatory and voluntary standards are at the unconstrained optimum. This conclusion is not general and does not hold when firms are not perfectly homogeneous.

The provisions of public standards are stricter than those of private ones. The former lead to higher Θ_h values than the latter. This is a general result that is well-known in environmental economics (e.g., Pearce & Turner 1990). A sufficient condition for the result is that the function $A(\theta x)$ is strictly increasing in θx. If this is the case, marginal social benefits are greater than marginal revenues (as in Figure 3-3) and the intersection with marginal costs requires higher level of Θ_h than private standards. The presence of externalities defines a market failure in the sense of Pigou (1924) and regulation may be used to achieve social optimum.[6]

The difference between the optimal provisions of private and public standards is expected to increase with the marginal value of externalities (the a parameter, in this model). **The more valuable the externalities, the larger the difference between the two solutions is** (the marginal social benefit curves shifts up). Instead, an increase in the cost parameter $\hat{c}$ is expected to reduce the difference between public and private optima, because the marginal cost curve becomes steeper.

1.7.3 Choosing optimal governance

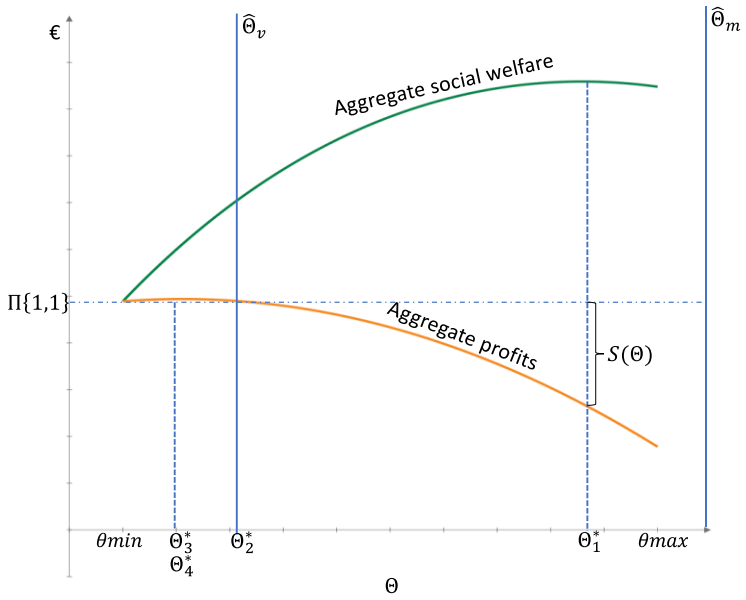
Once the optimal values of Θ_h were computed in Stage 2, it is possible to identify the most efficient governance (public vs. private, mandatory vs. voluntary standards). Figure 3-4 compares policy alternatives.

Mandatory public regulation imposes the highest standards of sustainability (Θ_1^*) and provides the highest value of social welfare. These results are achieved at the cost of a profit reduction for firms. In order to preserve Pareto efficiency of this policy, a subsidy $S(\Theta) = \pi\{1,1\} - \pi\{\Theta_1^*, \Theta_1^*\}$ can be paid to each firm. Figure 3-4 illustrates the magnitude of the aggregate subsidy $S(\Theta)$ as the vertical distance between the aggregate profits without regulation ($\Pi\{1,1\}$) and aggregate profits under socially optimal public mandatory standards.

Voluntary public standards are Pareto efficient: They increase social welfare with respect to unregulated markets without harming firms. The sustainability standards Θ_2^* and total social welfare are lower than in the case of public mandatory standards. Yet, subsidies can be paid to relax the constraint $\widehat{\Theta}_v$. Subsidized firms may adopt high-Θ voluntary standards if the payment is large enough to compensate the profit loss from overproviding sustainability. The amount of the aggregate subsidy is defined by the vertical distance between $\Pi\{1,1\}$ and aggregate profits for any desired level of Θ in Figure 3-4.

[6] In this regard, most of the literature focuses on subsidies or allocation of legal rights. In this report, we focus on standards only.

Figure 3-4: Comparing regulations and choosing optimal governance (*)



(*) Numerical values from Table 3-1, $\bar{c} = 1.8$; $\Pi\{1,1\}$ is aggregate profits in an unregulated market ($\theta x = \theta min$)

Private standards grant firms maximum profits, but they are less effective than public initiatives in promoting sustainability. In this case, a **Pigouvian subsidy** may provide private entities incentive to promote more sustainable practices (e.g., Baumol 1972). A Pigouvian subsidy decreases the marginal cost of producing sustainability (Figure 3-3) so the maximum of the profit function is achieved at a higher Θ than in the absence of subsidy. However, complex subsidy schemes may be necessary to ensure efficiency in the long run (e.g., Carlton & Loury 1980).

The choice of the optimal governance depends on the regulator's political objective. If the goal is to maximize sustainability, mandatory public standards may be considered. If, instead, the goal is to support firms in their transition to more sustainable production without incurring in profit losses public voluntary standards or Pigouvian subsidies of private standards may be preferable.[7]

1.7.4 Factors affecting optimal standards

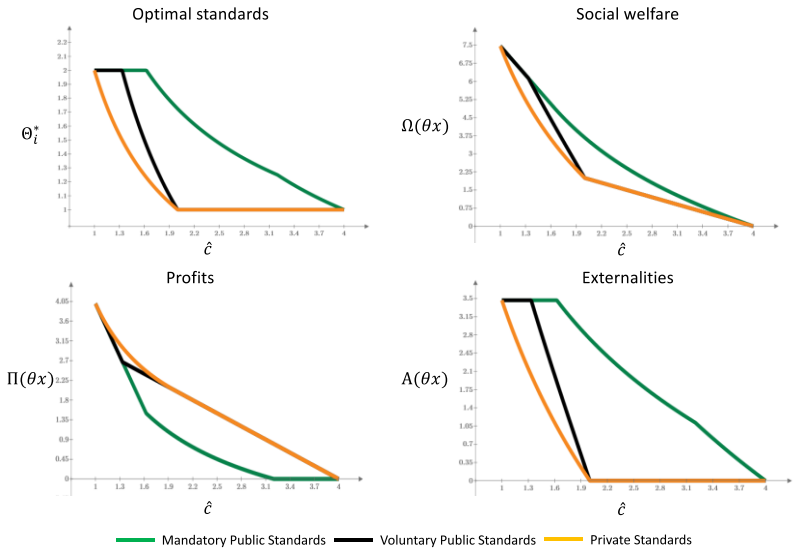
The solutions in Figure 3-4 depends on the values of three key parameters: Firms' cost of producing the sustainable attribute ($\bar{c}$), consumers' marginal willingness to pay for the sustainable attribute (R), and the magnitude of the externalities generated by the sustainability attribute (α). To describe the effects of the parameters on the equilibrium, Figure 3-5 reports the changes the main outcome variables (optimal standards Θ_i^*, social welfare $\Omega(\theta x)$, profits $\Pi(\theta x)$, and externalities $\mathrm{A}(\theta x)$) as a function of the three parameters.

The parameter $\bar{c}$ measures the costs firms incur in when they engage in sustainable production. Panel A in Figure 3-5 confirm the negative association between $\bar{c}$ and Θ_i^*. If firms are inefficient ($\hat{c}$ is high), constraints $\widehat{\Theta}_v$ and $\widehat{\Theta}_m$ prevent public regulators and private entities from setting high values of Θ_i^*. Instead, if $\hat{c}$ is low, standards can impose high Θ_i^*. As noted in Section 3.3.2, the relationship $\Theta_1^* \geq \Theta_2^* \geq \Theta_3^* = \Theta_4^*$ holds for any value of $\hat{c}$ in the range $[cmin, cmax]$. **Public mandatory standards are the one with the stricter sustainability requirements at the equilibrium**. As $\hat{c}$ approaches the value $\frac{R}{2} = 2$, private and voluntary public standards converge to the same value $\theta min = 1$ because any higher Θ would yield profits that are lower than the unregulated market.

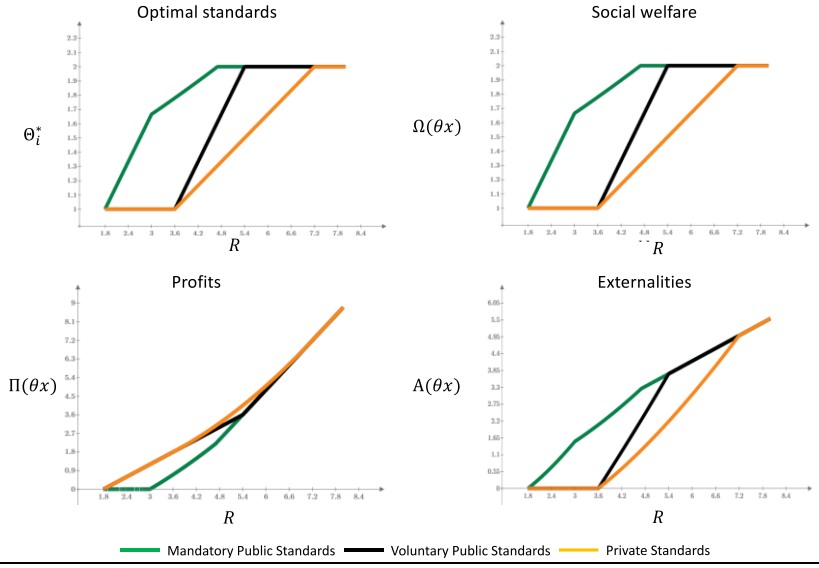
[7] In economic modeling, this choice can be represented with a weighted social welfare function. The weights to each addendum of the function represent the relative importance of the different policy goals.

Figure 3-5: Optimal standards, social welfare, profits and externalities as a function of firms' cost inefficiency ($\bar{c}$, panel A), consumers' marginal willingness to pay for sustainability (R, panel B), and economic value of externalities (α, panel C).

Panel A: Variables as a function of cost inefficiency in producing sustainability ($\bar{c}$).



Panel B: Variables as a function of consumers' marginal willingness to pay for the sustainability attribute (R).



Panel C: Variables as a function of the value of externalities (α).

The parameter R is the consumers' marginal willingness to pay for the attribute θx and it measures how much they value sustainability. If R is high, high values of Θ_i^* are possible, and social welfare, profits and value of the externalities are high as well (Figure 3-5, Panel B). It must be noted that for high values of R, the equilibrium from public regulation converges to the one from private governance. This means that **public standards are particularly beneficial when consumers' willingness to pay for sustainable food is relatively limited**. Instead, if the market can remunerate sustainable production, private governance is efficient.

Panel C in Figure 3-5 illustrates the effects of a change in the parameter α measuring the value of the externality. Private standards are unaffected by the changes in a because the value of the externality is not considered in the private entity's objective function. The values Θ_3^* and Θ_4^* do not change with α and firms always provide the same level of sustainability regardless of externalities. Social welfare and externality of private standards increase with a only because the per-unit social value of θx increases. The value of Θ_3^* in voluntary private standards is not affected by changes of α as well. The result is due to the selected parameter values resulting in a binding $\widehat{\Theta}_v$ constraint. Because $\Theta_2^* = \widehat{\Theta}_v$ and because the definition of $\widehat{\Theta}_v$ does not include a, the value of Θ_2^* does not change with a.[8] Public mandatory standards are deeply affected by the value of a. The value of Θ_1^* increases until the maximum θmax is reached, and social welfare and externality value increase accordingly.[9] When an exogenous increase in a results an increase in Θ_1^*, firm profits decrease because of the stricter regulation. **The relative efficiency of public mandatory standards compared to public voluntary or private standards increase with the value of externalities. The social gain is larger when the cost of producing the sustainability attribute is high.**

1.7.5 Conclusions from the model with homogeneous firms and costless perfect monitoring

The model with homogeneous firms and costless perfect monitoring is a simple representation of the problem that gives basic insights into the most important trade-offs in the design of sustainability standards. **It must be remembered that the results are derived from theory and are conditional to the model assumptions**. These limitations must be carefully considered before using the results for policy analysis. Table 3-6 provides a summary of the findings.

Public mandatory standards maximize sustainability and social welfare, but they may result in non-negligible profit losses for firms. For this reason, compensations for firms are necessary to achieve Pareto efficiency. If compensation is not possible, the magnitude of profit loss may discourage policy makers from imposing strict mandatory standards and sub-optimal mandatory standards may emerge in order to limit the negative consequences for firms.[10] The benefits of public mandatory standards compared to other governance forms are higher when consumers exhibit limited willingness to pay for sustainability (R is low), cost of sustainable production is high ($\bar{c}$ is high) and when the social or environmental externalities are valuable (a is high).

Public voluntary standards do not generate loss for firms because they are adopted only when profitable.[11] Pareto-efficiency is obtained at the cost of a reduced ability to promote sustainable production compared to mandatory standards. High voluntary public standards can be implemented if incentive subsidies are paid to firm adopting the standards. The benefits of public voluntary standards are higher than private standards when consumers exhibit limited willingness to pay for sustainability (R is not too low nor too high), cost of sustainable production is low ($\bar{c}$ is low) and full compensation for profit losses is not feasible.

Private standards maximize firm profits but have the lowest impact on sustainability, because they fail to consider positive externalities. Pigouvian subsidies may be paid to elicit the adoption of more sustainable practices. In general, the benefits from private standards increase when R is high and $\bar{c}$ is low.

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[8] Figure 3-5 was drawn assuming $\bar{c} = 1.8$. For lower values of $\bar{c}$ (such as 1.63 or lower), for low value of α constraint $\widehat{\Theta}_v$ is not binding and Θ_2^* increases with α. As α increases, Θ_2^* reach the point where $\widehat{\Theta}_v$ becomes binding and further increases in α do not affect Θ_2^* anymore.

[9] For higher values of $\bar{c}$, the constraint $\widehat{\Theta}_m$ can be binding imposing a ceiling to Θ_1^* that is lower to θmax.

[10] A formal discussion of this conclusion is possible by assuming a *weighted* social welfare function, where the regulator gives high weight to firms' profits.

[11] As noted in Section 1.7, this conclusion is driven by the model assumption that the price of a low-sustainability product (for example with $\theta x = 1$) is not affected by the existence of certified sustainable products in the market.

Table 3-6: Summary of results of the model with homogeneous firms and costless perfect monitoring.

Source	Nature	Pros	Cons	Subsidy	Effective if
Public	Mandatory	• Max social welfare • Max sustainability	• Profit loss for firm	• Compensation to ensure Pareto efficiency	• R is low • $\bar{c}$ is high • a is high • Firms can be compensated
Public	Voluntary	• Pareto efficient • Improved sustainability compared to unregulated market	• Less effective than mandatory public standards in improving sustainability	• Incentive to adoption for high sustainability standards	• R is "average" • $\bar{c}$ is low • Firms cannot be compensated
Private	Mandatory or Voluntary	• Max firm profits • No regulatory costs	• Less effective than public standards in improving sustainability • Coordination costs for firms	• Pigouvian subsidy to elicit sustainable production	• R is high • $\bar{c}$ is low

R: consumer marginal willingness to pay for sustainability (a measure of how much consumers are willing to pay for sustainability)

$\bar{c}$: marginal cost of producing sustainability (a measure of how costly sustainable food production is)

a: scale of the value of externalities (a measure of how important sustainable food production is for society)

1.8 Heterogeneous firms and costless, perfect monitoring.

In this section we relax the assumption of homogeneous firms and introduce firm heterogeneity. Firms differ for their cost parameter c_i that is a random variable uniformly distributed as $c_i \sim U[cmin, cmax]$. The key difference with the model of homogeneous firms is that the strategic choice of each heterogeneous firm depends on the value of their individual cost parameters.

For example, in Section 3.3, given mandatory standards Θ_m, all firms either comply or exit because they all share the same cost parameter $\bar{c}$. In this section, instead, we find that firms with $c_i \leq \mathrm{K}_{C,E}$ comply with the standard while firms with $c_i > \mathrm{K}_{C,E}$ exit the market.

Heterogeneity models are of particular interest for policy analysis because they investigate the effect of marketing standards on welfare distribution among groups of interest. In fact, the distribution of c_i may be related to exogenous factors. For example, small producers from developing countries or farmers from remote rural areas are expected to suffer from a cost disadvantage. Heterogeneity models allow researchers to illustrate how marketing standards affect different groups of producers.

Figure 3-6: Representation of the three-stage game for determining optimal regulation with heterogeneous firms and costless perfect monitoring

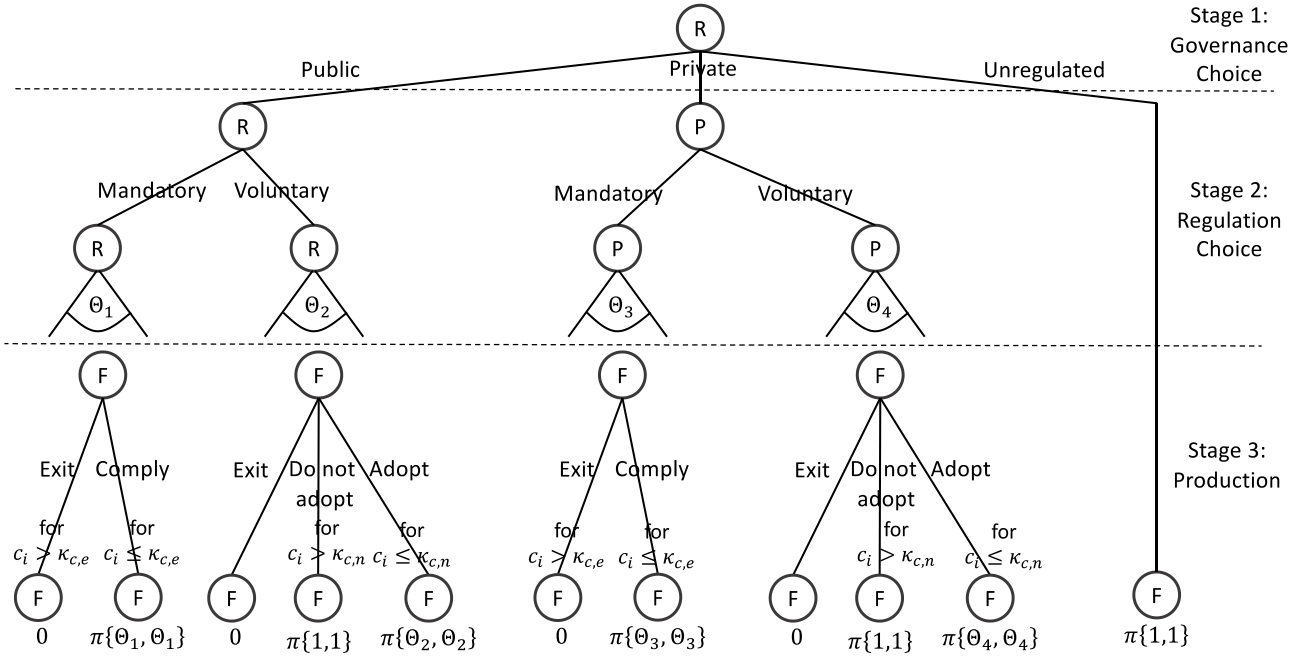


Figure 3-6 illustrates the structure of the three-stage game. The diagram is similar to the one for the case of homogeneous firms (Figure 3-1). The only difference is in Stage 3 where firms choose among the available alternatives based on the individual cost parameter c_i instead of using the common parameter $\bar{c}$.

1.8.1 Solution of stage 3: firm choices.

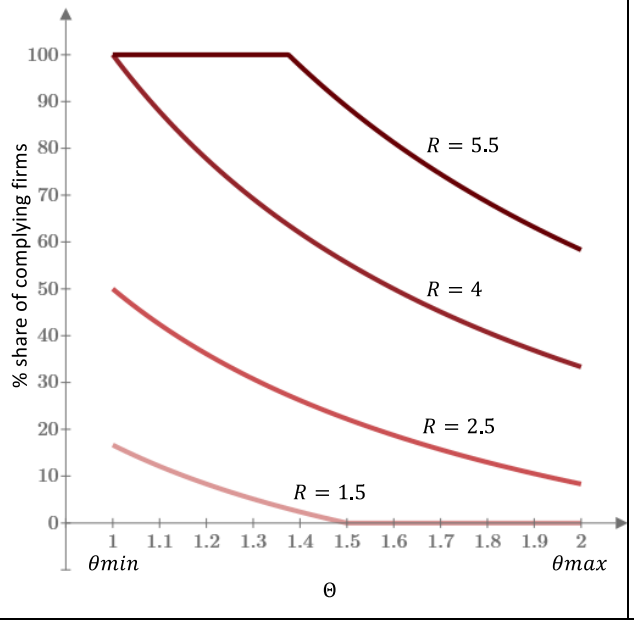
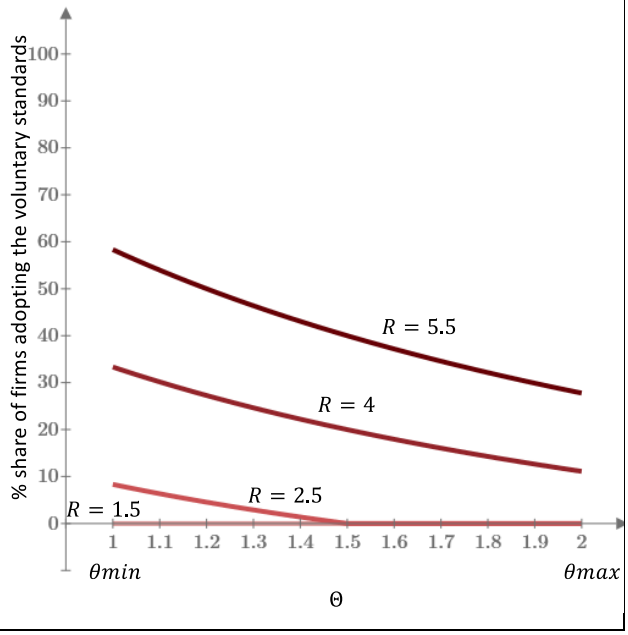
Under public or private mandatory standards firms comply if they achieve non-negative profits under the regulation. This condition is satisfied for $c_i \leq K_{C,E}$ (Table 3-12). Firms with $c_i > K_{C,E}$ achieve negative profits if they comply, therefore they prefer to exit the market. **This result illustrates the trade-off between high mandatory sustainability standards and firms' ability to compete**. From Table 3-12 we have that $K_{c,e}$ is negatively correlated with Θ_h. This means that as Θ_h increases, the share of firms that are forced to exit the market increases. Regulators must balance the positive impact of sustainability with the negative effect of a reduction in the number of firms in the market. It must be noted that the firms exiting the market are those with a cost disadvantage in producing θx.

Under public or private voluntary standards, firms adopt the standards if they achieve a payoff greater than what they have from selling a conventional product with $\theta x = \theta min$. This condition is satisfied if $c_i \leq K_{C,N}$. For $c_i > K_{C,N}$

conventional production is more profitable, and firms do not adopt the voluntary standards. Because $K_{C,N}$ is negatively correlated with Θ_h (Table 3-12), **regulators must balance a tradeoff between sustainability level of voluntary standards and share of firms adopting the standards**. The higher the value of Θ_h, the lower the share of firms adopting the standards. Therefore, a regulator setting high voluntary sustainability standards may find out that only a small number of firms are adopting the standards.

Figure 3-7 describes the trade-offs between compliance to mandatory standards (Panel A) and between adoption of voluntary standards and conventional production (Panel B). For any level of the sustainability requirements Θ, the share of firms complying with mandatory standards is higher than the share of firms adopting the voluntary standards. The result is driven by the relative value of the alternative options to voluntary and mandatory standards. Firms require profits higher than conventional production to adopt voluntary standards. Instead, non-negative profits only are required to comply with mandatory standards.

Figure 3-7: Share of firms complying with mandatory standards (Panel A) and adopting voluntary standards (Panel B) as a function of the sustainability requirements $\boldsymbol{\Theta_h}$ and for selected values of consumers' marginal willingness to pay for sustainability $\boldsymbol{R}$.

Panel A: compliance to mandatory standards (alternative: exit)	Panel B: adoption of voluntary standards (alternative: conventional production)
	

The shares of compliance and adoption for a given Θ_h depends on the value of the parameters R (marginal willingness to pay). Figure 3-7 illustrates the effects of a change in R. Holding Θ_h and all other parameter constants, the compliance and adoption shares increase with R.

1.8.2 Solving stage 2: Finding optimal provisions for public/private, voluntary/mandatory sustainability standards.

In Stage 2, the public regulator and the private entity must find the optimal sustainability requirement for mandatory and voluntary standards, given the respective objective functions and considering the rate of firms implementing the standards (Figure 3-7). Following the discussion in Section 3.3.2, they must find a balance between marginal benefits and marginal costs of a unit increase in Θ_h. Marginal benefits are the increase in consumers' willingness to pay and (for the public regulator only) an increase in the externality value. Marginal costs are the increase in production and a reduction in the share of firms complying with mandatory standards or adopting voluntary ones.

In the previous case of homogenous firms (Section 3.3.2) adoption and compliance were constraints for the public regulator and the private entity. If firms are homogeneous, adoption and compliance are binary variables (either all firms comply/adopt or all exit/not adopt). If all firms are unwilling to comply or adopt, the standards are ineffective. Therefore, the values of Θ_h must be low enough to provide incentive to compliance and adoption to the firms. These requirements were modeled as constraints $\widehat{\Theta}_m$ and $\widehat{\Theta}_v$.

In the case of heterogeneous firms, the shares of firms implementing the standards are continuous variables. The private entity and the public regulators must balance a trade-off between sustainability requirements and implementation, without having to meet any binary threshold. The trade-offs are modeled as part of the objective functions, without imposing constraints.

Table 3-7 illustrates the specifications of the objective functions for the four types of sustainability standards. The social welfare function for mandatory public standards is specified as the sum of the profits of compliant firms ($\Pi_{c,h}(\theta c, \theta x)$) plus the value of the externalities produced by the compliant firms ($\mathrm{A}_{c,h}(\theta x)$). Non-compliant firms must exit the market and they have zero profits and produce zero externalities.

Table 3-7: Objective functions for public/private, mandatory/voluntary standards with heterogeneous firms

Source	Nature	Objective function
Public	**Mandatory**	$\boldsymbol{\Omega_{m,h}(\theta x) = \Pi_{c,h}(\theta c, \theta x) + \mathrm{A}_{c,h}(\theta x)}$
where:	$\Pi_{c,h}(\theta x) = \int_{cmin}^{\mathrm{K}_{c,e}} \pi_i(\theta c, \theta x) dc_i$ are the profits of compliant firms	
	$\mathrm{A}_{c,h}(\theta x) = \int_{cmin}^{\mathrm{K}_{c,e}} \alpha \cdot ln(\theta x) dc_i$ is the externalities produced by compliant firms	
Public	**Voluntary**	$\boldsymbol{\Omega_{v,h}(\theta x) = \Pi_{v,h}(\theta c, \theta x) + \Pi_{n,h}(\theta min, \theta min) + \mathrm{A}_{v,h}(\theta x)}$
where:	$\Pi_{v,h}(\theta x) = \int_{cmin}^{\mathrm{K}_{c,n}} \pi_i(\theta c, \theta x) dc_i$ is the profits of firms adopting the standards	
	$\Pi_{n,h}(\theta min) = \int_{\mathrm{K}_{c,n}}^{cmax} \pi_i(\theta min, \theta min) dc_i$ is the profits of firms <u>not</u> adopting the standards	
	$\mathrm{A}_{v,h}(\theta x) = \int_{cmin}^{\mathrm{K}_{c,n}} \alpha \cdot ln(\theta x) dc_i$ is the externalities produced by adopting firms	
Private	**Mandatory**	$\boldsymbol{\Pi_{c,h}(\theta c, \theta x)}$
where:	$\Pi_{c,h}(\theta x) = \int_{cmin}^{\mathrm{K}_{c,e}} \pi_i(\theta c, \theta x) dc_i$ are the profits of compliant firms	
Private	**Voluntary**	$\boldsymbol{\Pi_{v,h}(\theta c, \theta x) + \Pi_{n,h}(\theta min, \theta min)}$
where:	$\Pi_{v,h}(\theta x) = \int_{cmin}^{\mathrm{K}_{c,n}} \pi_i(\theta c, \theta x) dc_i$ is the profits of firms adopting the standards	
	$\Pi_{n,h}(\theta min) = \int_{\mathrm{K}_{c,n}}^{cmax} \pi_i(\theta min, \theta min) dc_i$ is the profits of firms <u>not</u> adopting the standards	

In the case of public voluntary standards, the social welfare function is composed of three parts: the profits of the firms adopting the voluntary standard ($\Pi_{v,h}(\theta c, \theta x)$), the profits of firms engaged in conventional production ($\Pi_{n,h}(\theta min, \theta min)$) and the value of the externalities that are produced by adopting firms ($\mathrm{A}_{v,h}(\theta x)$). The value of externalities from conventional production is normalized to zero (i.e., $\mathrm{A}(\theta min) = 0$) so that the effects of sustainability standards on the value of externalities can be interpreted as a deviation from the status quo level.

The objective functions of the private entity consider only the profits of compliant firms ($\Pi_{c,h}(\theta c, \theta x)$) in the case of mandatory standards, and the sum of profits of adopting firms ($\Pi_{v,h}(\theta c, \theta x)$) and of firms with conventional production ($\Pi_{n,h}(\theta c, \theta x)$) in the case of voluntary ones. It must be noted that the difference between the objective functions of public and private standards is only the value of the externalities (as in the case of homogeneous firms).

The aggregate values are computed by taking the integral of the individual functions over the appropriate interval of the variable c_i (Table 3-7). The functions referring to firms complying to mandatory standards take integrals over the interval $c_i \in [cmin, \mathrm{K}_{C,E}]$, referring to the most efficient firms. The functions referring to firms adopting voluntary standards integrate over the interval $c_i \in [cmin, \mathrm{K}_{C,N}]$ and those referring to firms engaged in conventional production integrate over the interval $c_i \in (\mathrm{K}_{C,N}, cmax]$.

The optimization problem can be solved numerically. The results are presented in the next Section 3.4.3.

1.8.3 Choosing optimal governance

Figure 3-8 illustrates the solution of the three-stage game. Panel A of the figure describes the optimal regulation for each policy alternative, given the numerical values of the parameters. The solutions maximize the objective functions from Table 3-7.

Optimal public mandatory standards Θ_1^* yield the highest social welfare, given the model parameters (green solid dot in Figure 3-8, Panel A). Public voluntary standards have the highest sustainability requirements Θ_2^* (black solid dot in Figure 3-8, Panel A) but they achieve a lower social welfare than public mandatory standards.

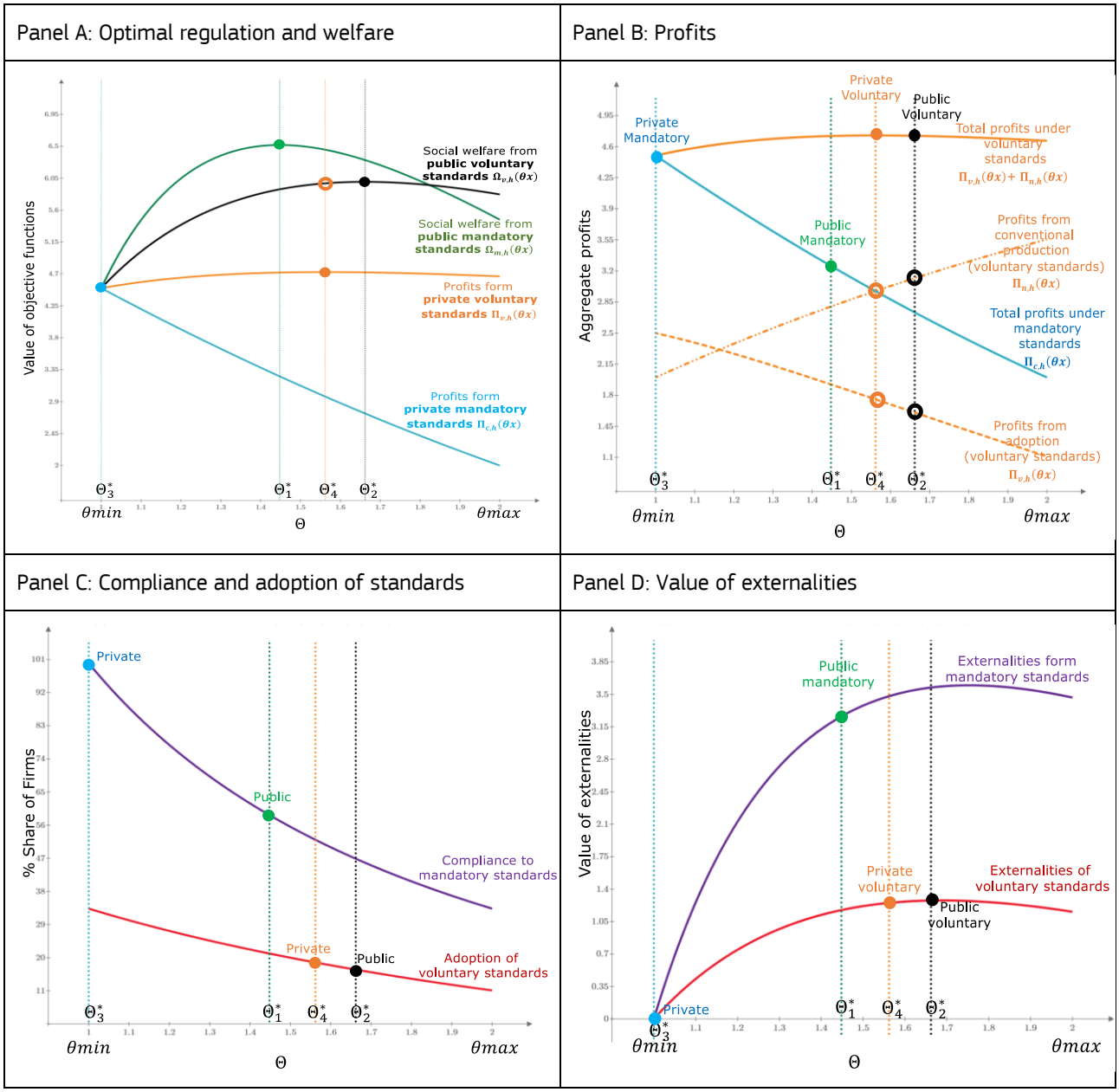
Private voluntary standards grant the highest firm profits (orange solid dot in Figure 3-8, Panel A) but achieve lower social welfare than public regulation (orange hollow dot in Figure 3-8, Panel A). The sustainability requirements are higher than under public mandatory standards but lower than public voluntary ones. Given the selected parameter values, private mandatory standards are not profitable, and they are not implemented ($\Theta_1^* = \theta min$, in Figure 3-8, Panel A).

Public mandatory standards are socially efficient (maximize social welfare) but are not Pareto efficient in the absence of compensation. Panel B in Figure 3-8 shows that firms under public mandatory standards achieve aggregate profits that are lower than the unregulated market (i.e., $\Pi(\theta min, \theta min)$). A compensation is needed to keep the firms indifferent between public mandatory standards and unregulated markets. Also, under this policy, a non-negligible number of firms may leave the market. For example, in Figure 3-8 Panel C (green solid dot), given the numerical values of the parameters, 42% of firms exit the market if optimal public mandatory standards are implemented. It must be noted that public mandatory standards provide the highest value of externalities (Figure 3-8 Panel C, green solid dot). The high performances of public mandatory standards in terms of social welfare and positive externalities are obtained at the expenses of firms. In the absence of compensation, lower profits and exits are expected from the adoption of this policy.

Optimal public voluntary standards have the highest sustainability requirements ($\Theta_2^* > \Theta_1^*$), but they deliver a value of externalities that is lower than public mandatory standards (black and green dots in Figure 3-8, Panel D). The explanation for this result is that the share of firms adopting the voluntary standards is much lower than the one of firms complying with mandatory standards (black and green dots in Figure 3-8, Panel D). Public voluntary standards do not harm firms. Figure 3-8, Panel B shows that firms achieve higher profits than in the unregulated market. Both adopting and not-adopting (conventional) firms are at least as profitable as in the absence of regulation (hollows black dots in Figure 3-8, Panel B). As noted in Section 3.3.5, public subsidies can be used to favor adoption of public voluntary standards, elicit higher sustainability standards, and improve the value of externalities.

Figure 3-8, Panel B shows that profits of firms adopting private standards (orange hollow dot) are higher than those of firms adopting public ones (black hollow dot). The rationale for this result is twofold: (i) more firms adopt private voluntary standards than public ones (black and orange dots in Figure 3-8, Panel C), and (ii) public standards are costlier because they impose higher sustainability requirements ($\Theta_2^* > \Theta_4^*$). The value of externalities from private voluntary standards is lower than the one from public ones. Pigouvian subsidies can be used to incentivize higher requirements and improve the provision of positive externalities.

Figure 3-8: Heterogeneous firms and costless perfect monitoring. Choice of optimal regulation and welfare implications.



1.8.4 Factors affecting optimal governance

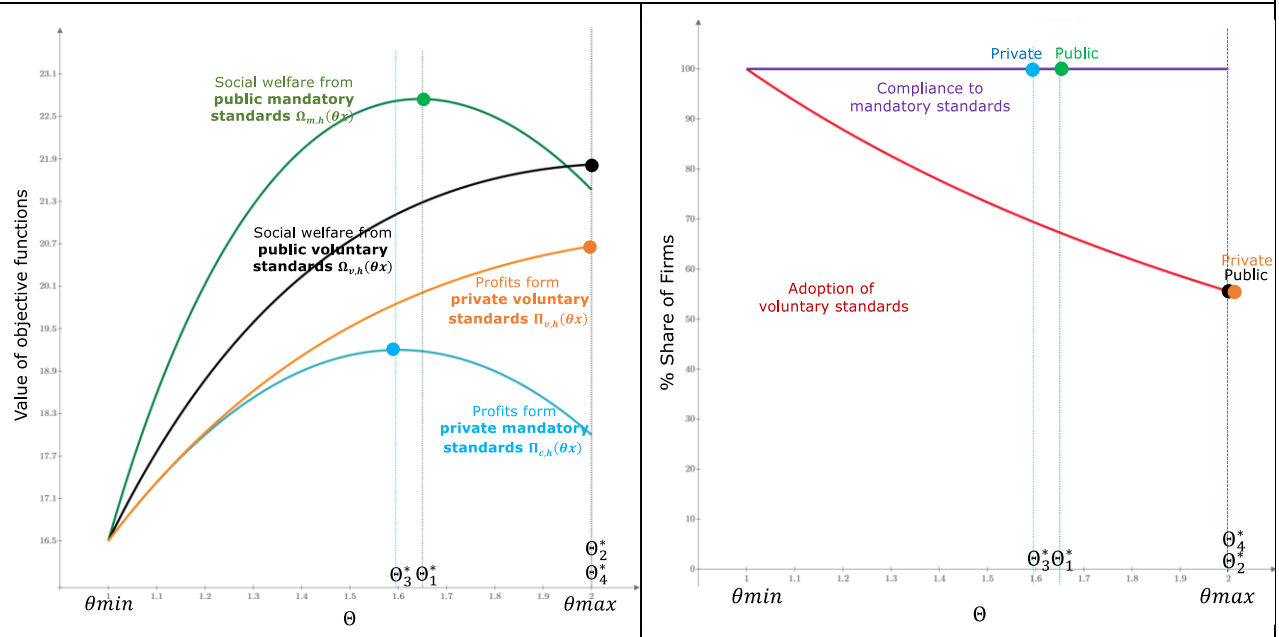
The results in Section 3.4.4 depends on the chosen numerical parameter values. Figure 3-9 reports the model outcome with different parameter choices. In Panels A and B, we assumed higher value of in consumers' marginal willingness to pay for sustainability ($R = 8$) than in Section 3.4.4 ($R = 4$), keeping all other parameters constant. In Panels C and D, we assume a higher value of the parameter a measuring the per-unit externality value of θx ($a = 10$ vs. $a = 5$). Comparing Figure 3-9 and Figure 3-8 provides an illustration of the effects of an exogenous increase in R and a.

Figure 3-9: Effects of an exogenous increase in consumers' marginal willingness to pay for sustainability ($\boldsymbol{R}$) and in per-unit externality value of sustainability attribute ($\boldsymbol{a}$) on optimal sustainability requirements and on the shares of adopting/complying firms

Panels A and B: Increase in consumers' marginal willingness to pay ($R = 8$)

Panel A: optimal sustainability requirements

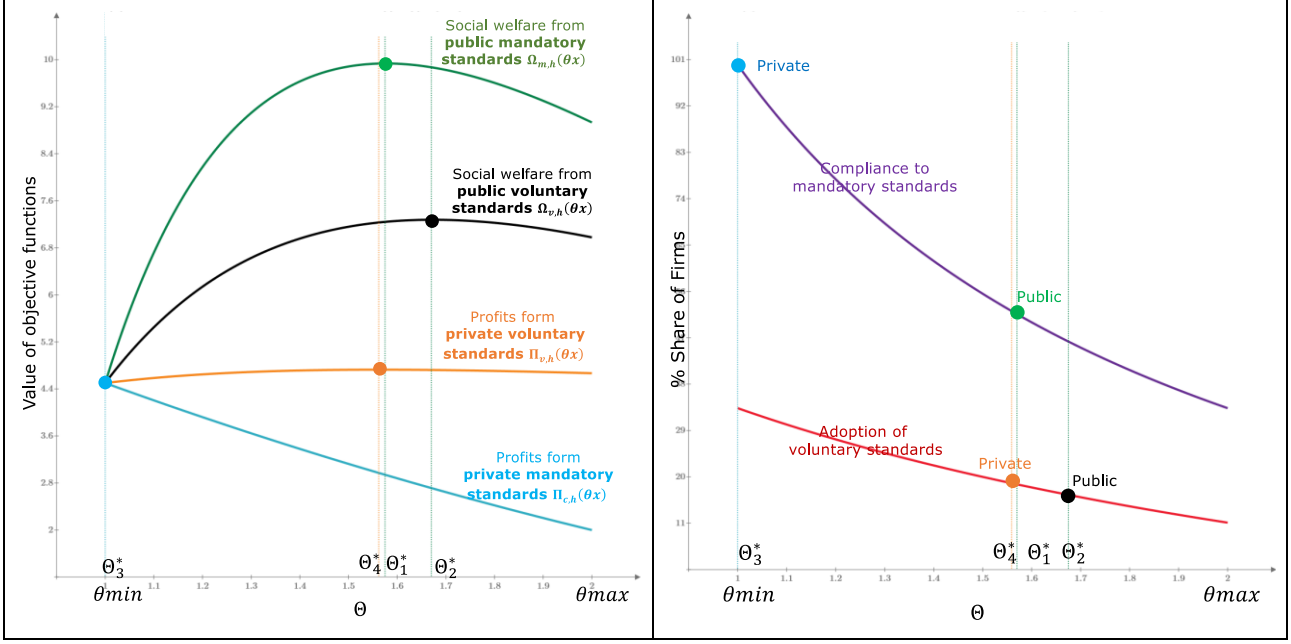
Panel B: shares of firms adopting/complying



Panels C and D: Increase in per-unit externality value of sustainability attribute ($a = 10$)

Panel C: optimal sustainability requirements

Panel D: shares of firms adopting/complying



An increase in R result in higher sustainability requirements Θ_h^* for all types of standards (Figure 3-9, Panel A). A key result is that as R increases, leaving all other parameters unchanged, the difference between public and private mandatory standards and between public and private voluntary standards decreases. For example, in Figure 3-9, Panel A the difference between Θ_3^* and Θ_3^* is smaller than in with Figure 3-8, Panel A. Both public and private voluntary standards achieve their optima for $\Theta_2^* = \Theta_4^* = \theta max$.

Given the high value of $R = 8$, all firms comply with mandatory standards even if the sustainability requirements were set to the maximum value θmax (Figure 3-9, Panel B). Nevertheless, the optimal value Θ_1^* is set at the lower value $\Theta_1^* < \theta max$ because the public regulator and the private entity must consider firms' profit reduction due to high requirements.

High values of R result in high shares of firms adopting voluntary standards: the shares in Figure 3-9, Panel B are higher than those in Figure 3-8, Panel C. In this case, the sustainability requirements are maximized because the inefficient firms that would incur in profit losses are free to keep conventional production.

For high values of R, mandatory private standards can be implemented. In Figure 3-9, Panel A the optimal requirements $\Theta_3^* > \theta max$.

As consumers' marginal willingness to pay for sustainability increases, all kinds of standards have incentive to increase their sustainability requirements. Also, the gain from public regulation over private action decreases.

An increase on the per-unit externality value a does not affect private standards (Figure 3-9, Panel C). The optimal sustainability requirements are set by the private entity considering firm profits only. Thus, even if the production of θx becomes more beneficial for society, private entities does not want to incur in additional costs that are not rewarded by the market. Instead, **public regulators increase sustainability requirements Θ_1^* and Θ_2^* with a** because the value of the externalities is enough to compensate for increased costs of production. As a result, the shares of firms adopting voluntary public standards or complying with mandatory public standards decrease (Figure 3-9, Panel C).

1.8.5 Conclusions from the model with heterogeneous firms and costless perfect monitoring

An extensive literature debated whether safety, quality or sustainability standards may act as trade barriers (e.g., Henson 2008, Disdier et al. 2008, Swinnen 2016, Beghin et al. 2017, Medin 2019) or may harm small farmers, especially in developing countries (e.g., Herzfeld 2011, Schuster & Maertens 2013). The model of heterogeneous firms and costless perfect monitoring provides insights into the exclusion effects of sustainability standards, i.e., the incentive that these standards can give to groups of firms to exit (or do not enter) a regulated market (Lee et al. 2012, Macedoni & Weinberger 2022). The model adapts a typical industrial organization setting (e.g., Gabszewicz & Thisse 1980) to summarize the conclusions of theoretical literature. Table 3-8 summarizes the findings of the model with heterogeneous firms.

Optimal public mandatory standards can result in the exclusions of least efficient firms in the market. The exclusion effect increases as consumers' marginal willingness to pay for sustainability ($\boldsymbol{R}$) decreases and as the per-unit value of sustainability ($\boldsymbol{a}$) increases. Under these conditions, a public regulator willing to maximize social welfare sets the sustainability requirements Θ_1^* at a level that is so high (because of the high a) that least efficient firms cannot recover their production costs (because of the low R) and must leave the market. It must be noted that these conditions (low $\boldsymbol{R}$ and high $\boldsymbol{a}$) also ensure efficiency dominance and high sustainability benefits of public mandatory standards with respect to all other types of standards (Figure 3-8 and Figure 3-9). If R is low, public voluntary standards and private standards must have low sustainability requirements in order to preserve firms' incentive for adoption or compliance. Low sustainability requirements when a is high result in a severe welfare loss because sustainability is highly valuable for society. Thus, the model suggests that the exclusion effect of public mandatory standards is particularly severe when this policy is highly efficient.

In order to balance this trade-off, public regulator may decide to adopt sub-optimal (lower) Θ_1^* or to compensate least efficient firms to avoid exit. **Efficient compensation** requires that each firm is paid the minimum amount of money that is sufficient to avoid exit (or to grant farmers a socially acceptable income). This strategy **requires that (i) c_i is observable and (ii) compensation can vary depending on the value of c_i.** If these two conditions are not met because the parameter is unobservable or the regulator cannot discriminate firms, compensation can be costly and inefficient. In this extreme case, all firms (including the efficient ones) receive a compensation that is sufficient to keep inefficient firms in the market. This results in overcompensation of efficient firms and in a possible market distortion.

If efficient compensation is not feasible or too costly, and R is not low, voluntary standards may be preferable. The policy can be accompanied with subsidies that are conditional to the implementation of higher sustainability requirements in order to increase the share of firms adopting the voluntary standards.

Private standards are less effective than public ones in producing positive externalities. Nevertheless, if R is high enough, they can be an efficient solution to increase sustainability without incurring in the regulatory costs of public intervention.

Table 3-8: Summary of results of the model with heterogeneous firms and costless perfect monitoring**.**

Source	Nature	Pros	Cons	Subsidy	Effective if
Public	Mandatory	• Max social welfare • Max sustainability	• Profit loss for firm • Possible firm exits • Compensation may be difficult if c_i's are unobservable.	• Compensation to ensure Pareto efficiency and to prevent exit	• R is low • α is high • Firms can be compensated
Public	Voluntary	• Pareto efficient • Improved sustainability compared to unregulated market or private standards	• Less effective than mandatory public standards in improving sustainability	• Incentive to adoption for high sustainability standards	• R is "average" • Firms cannot be compensated
Private	Mandatory	• Increase firms' profits • No regulatory costs	• Possible firm exits • Less effective than public standards in improving sustainability	• Pigouvian subsidy to elicit sustainable production	• R is high
Private	Voluntary	• Max firm profits • Higher adoption rate than public voluntary standards • No regulatory costs	• Less effective than public standards in improving sustainability	• Compensation to prevent exit • Pigouvian subsidy to elicit sustainable production	• R is high

R: consumer marginal willingness to pay for sustainability (a measure of how much consumers are willing to pay for sustainability)

c_i: Heterogeneous and unobservable cost parameter measuring firm i's inefficiency in sustainable production

α: scale of the value of externalities (a measure of how important sustainable food production is for society)

1.9 Moral hazard models

In this section, the implication of firms' opportunistic behavior is debated. If implementation of standards is costly, incentives exist to cheat and commit frauds (e.g., Silvestre et al. 2020, Meemken et al. 2021). This is a typical moral hazard problem where an agent (the firm) is taking advantage of the inability of others (the public regulator and consumers) to monitor performance (delivery of $\theta x = \Theta_h$) perfectly (Salanié 2005). A firm can gain extra-profits by claiming to adopt the sustainable production practices that are required by the standards, while they are producing using conventional technology.

1.9.1 Definition of opportunistic behavior and structure of the game

The illustrative example can be adapted to incorporate moral hazard easily. If a firm uses conventional technology, the production cost is $C_i(\theta x_i) = c_i \cdot \theta min^2$. If the same firm falsely claims that they are implementing a standards Θ_h, consumers are willing to pay for the product $wtp(\theta x) = R \cdot \Theta_h$, because they assume that the sustainability level that is offered by the firm is Θ_h (see Section 3.2.1 and the technical appendix for a discussion of the assumptions about consumer behavior). In the absence of monitoring, the payoff of moral hazard is $\pi_i\{\Theta, \theta min\} = R \cdot \Theta - c_i \cdot \theta min^2$. The moral hazard payoff is greater or equal than the payoff from compliance/adoption $\pi_i\{\Theta_h, \Theta\} = R \cdot \Theta_h - c_i \cdot \Theta_h^2$ because $\Theta_h \geq \theta min$. For any $\Theta_h > \theta min$ all firms have incentive to commit fraud.

The gain from opportunistic behavior (fraud) is:

$\psi_{m,i} = (\pi_i\{\Theta_1, 1\} - F_m) - \pi_i\{\Theta_1, \Theta_1\} = c_i(\Theta_1^2 - \theta min^2) - F_m$ for mandatory standards, and

$\psi_{v,i} = (\pi_i\{\Theta_2, 1\} - F_v) - \pi_i\{1,1\} = R \cdot (\Theta_2 - \theta min) - F_v$ for voluntary standards.

Figure 3-10: Structure of the three-stage game of moral hazard with heterogeneous firms.

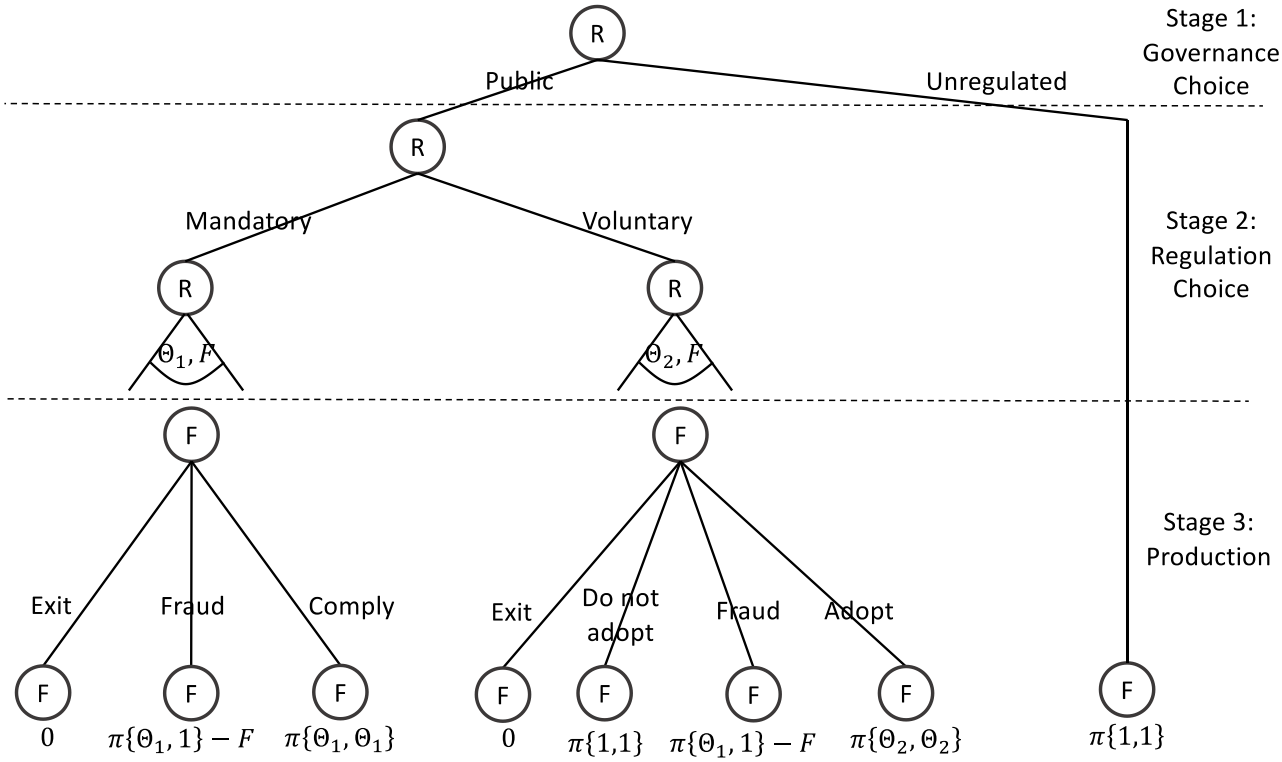


Figure 3-10 illustrates the structure of the three-stage game of moral hazard with heterogeneous firms. In stage 1 the public regulator decides the kind of standards (voluntary or mandatory), if any. Unlike previous models in this

report, this Section focuses on public standards only, because the strategies for preventing moral hazard in the private sectors are different from the one available to public authorities and the two approaches may be difficult to compare.[12]

In the second stage, the public regulator chooses the optimal strategy $\{\Theta_j, F_j\}$, where Θ_j is the sustainability requirement of the standards, F_j is the expected value of the penalty that a firm must pay if engages in opportunistic behavior, and j is an indicator variable that is equal to 1 if public standards are mandatory and equal to 2 if they are voluntary.

Following Starbird (2000) the value of F_j is determined as the product between the probability of being detected if committing frauds (for example, the probability of undergoing an inspection) and the negative consequences of being detected (for example, fines and/or loss of reputation). We assume that increasing F_j is costly for the public regulator. For example, more inspections must be conducted to increase the probability of detection, or a political cost must be paid to impose very expensive fines to firms even for small violations of the standards (the monitoring cost function is defined in Table 3-2).

In stage 3, firms choose between the available options. Under mandatory standards, there are three available options: to comply with the standards, to exit the market or to commit a fraud. Under voluntary standards, there are four options: to adopt the standards, do not adopt the standards (conventional production), to exit the market or to commit a fraud. The firm chooses the option that maximizes payoffs. It must be noted that because $\pi_i\{1,1\} \geq 0$ by assumption, exit is not a rational choice under voluntary standards.

1.9.2 Solution of stage 3: firms' optimal choice

In stage 3, firms take the pairs (Θ_1, F_m) and (Θ_2, F_v) as given and they choose the best option based on their individual cost parameter c_i. Figure 3-11 illustrates the choice in the case of mandatory standards (Panels A and B) and voluntary standards (Panels C and D). The plots report the values of the parameter $c_i = K_{X,Y}$ that make firms indifferent between two options X and Y. For example, the red lines in Panels A and B are the set of values of $c_i = K_{F,E}$ such that the firm is indifferent between committing a fraud and exiting the market for any value of F_m and for the selected value of $\Theta_1 = 1.4$ and $\Theta_1 = 1.7$. The equations defining the lines and the formal definition of $K_{m,n}$ are reported in Table 3-12 and in the technical appendix.

It must be noted that the values $\kappa_{m,n}$ can be used to compute the share of firms choosing a given alternative. Because c_i is uniformly distributed, the share of firms choosing option X over Y can be computed as:

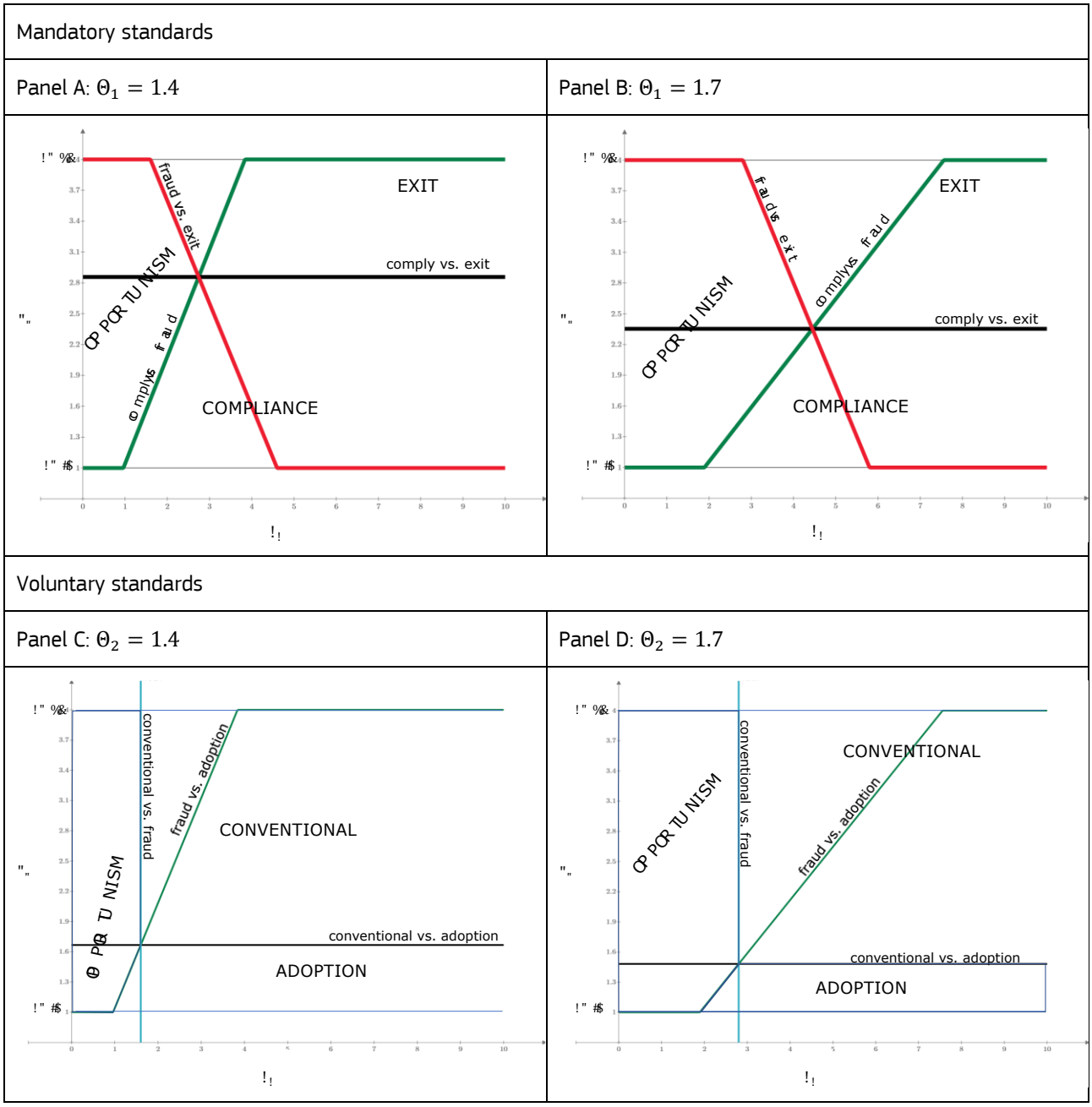
$$s_{X,Y} = \frac{K_{Y,X} - cmin}{cmax - cmin}$$

if option X is chosen for $c_i \leq K_{X,Y}$. If option X is chosen for $c_i > K_{X,Y}$, the share is $1 - s_{X,Y}$.

In the case of mandatory standards, Panels A and B in Figure 3-11 identify three areas. The area of compliance (green shaded area) is the set of c_i values that are lower than $K_{C,E}$ (black line) *and* $K_{C,F}$ (green line). It represents the firms that are so efficient in producing the sustainability attribute that (i) they achieve non-negative profits from compliance with the mandatory standards, and (ii) they have a small gain from opportunism (because $\psi_{m,i}$ is directly proportional to c_i).

[12] In this model, we assume that public regulators may implement only sampling controls for monitoring moral hazard. Instead, private firms may use incentive contracts and bonding to ensure the delivery of credence attributes (Russo et al. 2014).

Figure 3-11: Optimal firm choice when moral hazard is possible.



The area exit (gray shaded area in Panels A and B in Figure 3-11) identifies the set of firms that are so inefficient in producing the sustainability attribute that prefer to leave the market even if opportunism is possible. If the expected penalty for opportunism is large enough even inefficient firms prefer to avoid committing fraud.

The area of opportunism (red shaded area in Panels A and B in Figure 3-11) defines the set of firms committing frauds as the values of c_i higher than $K_{C,F}$ (green line) and lower than $K_{E,F}$ (red line). For low values of F_m opportunism is profitable, but when expected penalties increase the incentive to commit frauds decreases.

In the case of voluntary standards (Panels C and D in Figure 3-11), the three areas are *adoption of the standards* (in green), *conventional production* (yellow) and *opportunism* (red). Exit is not adoption if conventional production yields non-negative profits. The definition of the areas is similar to the case of voluntary standards. Adoption is profitable if c_i is lower than $K_{A,N}$ and $K_{A,F}$. Opportunism is chosen if F_v is low and c_i is greater than $\kappa_{A,F}$. Conventional production is the optimal choice when if F_v and c_i are high.

As the sustainability requirements increase (from 1.4 to 1.7 in the example in Figure 3-11) the share of firms complying with mandatory standards or adopting voluntary standards decrease. The incentive to opportunism increases as well (the red area is larger) and higher expected penalties are necessary to prevent it.

1.9.3 Solution of stage 2: optimal standards

Given the firms' choices in stage 3, the public regulator can find the optimal mandatory standards $\{\Theta_1^*, F_m^*\}$ and the optimal voluntary standards $\{\Theta_2^*, F_v^*\}$ that maximize social welfare. In moral hazard models, the social welfare function is more complex, and it considers more variables than the ones in Sections 3.3.2 and 3.4.2.

In the case of mandatory public standards, the social welfare function includes the following components:

- $\Pi_{c,f}$: The profits of firms complying with the mandatory standards (setting $\theta c = \theta x = \Theta_1$).
- $\mathrm{A}_{c,f}$: The value of the positive externalities from the production of complying firms.
- $\Pi_{f,f}$: The profits of opportunistic firms (i.e., setting $\theta x = \theta min$ but claiming $\theta c = \Theta_1$).
- Φ_f : The value of the penalties that opportunistic firms pay to the regulator (fines).
- $\gamma(F_m)$: The monitoring cost.
- Υ: Consumers' loss in surplus due to firms' opportunistic behavior.

Table 3-9: Objective functions for the model with moral hazard

Nature	Specification of social welfare function
Mandatory	$\boldsymbol{\Omega_{m,f}(\theta x) = \Pi_{c,f}(\Theta_m, \Theta_m) + \mathrm{A}_{c,f}(\theta x) + \Pi_{f,f}(\Theta_m, \theta min) + \Phi_f\ (F_m) - \gamma(F_m) - \Upsilon(\Theta_m)}$ Where: $\Pi_{c,f}(\Theta_m, \Theta_m) = \int_{cmin}^{\min(\mathrm{K}_{C,E};\mathrm{K}_{C,F})} \pi_i(\Theta_m, \Theta_m) dc_i$ are the profits of compliant firms $\mathrm{A}_{c,f}(\theta x) = \int_{cmin}^{\min(\mathrm{K}_{C,E};\mathrm{K}_{C,F})} a \cdot ln(\Theta_m) dc_i$ is the externalities produced by compliant firms $\Pi_{f,f}(\Theta_m, \theta min) = \int_{K_{C,F}}^{K_{E,F}} \pi_i(\Theta_m, \theta min) dc_i$ are the profits of opportunistic firms $\Phi_f\ (F_m) = \int_{K_{C,F}}^{K_{E,F}} F_m dc_i$ are the expected fines collected from opportunistic firms $\gamma(F_m) = g \cdot F_m$ is the monitoring costs $\Upsilon(\Theta_m) = \int_{K_{C,F}}^{K_{E,F}} R \cdot (\Theta_m - \theta min) dc_i$ is the loss in consumer surplus due to opportunism
Voluntary	$\boldsymbol{\Omega_{v,f}(\theta x) = \Pi_{a,f}(\Theta_v, \Theta_v) + \mathrm{A}_{a,f}(\theta x) + \Pi_{n,f}(\theta min, \theta min) + \Pi_{f,f}(\Theta_v, \theta min) + \Phi_f\ (F_v) - \gamma(F_v) - \Upsilon(\theta x)}$ Where: $\Pi_{a,f}(\theta x) = \int_{cmin}^{\min(\mathrm{K}_{A,N};\mathrm{K}_{A,F})} \pi_i(\Theta, \Theta) dc_i$ are the profits of adopting firms $\mathrm{A}_{c,f}(\theta x) = \int_{cmin}^{\min(\mathrm{K}_{A,N};\mathrm{K}_{A,F})} a \cdot ln(\theta x) dc_i$ is the externalities produced by adopting firms $\Pi_{f,f}(\theta x) = \int_{K_{A,F}}^{K_{N,F}} \pi_i(\Theta, 1) dc_i$ are the profits of opportunistic firms $\Pi_{n,f}(\theta x) = \int_{\max(\mathrm{K}_{A,N};\mathrm{K}_{N,F})}^{cmax} \pi_i(1,1) dc_i$ are the profits of conventional firms $\Phi_f\ (F_m) = \int_{K_{A,F}}^{K_{N,F}} F_m dc_i$ are the expected fines collected from opportunistic firms $\gamma(F_m) = g \cdot F_m$ is the monitoring costs $\Upsilon(\theta x) = \int_{K_{N,F}}^{K_{N,F}} R \cdot (\Theta - \theta min) dc_i$ is the loss in consumer surplus due to opportunism

In the case of voluntary standards, the specification of the social welfare function includes:

- $\Pi_{a,f}$: The profits of firms adopting the voluntary standards (setting $\theta c = \theta x = \Theta_2$).
- $A_{a,f}$: The value of the positive externalities from the production of adopting firms.
- $\Pi_{f,f}$: The profits of opportunistic firms (i.e., setting $\theta x = \theta min$ but claiming $\theta c = \Theta_2$).
- $\Pi_{n,f}$: The profits of firms with conventional production (i.e., setting $\theta x = \theta min$)
- Φ_f : The value of the penalties that opportunistic firms pay to the regulator (fines).
- $\gamma(F_m)$: The monitoring cost.
- Υ: Consumers' loss in surplus due to firms' opportunistic behavior.

Compared to the models of perfect and costless monitoring, the profits from opportunism, the net cost of monitoring and consumer damage must be considered. Table 3-9 reports the specification of the social welfare functions and of all components.

Figure 3-12: Social welfare of mandatory and voluntary standards for selected values of the sustainability requirements

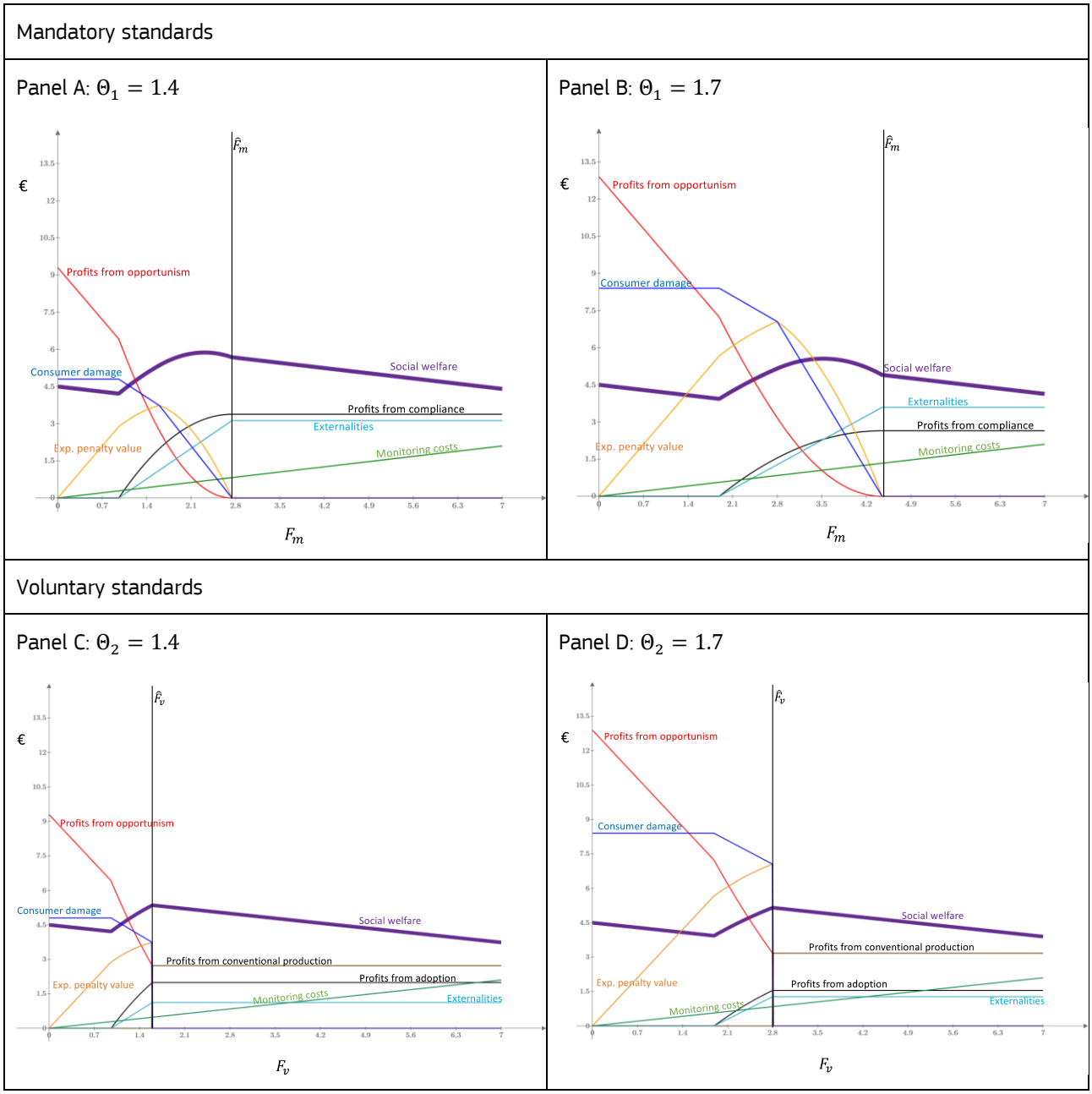
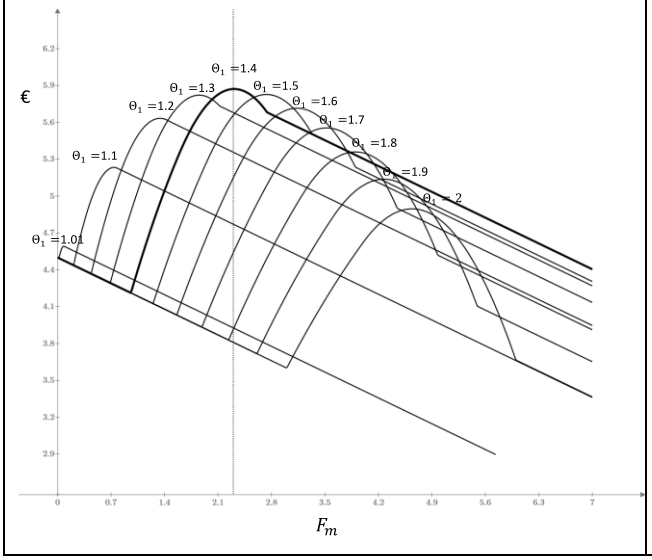
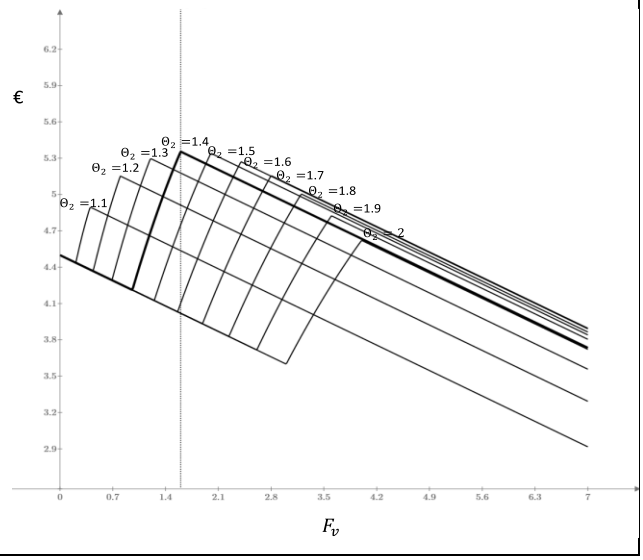


Figure 3-12 illustrates the computation of social welfare for mandatory and voluntary standards for selected values of sustainability requirements Θ_1 and Θ_2. The numerical example provides two important insights:

- **Mandatory standards maximize welfare when allowing a limited share of firms to be opportunistic.** In Figure 3-12 Panels A and B, the maximum of the function is achieved at a value $F_m < \hat{F}_m$, where $\hat{F}_m$ is the smallest expected penalty ensuring that no firm has incentive to commit frauds. **This result does not hold for voluntary standards, where the social welfare is maximized when no frauds are allowed**.
- As the sustainability requirements increase, incentive to fraud increase and consumer loss of surplus is more severe. Higher expected penalties are required to prevent frauds. As Θ_1 or Θ_2 increase from the selected value 1.4 to 1.7 (Figure 3-12), profits from opportunisms and consumer damage are higher and the values of $\hat{F}_m$ and $\hat{F}_v$ increase.

The optimal standards can be found via grid-search of the possible combinations of sustainability requirements and expected penalty. Figure 3-13 illustrates the solutions under the selected parameter values (see Table 3-1). The optimal mandatory standards are defined by the pair $\Theta_1^* = 1.4$ and $F_m^* = 2.3$ (Figure 3-13 Panel A) and the optimal voluntary standards are $\Theta_1^* = 1.4$ and $F_v^* = 1.6$

Figure 3-13: Optimal mandatory and voluntary standards when moral hazard is possible

Panel A: Mandatory standards	Panel B: Voluntary standards
	

1.9.4 Solution of stage 3: comparison of mandatory and voluntary standards

Comparing Panels A and B in Figure 3-13, Panels A and C in Figure 3-12, and Panels A and C in Figure 3-11, the following differences emerge between voluntary and mandatory standards.

- **Optimal mandatory standards yield higher social welfare than voluntary standards but are not Pareto efficient**. Inefficient firms incur in profit losses compare to the unregulated market and may even leave the market. In the numerical example, 23.3% of firms exit the market (Figure 3-11) and 24.3% make less profits than in the unregulated market. Regulators may consider compensations for firms. **Voluntary standards do not harm firms**, because inefficient firms can keep the conventional technology.
- The share of firms complying with mandatory standards is higher than the share of firms adopting voluntary standards (Figure 3-11). This result is driven by the fact that the cost of non-compliance under mandatory standards (exiting the market) is higher than the cost of non-adoption under voluntary standards (conventional production). In the numerical example, 46.7% of firms complied with the mandatory standard and 22.2% of firms adopted the voluntary standards.
- **The value of environmental externalities is higher under mandatory standards than under voluntary standards.** This result is driven by the difference in the shares of compliance/adoptions. Because more firms comply with mandatory standards, the impact on sustainability is greater than under voluntary standards.

- **Mandatory standards give more incentive to opportunistic behavior than voluntary ones.** The optimal expected penalty under mandatory standards F_m^* is lower than the one under voluntary standards F_v^*. Consequently, **opportunism is possible because the value of the expected penalty is not enough to discourage all firms from committing frauds**. In the numerical example, 30% of firms behaves opportunistically under optimal mandatory standards. If the regulator applies a sub-optimal expected penalty $F_m = \hat{F}_m$, no frauds are committed, more firms exit the market, and social welfare is reduced.

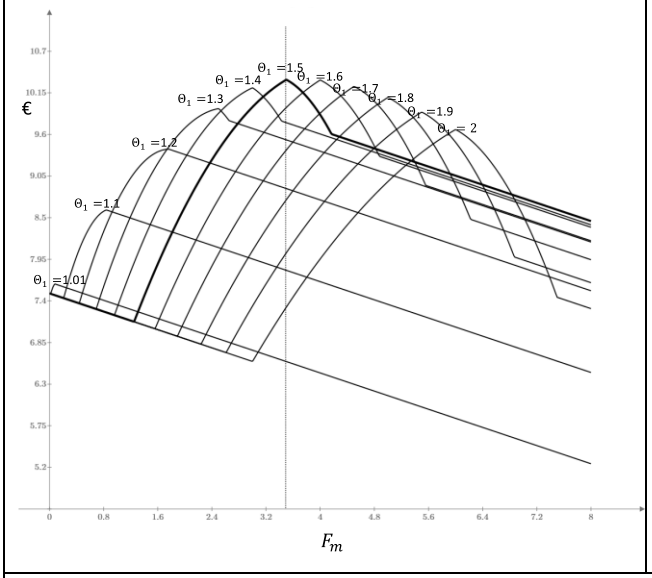
1.9.5 Parameters affecting the equilibrium

The solution in Section 3.5.4 depends on the selected values of the parameters in the numerical example. Figure 3-14 illustrates the effects of changes in consumers' marginal willingness to pay for sustainability (a change in R from 4 to 5) and in the value of the externality (a change in a from 5 to 10).

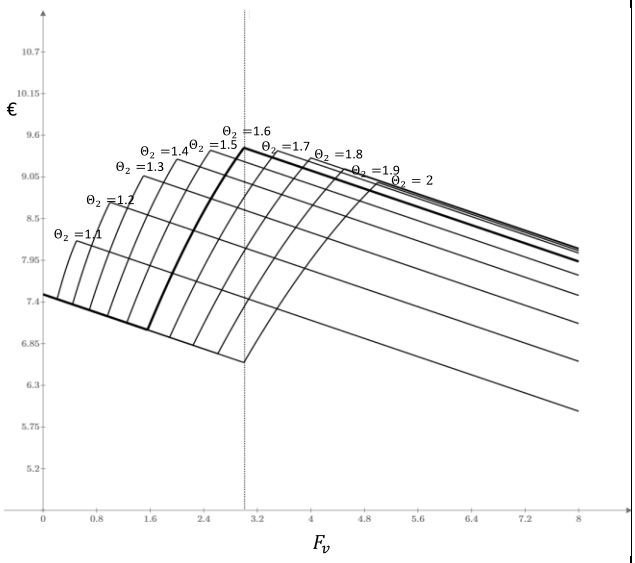
Figure 3-14: Solution of the regulatory problem for alternative values of the model parameters

Solution for $R = 5$

Panel A: Mandatory standards

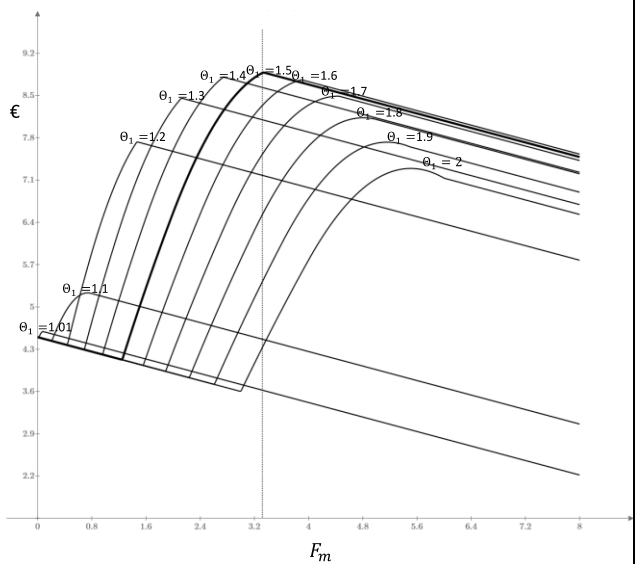


Panel B: Voluntary standards

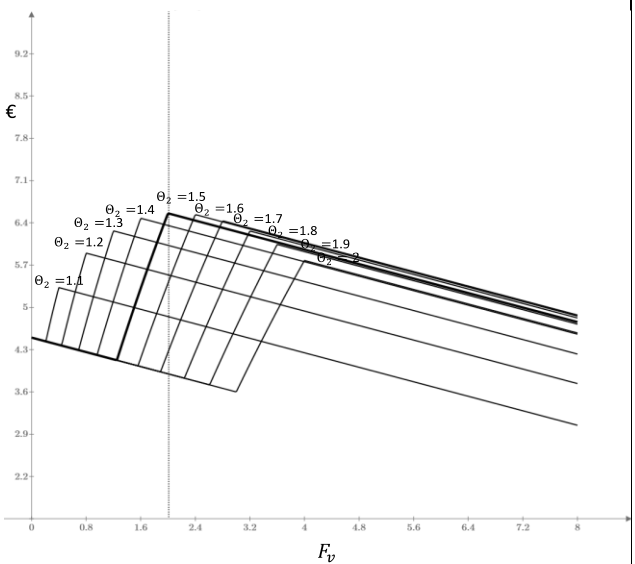


Solution for $a = 10$

Panel C: Mandatory standards



Panel D: Voluntary standards



An increase in R results in higher social welfare, higher sustainability requirements and higher expected penalties at the equilibrium. The conclusion holds for mandatory and voluntary standards alike. As R increases, the marginal

benefits of increasing θx are higher, and sustainable production is more valuable. Firms are willing to comply with or adopt higher sustainability requirements because the market price is enough to cover the increase in costs.

An increase in a leads to higher sustainability requirements and higher social welfare as well. In this case, the marginal benefit of an increase in θx is due to the positive externality, while market prices are constant.

The main difference between the two cases is that an increase in R benefits firms directly, while an increase in a does not affect market prices. If consumers' willingness to pay increases, there is a private benefit for firms in increasing sustainability. Public regulators can use this private incentive to impose higher sustainability requirements for the public good. Instead, if the change is in the value of externality only, firms have no incentive to increase sustainability. The consequence to higher requirements that public regulator adopts are higher shares of firms exiting the market or going back to conventional production. This limits the social benefits from an increase in the externality value.

1.9.6 Conclusions from the model of moral hazard

Sustainability marketing standards play two roles in agricultural markets. Like other standards (such as safety, quality ones) they are used to solve asymmetric information problems when consumers are not able to observe credence attributes. In addition to this function, sustainability standards are used to solve a typical externality problem. Sustainable food production is beneficial for the entire society, but market prices capture only the benefits for consumers. Thus, the market is unable to provide the sustainability level that is socially desirable. Table 3-10 summarizes the results from the moral hazard models.

The moral hazard model suggests that the two objectives of the standards may be conflicting with each other. Firms' behavior plays a key role in the solution of the multidimensional problem. In fact, high sustainability requirements may address the externality issue, but they give more incentive to opportunistic behavior making the information asymmetry problem worse. For this reason, the implementation of high sustainability requirements must be sustained with effecting monitoring by public authorities.

Table 3-10: Summary of results of the model with heterogeneous firms and moral hazard

Source	Nature	Pros	Cons	Subsidy	Effective
Public	Mandatory	• Max social welfare • Max sustainability	• Profit loss for firm • Possible firm exits • Compensation may be difficult if c_i's are unobservable. • Frauds may be tolerated to alleviate exits	• Compensation to ensure Pareto efficiency and to prevent exit	• R is low • a is high • Firms can be compensated
Public	Voluntary	• Pareto efficient • No incentive to tolerate frauds	• Less effective than mandatory public standards in improving sustainability	• Incentive to adoption for high sustainability standards	• R is high • Firms cannot be compensated

R: consumer marginal willingness to pay for sustainability (a measure of how much consumers are willing to pay for sustainability)

c_i: Heterogeneous and unobservable cost parameter measuring firm i's inefficiency in sustainable production

a: scale of the value of externalities (a measure of how important sustainable food production is for society)

1.10 Coexistence of mandatory and voluntary standards.

In previous sections it was assumed that only one type of standards can be implemented at the time. The public regulator could choose whether the governance is private or public or whether standards are mandatory or voluntary, but only one combination was allowed in the market. In this section, we allow for the coexistence of two types of standards. The topic is important because several certifications, public and private marketing standards already are established in agricultural markets. New regulations are expected to have consequences for existing institutions. **The discussion in this section assumed that firms are heterogeneous. The conclusions do not hold if all firms have the same level of efficiency in producing sustainable food ($c_i = \bar{c}\ \forall i$).**

In evaluating coexistence of standards, the timing of the game is important. For this reason, two cases are examined. In case one, mandatory and voluntary standards are established at the same time. Instead of considering whether to use one or the other, the public regulator uses the mandatory standards to establish a "minimum degree" of sustainability and the voluntary ones to enable efficient firms to increase their sustainable production. In the second case, a voluntary standard is already in the market and the public regulator must find the optimal mandatory standards. In order to simplify the presentation, the cases are discussed under the assumptions of perfect and costless monitoring (no moral hazard is allowed).

1.10.1 Combining mandatory and voluntary standards (simultaneous entry)

In this section, a public regulator is considering adopting both mandatory and voluntary standards in a market. The two standards are adopted simultaneously, and they are designed to maximize social welfare.

Figure 3-15: Representation of the game of simultaneous adoption of mandatory and voluntary standards

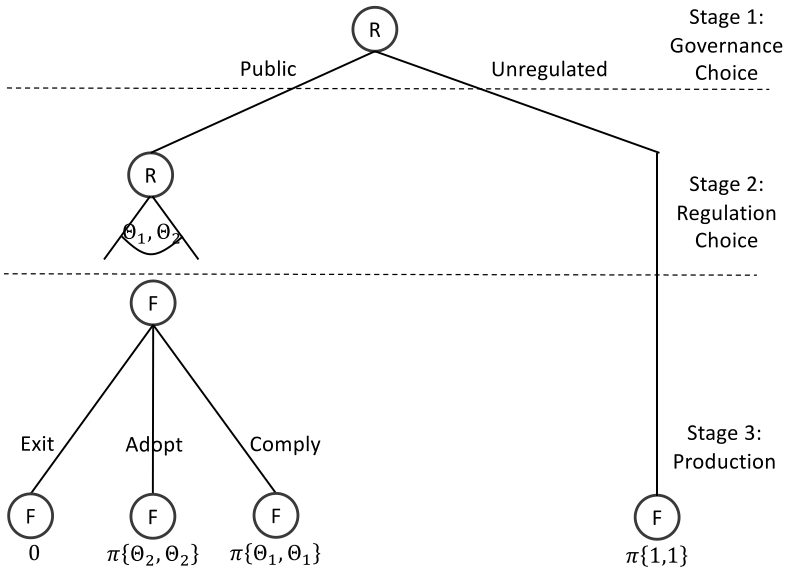
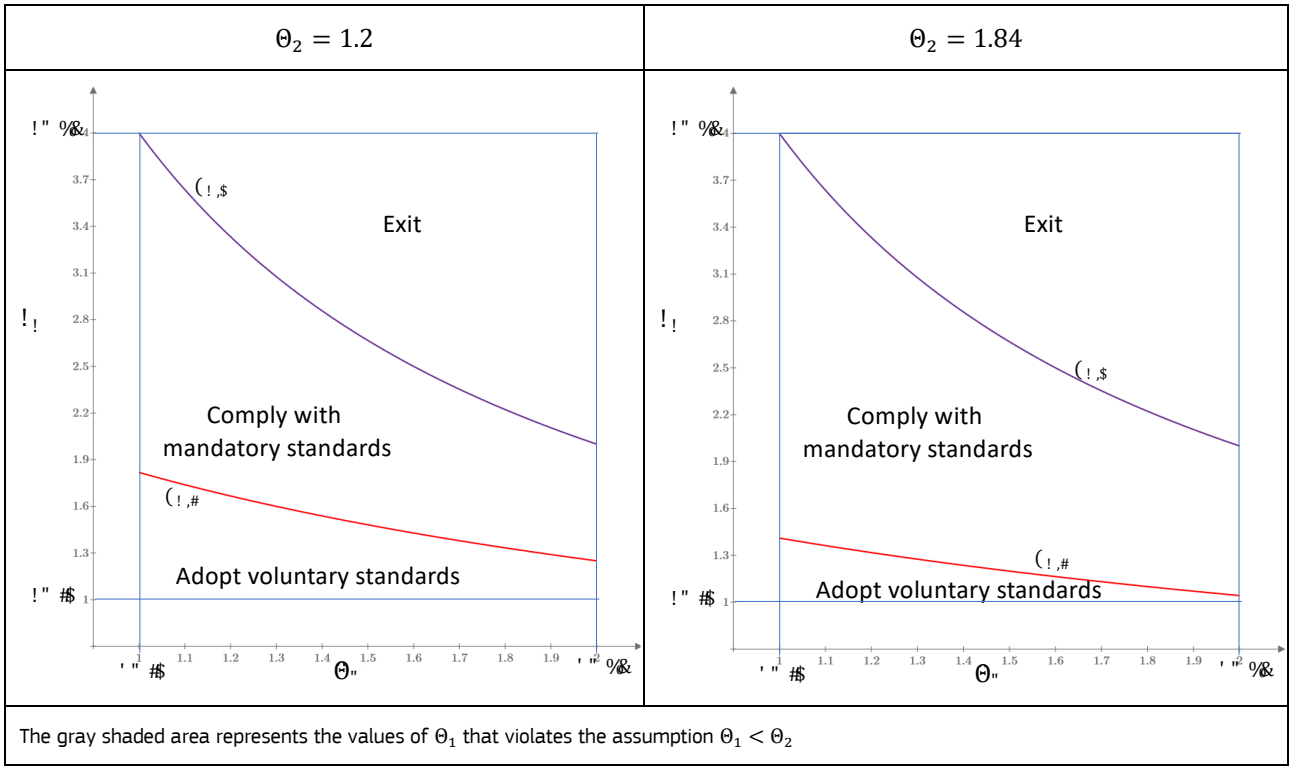


Figure 3-15 illustrates the three-stage game. In stage 1, the public regulator decides whether to regulate the market or not. In stage 2, the public regulator sets the sustainability requirements $\Theta_1$and Θ_2 for mandatory and voluntary standards, respectively (with $\Theta_2 > \Theta_1$). In stage 3, the firms choose among three available options: to comply with the mandatory standards, to adopt the voluntary standards, or to exit the market (note that because of the mandatory standards conventional production is not possible anymore). Because of the assumption of perfect monitoring, frauds are not allowed. The game is solved by backward induction.

Figure 3-16: Optimal firm choice when mandatory and voluntary standards are implemented



The gray shaded area represents the values of Θ_1 that violates the assumption $\Theta_1 < \Theta_2$

Figure 3-16 illustrates the optimal firm choice for any value of the mandatory standards requirements Θ_1 and for two selected values of the voluntary standards requirements Θ_2. Given any pair Θ_1, Θ_2, firm choice depends on the individual cost parameter c_i. Let $\mathrm{K}_{C,A}$ and $\mathrm{K}_{C,E}$ the values of c_i that make a firm indifferent between comply with mandatory standards and adopt voluntary standards or exit, respectively. Any firms with $c_i < \mathrm{K}_{C,A}$ maximizes profits by adopting voluntary standards. Firms with $\mathrm{K}_{C,A} < c_i \leq \mathrm{K}_{C,E}$ prefer to comply with the mandatory standards and firms with $c_i > \mathrm{K}_{C,E}$ leave the market.

Because c_i is uniformly distributed, for any pair Θ_1, Θ_2, the vertical distance between $cmin$ and $\mathrm{K}_{C,A}$ measures the share of firms adopting the voluntary standards, the vertical distance between $\mathrm{K}_{C,A}$ and $\mathrm{K}_{C,E}$ the share of firms complying with the mandatory standards, and the vertical distance between $\mathrm{K}_{C,E}$ and $cmax$ is the share of firms leaving the market. Figure 3-16 shows that as Θ_1 increases, the shares of firms adopting the voluntary standards and complying with mandatory standards decrease and the share of firms leaving the market increases. As Θ_2 increases, the share of firms adopting the voluntary standards decreases, the share of complying firms increases, and the share of firms leaving the market is constant.

The public regulator sets the optimal sustainability requirements in stage 2 taking firms' behavior as given. The social welfare function is defined as the sum of four components:

- $\Pi_x(\Theta_2, \Theta_2)$: Profits of firms adopting voluntary standards
- $\Pi_x(\Theta_1, \Theta_1)$: Profits of firms complying with mandatory standards
- $\mathrm{A}_x(\Theta_2)$: Value of the externalities produced by firms adopting voluntary standards
- $\mathrm{A}_x(\Theta_1)$: Value of the externalities produced by firms complying with mandatory standards

Table 3-11 illustrates the specifications of the functions.

Table 3-11: Specification of the objective function.

Social welfare (objective):	$\boldsymbol{\Omega_x(\Theta_1, \Theta_2) = \Pi_x(\Theta_2, \Theta_2) + \Pi_x(\Theta_1, \Theta_1) + A_x(\Theta_2) + A_x(\Theta_1)}$
Profits of firms adopting voluntary standards	$\Pi_x(\Theta_2) = \int_{cmin}^{K_{C,A}} \pi_i(\Theta_2) dc_i$
Profits of firms complying with mandatory standards	$\Pi_x(\Theta_1) = \int_{K_{C,A}}^{K_{C,E}} \pi_i(\Theta_1) dc_i$
Value of the externalities from voluntary standards	$A_x(\Theta_2) = \int_{cmin}^{K_{C,A}} \beta(\Theta_2) dc_i$
Value of the externalities from mandatory standards	$A_x(\Theta_1) = \int_{K_{C,A}}^{K_{C,E}} \beta(\Theta_1) dc_i$

The regulator's problem was solved numerically. Figure 3-17 illustrates the grid-search method. The objective function is maximized for the pair $\Theta_1^{**} = 1.3$ and $\Theta_2^{**} = 1.84$

Figure 3-17: Optimal combination of voluntary and mandatory standards

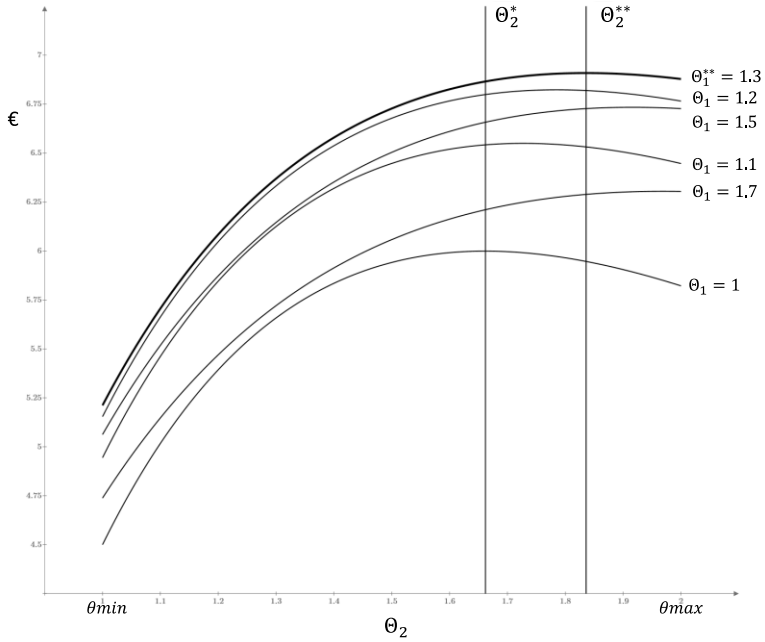
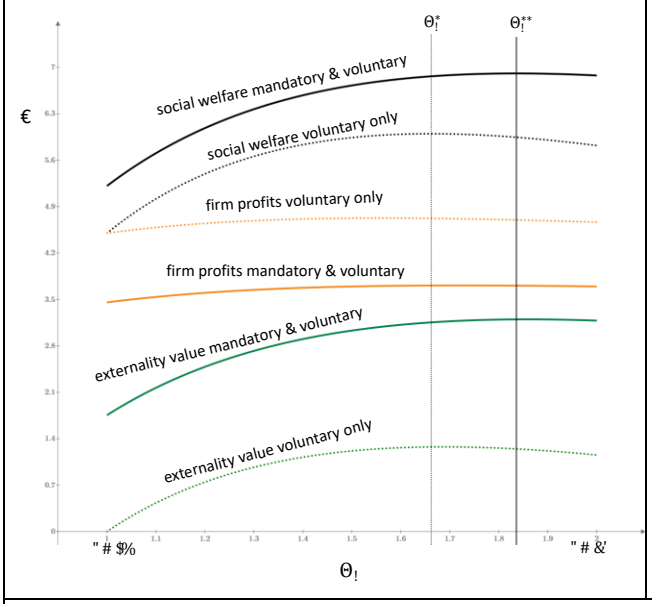
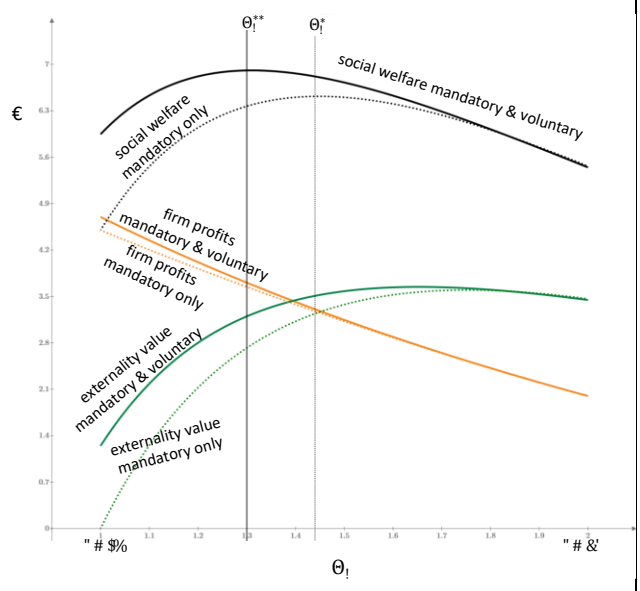


Figure 3-18 compares the outcome of the joint use of mandatory and voluntary standards with the use of voluntary standards only (Panel A) or mandatory standards only (Panel B). The illustrative example gives the following results:

- The combination of standards results in lower mandatory sustainability requirements and higher voluntary requirements than in a single type of standards approach ($\Theta_1^{**} < \Theta_1^*$ and $\Theta_2^{**} > \Theta_2^*$).
- Social welfare from combined standards is higher than social welfare from mandatory or voluntary standards alone.
- Firms' profits from combined standards are higher than profits from mandatory standards alone, but lower than profits from voluntary standards alone. The profit reduction compared to voluntary standards is due to the exclusion of the least efficient firms from the market (Figure 3-16).
- **The value of externalities is higher under combined standards is higher than any of the single standards.** The combined standards pool high share of firms complying with mandatory standards and high level of sustainability that is produced by efficient firms adopting voluntary standards.

Figure 3-18: Comparing welfare from joint application of voluntary and mandatory standards with the use of voluntary standards only (Panel A) or mandatory standards only (Panel B)

Panel A: comparison with voluntary standards only	Panel B: comparison with mandatory standards only
	

The gray shaded area represents the values of Θ_1, Θ_2 that violate the assumption $\Theta_1 < \Theta_2$

When firms are heterogeneous, combined standards are more efficient than voluntary or mandatory standards alone, and they yield higher value of externalities. These results are obtained at the expenses of lower profits for firms compared to those that can be obtained under voluntary standards alone. The result is driven by the exclusion of inefficient firms that is due to the mandatory standards. However, it must be noted that the share of firms leaving the market under combined standards is smaller than under mandatory standards alone, because $\Theta_1^{**} < \Theta_1^*$.

1.10.2 Introducing public mandatory standards when private voluntary standards are already in place.

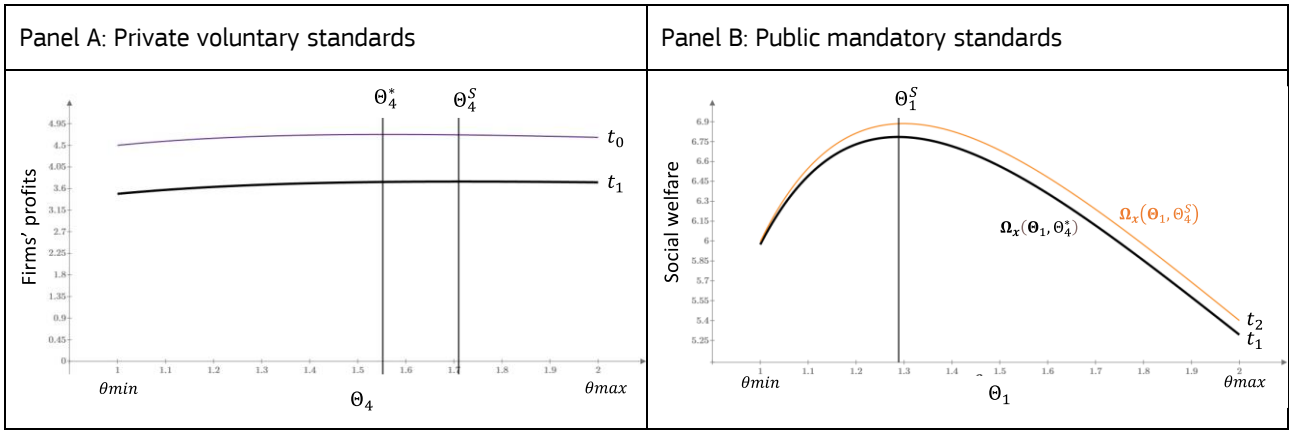
In this section, a market where private voluntary standards are already in place is considered. The regulator ponders to add mandatory standards in order to increase sustainability and achieve higher social welfare. A similar setting, with a more sophisticated mathematical approach and similar findings, is found in Gaigné & Larue (2016).

It must be noted that Fisher et al. (2009) found that a crowding-out effect is possible, and private standards may have limited effect when similar mandatory standards exist. The discussion in this section assumes that the differences in sustainability requirements are such that no overlapping between the two types of standards exists.

Figure 3-19 illustrate the effects of the introduction of the new standards. At time t_0, the private entity sets the sustainability requirements at level $\Theta_4^* = 1.55$ to maximize the objective function $\Pi_{v,h}(\theta x)$ from Table 3-7 for the game with heterogeneous firms and perfect monitoring (the purple line in Figure 3-19, Panel A).

At time t_1 the public regulator decides to impose mandatory public standards to improve social welfare and sustainability. The objective function is $\Omega_x(\Theta_1, \Theta_4^*)$ from Table 3-11 for the game of combined mandatory and voluntary standards, where the requirements of the voluntary standards are taken as given and equal Θ_4^* (the black line in Figure 3-19, Panel B). The sustainability requirements that maximize $\Omega_x(\Theta_1, \Theta_4^*)$ are labeled in the figure as Θ_1^S. It must be noted that the introduction of the public mandatory standards increases social welfare (i.e., $\Omega_x(\Theta_1, \Theta_4^*) > \Omega_x(\theta min, \Theta_4^*)$).

Figure 3-19: Introducing public mandatory standards when private voluntary ones are already in place



The introduction of the mandatory standards affects firms' profits because (i) firms with $c_i < \mathrm{K}_{C,E}$ that were engaged in conventional production at time t_0 are excluded from the market at time t_1 and (ii) firms with $\mathrm{K}_{A,N} < c_i < \mathrm{K}_{C,A}$ that adopted the voluntary standards at time t_0 move to the mandatory standards at time t_1. Thus, the profit function at time t_1 is $\Pi_x(\Theta_4|\Theta_1 = \Theta_1^S)$ from Table 3-11, where the firms take the requirements $\Theta_1 = \Theta_1^S$ as given (black line in Figure 3-19, Panel A).

Function $\Pi_x(\Theta_4|\Theta_1 = \Theta_1^S)$ has a maximum at $\Theta_4 = \Theta_4^S$ (Figure 3-19, Panel A). The private entity has incentive to update the voluntary standards to adjust to the introduction of the voluntary standards. The actual change in the sustainability requirements of the private voluntary standards depends on the cost of adjustment (i.e., the cost of designing and promoting the new requirements).

In the case of free adjustment, the private entity reacts to the new regulation by increasing the sustainability requirements to Θ_4^S. This change affects the social welfare function that is updated to $\Omega_x(\Theta_1, \Theta_4^S)$ (the orange line in Figure 3-19, Panel B), and the public regulator has incentive to update the mandatory standards. In this numerical example of costless adjustment, the iterative adjustment procedure converges to an equilibrium in $\Theta_1 = 1.3$ and $\Theta_4 = 1.72$.

The model of sequential adoption of standards, yields the important conclusions. Introducing public mandatory standards when private voluntary standards are in place may:

- Increase social welfare, therefore may be socially desirable.
- **Reduce firms' profits due to exclusion effects and higher production costs**. This point may explain why entrepreneurs oppose marketing standards in sectors where private standards are established already (Russo et al. 2022).
- **May reduce participation existing private voluntary standards**, because firms may find the public mandatory standards more profitable than the existing private standards.
- **Trigger an adjustment in voluntary standards.** According to the industrial organization literature about vertical quality, the introduction of public mandatory standards forcing inefficient producer to increase sustainability (quality) is expected to determine an increase in the sustainability requirements of the voluntary standards that are adopted by efficient producers (e.g., Tirole 1988, Fischer and Lyon 2019).

1.11 Summary and Conclusions.

This section summarizes the main findings from the illustrative model. The conclusions are organized in four themes.

1.11.1 Need for regulation: public vs. private standards

Sustainability public standards serve two main policy goals:

- **They can solve asymmetric information issues** due to credence nature of sustainability attributes. Certifications, marketing standards and labeling can support the decisions of consumers and buyers in the supply chains (McCluskey 2000, Golan et al. 2001). In theory this problem can be solved by the private sector using private standards. The role of public sector may be (i) adding credibility to certification (public inspections), (ii) reducing transaction costs and favoring coordination (as in geographical indications), (iii) developing voluntary standards when firms are unable to bear the costs, (iv) reducing barrier to trade and leveling playing field (v) developing voluntary standards with higher sustainability requirements than private ones (Russo et al. 2022).
- **They can increase the production of positive social and environmental externalities**. Because market prices may fail to capture the value of the externalities, firms may adopt technologies resulting in a production that is less sustainable than the social optimum even under perfect information. Mandatory standards can constrain firms to adopt socially desirable production processes (Schubert & Blasch 2010, Pretty et al. 2001, Meemken et al. 2021). Voluntary standards provide efficient firms the opportunity to exploit their potential for sustainable food production.

The need for regulation depends on the industry characteristics. It increases under two main conditions:

- **Low private incentives**. Consumers' willingness to pay for sustainable product is low and the cost of using sustainable production processes is high. These conditions imply that firms have low incentive to provide sustainability, even if the asymmetric information problem is solved.
- **High social incentives**. The social value of externalities is high. Under this condition, firms underprovide sustainability even if the asymmetric information problem is solved. As sustainable food production becomes more and more important for society, the need for regulation increases. In this regard, the Farm to Fork strategy is a key decision, establishing the high social value of sustainability.

An ideal setting for regulation is a market where externalities are high, but consumers' willingness to pay for sustainability is low. Instead, if consumers' willingness to pay is high and externalities are low, private initiative may be efficient. In general, we expect that as public concern about social consequences of unsustainable food production increases, the incentive to public regulation increases as well.

1.11.2 Comparing public mandatory and voluntary standards: the trade-off between profits and externality value

The illustrative model identified a key trade-off between profits and externality value to be considered when choosing between public mandatory and public voluntary standards.

Mandatory standards may be more effective in promoting positive externalities than voluntary ones, but they may harm firms. The impact on profits is the consequence of three effects:

- Exclusion of the least efficient firms that achieve negative profits under the mandatory standards (least cost-efficient firms).
- Reduction of profits of firms that must meet sustainability requirements that are too high for their cost structure but not high enough to result in negative profits.
- Increase in profits for efficient firms that fully benefit of the consumer higher willingness to pay for certified products.

Voluntary standards allow firms to keep conventional production if meeting the requirements is not profitable. **As a general conclusion, industrial organization literature found that voluntary standards are beneficial to the adopters** because firms are free to keep conventional production. Effects of voluntary standards on conventional firms depend on model assumptions. In the illustrative model mandatory standards are Pareto-efficient (help adopters without harming conventional producers) because it is assumed that prices of conventional products are unaffected by the standards. This is not a general conclusion, and it depends on how competition among firms is modeled. Several contributions found that introducing a voluntary standard (i.e., a high quality good) may determine a price and profit reduction for the conventional (low quality) product (e.g., vertical quality models, Tirole 1988). Thus, **there is a**

possibility that introducing voluntary standards may make conventional products less appealing to consumers.

Voluntary standards may result in a lower value of the externalities from sustainability than mandatory ones, even if their sustainability requirements may be higher than mandatory regulation. This result is driven by the rate of adoption of voluntary standards. While all firms in the market must comply with mandatory standards, only a share of producers adopts voluntary standards. If this share is smaller than the share of firms that stay in the market under mandatory standards, voluntary standards may result in lower externality value. Also, it must be noted that voluntary standards are attractive for efficient firms that have a low cost of implementing sustainable production processes. While mandatory standards impose constraints on all firms, voluntary ones provide profit opportunities to the ones who are already more sustainability oriented.

The policy goal can affect the decision between mandatory and voluntary standards. If the objective is to support firms in providing attributes consumers desire and are willing to pay for (focus on solving information asymmetry), voluntary schemes may be preferable. Instead, if the objective is to promote a transition of all firms in the agri-food system toward socially desirable sustainable food production (focus on externalities), mandatory standards may be preferable.

1.11.3 Combining multiple standards

Combining voluntary and mandatory standards may be efficient if firms are heterogeneous. The two regulations are complementary, and they are not mutually exclusive (see Section 3.6 for a complete discussion). When combining the two instruments:

- Mandatory standards in combination with voluntary standards can ignore the highly efficient firms and focus on the least efficient segment. In this way, sustainability requirements can be lower than under mandatory standards alone. **This strategy attenuates the exclusion effect (more firms stay in the market) and the negative impact on profits of the least efficient remaining firms**. At the same time all remaining firms must move to more sustainable production, either complying with the mandatory standards or adopting the voluntary standards.
- Voluntary standards in combination with mandatory standards can ignore less efficient firms (as they are managed by the mandatory standards) and focus on the highly efficient segment only. As a result, sustainability requirements may be higher than under a single instrument approach. It must be noted that, under the model assumptions, higher requirements imply that: (i) consumers' willingness to pay for certified product is higher, and (ii) the value of the externality is higher (see Table 3-1 for the definition of the variables). Consequently, p**rofits of highly efficient firms increase** (because of higher consumer willingness to pay for certified goods)**, and they deliver more sustainability externalities**. However, the share of firms adopting the voluntary standards is expected to decrease compared to a market with voluntary standards only, because of the cost of implementing the higher requirements (as described in Section 3.6).

A case of interest is the combination of public mandatory standards and pre-existing private standards. The actual outcome of the policy depends on the costs of adjusting the standards (developing and implementing new requirements and promoting them to consumers) and on the assumption regarding the consumers' willingness to pay for high level of sustainability in food production. In general, two effects were found:

- Aggregate profits of firms adopting the private voluntary standards decrease.
- There is an incentive to increase the sustainability requirements of the voluntary standards.

The conclusions of the illustrative model are consistent with existing literature (e.g., Ronnen 1991), however, the motivation differs because of the different assumption about firm behavior. The illustrative model assumes that firms are price takers and the reduction in profits is due to a decrease in the firms adopting the voluntary standards. In typical vertical quality models, firms set prices and the reason for the drop in profits is that high quality firms must lower prices to face the quality increase of low-quality firms.

In general, the introduction or strengthening of public mandatory sustainability standards is expected to lower the value of existing certifications. It must be noted that this result may concerns organic certification as well.

1.11.4 Combining sustainability standards with other policies

The illustrative model identified the weaknesses of the various types of standards. Mandatory standards promote sustainability but may harm firms; Voluntary standards may be profitable, but they are less efficient than mandatory ones in promoting sustainability; private standards maximize profits but provide sustainable food only as far consumers are willing to pay for it. To overcome these limitations, sustainability standards may be accompanied with other policies, such as subsidies. In particular, two approaches have been considered in the report:

- **Compensation subsidies** are transfers that are paid to compensate or reduce the harm to firms or consumers that incurred in a loss because of public regulation. In the case of of public mandatory standards, the regulator sets the sustainability requirements and by doing so causes profit losses to least efficient firms. In order to reduce the loss and the exclusion effect, two actions are possible: (i) sustainability requirements are set at a low level to attenuate the damage, or (ii) compensation is paid to inefficient firms. A *full* subsidy requires that each firm is paid exactly the amount that makes the firm indifferent between complying with the mandatory standards and conventional production. A *minimum* subsidy requires that each firm is paid the minimum amount that is necessary to keep a firm at zero profits. A full subsidy keeps a firm indifferent between conventional production and the sustainability standards, a minimum subsidy prevents exit.
- **Incentive subsidies** are transfer that are paid to elicit socially desirable behavior. In this case, they are paid to induce firms to adopt more sustainable production process (Pigouvian subsidy). Incentive subsidies are conditional and proportional to the desired behavior; they must ensure that a firm achieves higher profits through sustainable production than through conventional production (*full subsidies* are required because a *minimum* subsidy is not sufficient to induce adoption). Payments for the adoption of organic production are an example of incentive subsidy.

Both types of subsidies must be computed comparing the increase in costs due to the standards with the consumers' willingness to pay for sustainable production. Full subsidies cover for the entire difference, while minimum subsidies cover for part of it only. However, an efficient compensation scheme requires that:

- Production costs and consumers' willingness to pay are observable or at least unbiased and efficient estimates must be available, so that the amount of the subsidy can be computed. If the variables are not known to the regulator, beneficiaries may have incentive to claim high production costs in order to obtain higher subsidies.
- It is possible to offer at least a menu of payments if firm production costs are heterogeneous. If discrimination is not possible, overcompensation of efficient firms and under-compensation of inefficient firms may occur.

A key finding in the literature is that combining standards and subsidies may increase the incentive to opportunism. As noted in Section 3.5 the expected penalty must be able to offset the gain from opportunism. Compensation or incentive subsidies increase the gain from frauds because the opportunistic firms gain higher prices and the payment by claiming to be producing according to the standards. **For this reason, the combination of standards and subsidies may require a strict monitoring system to prevent frauds**.

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1.13 Technical appendix

The purpose of this appendix is to provide additional details about model assumptions, variables, solution equations and model calibration. The detail discussion may be a useful reference for the reader to assess the generality of model conclusions and explains how the results are achieved.

1.13.1 Sustainability as vertical quality attribute with externalities.

In this illustrative example, we focus on voluntary or mandatory sustainability standards, that is a set of norm, arrangements and regulations requiring firms to adopt good environmental, social, ethical, and food safety practices. We represent sustainability standards in a vertical quality model, where sustainability of production is measured with a scalar variable $\theta x \in [\theta min, \theta max]$ (e.g., Arora & Gangopadhyay 1995; Cremer & Thisse1999; see also Lyon & Maxwell 2020 for a review of the modeling alternatives). The higher the value of θx, the "more sustainable" firm production is. Summarizing the multi-dimensional concept of sustainability into a scalar is a great simplification that was introduced to keep mathematical tractability of the model. The assumption postulates a "sustainability function" exists such that all possible combinations of the many dimensions of sustainability are mapped into the variable θx. By imposing this assumption, we can model sustainability as a vertical quality attribute that has positive externalities. We assume that the value of the externality is a concave function of θx and a constant parameter a.

1.13.2 Consumers: homogeneous and imperfectly informed passive players.

Following vertical quality literature (e.g., Gabszewicz & Thisse, 1979), we assume that the consumer willingness to pay for the goods (wtp) is a linear function of θx, where $wtp(\theta x) = R \cdot \theta x$, and R is a parameter measuring consumer "taste" for sustainability (a constant marginal $wtp(\theta x)$ for an additional unit of θx). Consumer surplus is defined as $CS(\theta x) = R \cdot \theta x - p$ (Saitone & Sexton 2010b).

Three additional assumptions were introduced, deviating from the standard vertical model (e.g., Tirole 1988):

- *Homogeneous consumers*. Consumers are perfectly homogeneous and share the same value of the parameter R.
- *Zero consumer surplus under perfect information*. Consumers are willing to buy infinite quantity of the product for any price $p \leq wtp(\theta x)$. Because supply is limited, demand is large enough to ensure that consumers bid up for a limited supply of product. Consequently, at the equilibrium, price $p(\theta x) = wtp(\theta x)$ and consumers achieve zero surplus if they are perfectly informed about sustainability.
- *Imperfect information*. We model sustainability as a credence attribute (Darby & Karni 1973). Consumers are unable to observe the actual level of sustainability and may form expectations $\widehat{\theta x}$ based on available information (e.g., Rege 2000). In our illustrative example, if firms *claim* to comply with a marketing standard requiring $\theta x = \Theta$, consumers believe the claim and $\widehat{\theta x} = \Theta$; If no claim is made, consumers assume that firms offer minimum sustainability and $\widehat{\theta x} = \theta min$.[13] Under imperfect information, consumers' willingness to pay and market prices are function $wtp(\widehat{\theta x})$ and $p(\widehat{\theta x})$ of $\widehat{\theta x}$, respectively.
- Because consumers value sustainability, they incur in a welfare loss if $\widehat{\theta x}$ is overestimated (i.e., if the firms claim $\theta x = \Theta$, but in reality $\theta x < \Theta$).

1.13.3 Firms: infinite number of infinitesimal competitive suppliers.

The illustrative example considers an infinite number of firms, each producing an infinitesimal product quantity *m*. The total quantity that is supplied to the market is *M*.

The cost of production of the *i*th firm $C_i(\theta x_i | b, c_i)$ is a convex function of the sustainability attribute θx_i that is delivered by the firm and a parameter c_i measuring firm i's cost of delivering the sustainability attribute.

We assume that firms are competitive, take price $p(\widehat{\theta x})$ as given and then decide the level of the sustainability attribute θx_i according to a profit maximization principle. Note that many vertical quality model assume that firms are price or quantity setter.

[13] These beliefs are rational under the assumptions that (a) an efficient monitoring system preventing frauds is in place if firms claim compliance with a standard and (b) firms have no incentive to provide sustainability beyond θmin in the absence of a monitoring system.

1.13.4 Compliance, fraud, and monitoring under consumer imperfect information

If consumers act under imperfect information, firms may have incentive to commit fraud, by falsely claiming that they comply to a standard Θ, while they are delivering a product with minimal sustainability attributes θmin. It must be noted that, under the model assumption, a firm would be irrational to commit a fraud and provide any $\theta x > \theta min$.

In this way, firms can charge high price $p(\Theta) > p(\theta min)$ while incurring in a production cost $C_i(\theta min|c_i) < C_i(\Theta|c_i)$. This behavior is a typical moral hazard problem, where opportunistic firms take advantage of the consumers' inability to assess the actual quality of credence goods.

Because firms operate according to pure economic rationality, a monitoring system must be implemented to prevent frauds. If the monitoring system is in place, firms committing frauds pay a penalty F, representing the monetary certainty equivalent of a vector of negative consequences (including fines, reputation loss, loss of future business, etc.) the firm incur in if the fraud is detected. Noticeably, the value of F depends not only on the magnitude of the consequences (e.g., the amount of the fines) but also on the probability of being detected and on firm's risk aversion and time preferences. For simplicity, we assume that:

- F is the same for all firms (this can be obtained assuming risk neutrality);
- F is a function of the value of monetary fines and the probability of detecting the opportunistic behavior (i.e., the expected value of the fines);
- The value of fines that are paid by opportunistic firms is a revenue for the monitoring entity;
- The cost of monitoring is strictly increasing with F, for example due to more frequent on-site inspections.

1.13.5 Firms' choice of strategic alternatives

In the illustrative model, firms must choose between a given set of strategic alternatives including:

- Complying with mandatory standards imposing requirements Θ_m. The payoff of this strategy is $\pi_i(\Theta_m, \Theta_m) = R\Theta_m - c_i\Theta_m^2$.
- Adopting voluntary standards imposing requirements Θ_v. The payoff of this strategy is $\pi_i(\Theta_m, \Theta_m) = R\Theta_v - c_i\Theta_v^2$.
- Committing frauds claiming $\theta c = \Theta_m$ or Θ_v but setting $\theta x = \theta min$. The payoff of this strategy is $\pi_i(\Theta_j, \theta min) = R\Theta_j - c_i\theta min^2$, with $j = m, v$.
- Exiting the market. The payoff of this strategy is zero.

Table 3-12: Conditions for pairwise strict dominance of alternatives

Compared to	Preferred alternative			
	Comply with mandatory s.	Adoption of voluntary s.	Conventional production	Fraud
Adoption of voluntary s.	$c_i < \frac{R}{(\Theta_m + \Theta_v)}$		-	
Conventional production	$c_i < \frac{R}{(\Theta_m + \theta min)}$	$c_i < \frac{R}{(\Theta_v + \theta min)}$		
Fraud	$c_i < \frac{F}{(\Theta_m^2 - \theta min^2)}$	$c_i < \frac{F}{(\Theta_v^2 - \theta min^2)}$	$F > R(\Theta - \theta min)$	-
Exit	$c_i < \frac{R}{\Theta_m}$	$c_i < \frac{R}{\Theta_v}$	$c_i < \frac{R}{\theta min}$	$c_i < \frac{R\Theta - \mathrm{F}}{b \cdot \theta min^2}$

Because firms are rational profit maximizers, the specifications of payoffs can be used to identify the conditions for pairwise dominance of an alternative over another. By imposing that the payoff of alternative *X* is greater than the one form alternative *X* and solving for the variable of choice to derive the conditions. In Table 3-12, we report the conditions with respect to c_i, the variable expressing firm heterogeneity. In this way, it is possible to identify the groups of firms choosing each alternative (i.e., how many will be leaving the market, adopting the standards, etc.). An exception

is the condition comparing Non-compliance with Fraud, that is reported as a function of F, because the choice between the two alternatives does not depend on the firm cost structure.

Conclusions

Carlo Russo

In this chapter, the findings from the bibliometric review and the illustrative model are organized into consistent answers to the four research questions from Chapter 1. The answers are based on the discussion in previous chapters, and they do not develop new material. For easy of reference, each answer is organized in subsections addressing specific issues related to the questions.

1.14 Do mandatory standards generate better outcomes in terms of increasing production and supply of sustainable food than voluntary standards?

1.14.1 Complementarity between mandatory and voluntary standards.

In principle, the literature suggests that mandatory and voluntary standards must not considered as alternative policy measures. Instead, **if firms are heterogeneous**, a strong complementarity exists between the two tools. They attenuate each other weaknesses and reinforce strengths.

- When voluntary standards are in place, mandatory ones may set lower sustainability requirements, therefore exclusion effect and profit losses are attenuated.
- When mandatory standards are in place, voluntary standards may focus on a smaller set of firms and high sustainability requirements can be implemented. In this way, the profits of adopting firms increase.
- The overall efficiency of regulation and the value of externalities increase.

In a combined approach, mandatory standards focus on the least efficient firms and constrain them to use production processes that are more sustainable but are still compatible with their cost structure.[14] Voluntary standards instead, focus on the efficient firms and allow them to profit from consumers' willingness to pay for sustainability.

In a heterogeneous market, where efficient and inefficient firms coexist, a public regulator may want to use both type of standards jointly, instead of considering them as mutually exclusive alternatives.

1.14.2 Policy objectives

Voluntary and mandatory public sustainability standards pursue similar but distinct objectives. Their goal is to promote sustainable food production, but they operated in a different way.

Mandatory standards set the minimum requirements that a product must meet to be allowed in the market. Their practical effect is twofold:

- They increase the sustainability of production of the lower tiers of firms, those who were below the minimum requirements before regulation (or forces them out of the market),
- They give incentive to firms that were already sustainable before regulation to increase the sustainability of their processes even further as a competitive reaction to the changes in the lower tier.

The result is an increase in sustainable food production involving many firms although in different way. The effects on the lower tier (either compliance or exclusion) are expected to larger that on the efficient firms. In order to minimize unintended consequences on the lower tier, such as profit loss or exclusion form the market, sustainability requirements of mandatory standards must be lower than the ones of voluntary standards.

Voluntary standards set the reference requirements that a product must meet to be certified and labeled as "sustainable". Certification and labeling allow adopting firms to benefit from consumers' willingness to pay for sustainability and therefore increase profits. Voluntary standards focus on the most efficient firms and provide economic incentive to become even more sustainable. The literature on the effects of voluntary standards on conventional firms (i.e., on the non-adopting firms) is very limited. Vertical quality models suggest that if adoption of voluntary standards implies an increase in quality and price, conventional firms may increase their market share (Tirole 1988). However, all results in this area are conditional to the assumed distribution of consumers' willingness to pay.

[14] As defined in Chapter 3, for the purpose of this report a firm is defined as "inefficient" if the cost of implementing sustainable production processes is high compared to competitors.

If the main objective of the policy action is helping efficient firms to be even more sustainable, voluntary standards may be preferable. Instead, if the main objective is to lead all firms (and the least efficient ones in particular) to ensure at least a minimum level of sustainability, mandatory standards may be preferable.

1.14.3 Subsidies

Previous results hold if the use of marketing standards is not accompanied with subsidies. In fact, payments can be used to enhance the role of standards in ensuring production and supply of sustainable food. In particular:

- Compensative payments can attenuate the exclusion effect and profit losses from the use of mandatory standards. These subsidies are paid to all firms in the market as a full or partial compensation of the higher costs of production due to the mandatory rules. Higher sustainability requirements can be imposed and exit of firms can be prevented at the same time.
- Incentive payments can increase the share of firms adopting voluntary standards. Higher sustainability requirements and participation are achieved at the same time when financial transfers or other benefits are paid to adopters.

In practice, the outcome in terms of sustainable food production of voluntary and mandatory standards is affected by the value of subsidies that the regulator is willing to pay to promote the policy. The examples of organic food or animal welfare suggest that payments can be effective in promoting the adoption of voluntary standards. In principle, if the subsidy is high enough voluntary standards can achieve high level of participation.

Three key issues in the use of subsidies to promote standards are identified:

- **Distributive effects of the subsidy**. In principle, an incentive subsidy should be exactly equal to the cost increase that the beneficiary incurs in when adopting the voluntary standards. Similarly, a compensative subsidy should cover the cost increase at least to the point that negative profits are prevented. If costs are heterogeneous and unobservable or if the regulator cannot discriminate beneficiaries (i.e., must pay the same subsidy to all firms, without being able to calibrate the transfer to the individual costs), efficient firms may gain a policy rent (i.e., can receive more subsidies than it is necessary to compensate the cost of compliance or to elicit adoption). Less efficient firms may be undercompensated instead. Under these conditions, subsidies can have a distributive effect, favoring efficient firms.
- **Incentive to frauds**. Subsidies increase firms' benefits from implementing the standards. However, they also increase the benefits from frauds. By falsely claiming to use the standards, a firms can obtain higher prices *and the subsidy* without incurring in the high production costs. For this reason, when subsidies are paid the expected penalty for frauds must be higher than in a market without subsidy.
- **Barrier to international trade**. When using subsidies, the regulator can set high sustainability requirements without incurring in unacceptable firm exits (in the case of mandatory standards) or in low adoption rate of voluntary standards. However, if subsidies are paid to domestic firms only, these high requirements may be a barrier to trade. Without subsidies, international producers may find the standards unprofitable and prefer to opt out. The issue is of particular importance in the case of mandatory standards.

1.15 Voluntary vs. mandatory standards: which is the more efficient in stimulating firms to shift towards production and supply of sustainable food?

Industrial organization literature measures the efficiency of a policy with the changes in social welfare. In this regard, the findings are conflicting, and results depend on the model assumptions (see Chapter 3). This implies that **relative efficiency depends on the actual characteristics of the market**.

Two market features are of particular importance in the case of sustainability standards: (i) asymmetric information, and (ii) externalities. Both features refer to typical causes of market failure when the market fails to maximize social welfare. The presence of either of this feature is sufficient condition for efficient regulation.[15]

If food sustainability is a credence attribute, standards can help firms and consumers to identify and select the products with the desired characteristics (Leland 1979, Garella & Petrakis 2008). In a typical Akerlof (1978) setting, solving information asymmetry is beneficial for sustainable firms, that can benefit of consumers' willingness to pay for sustainable food.

[15] The conditions are not necessary because it is possible that marketing standards are socially efficient even in the absence of these two market features.

If sustainable production of food provides positive externalities, standards can help achieving the socially desirable level of sustainability (e.g., Ronnen 1991). For example, mandatory standards may drive inefficient out of the market and reallocate production to sustainable firms (Macedoni & Weinberger 2022).

Voluntary standards may be more efficient when the main goal is to solve asymmetric information and mandatory standards may be more efficient when the objective is to promote the production of positive externalities (Chapter 3).

As noted in Section 4.1.1, the combined use of mandatory and voluntary standards may grant a more efficient shift toward sustainable food production than each type alone.

1.16 Under which conditions voluntary vs. mandatory standards are more effective in promoting transition to a sustainable food system?

Several factors affect the relative efficiency of voluntary and mandatory standards and, consequently, regulator's optimal choice. The following variables are of particular importance:

- **Cost functions**. The nature of costs for sustainable production (variable or fixed), their magnitude and heterogeneity are key parameters. Costs are a key factor determining the exclusion effect of mandatory standards or the adoption decision for voluntary standards.
- **Consumer demand**. Consumer willingness to pay for sustainability and their ability to identify sustainable food enable the market to reward sustainable food production. If willingness to pay is low, the adoption rate of voluntary standards may be low and mandatory standards may be preferable. If consumers' willingness to pay is heterogeneous, the joint use of voluntary and mandatory standards can be considered.
- **Competition models**. The strategic interaction between firms is a key determinant of the policy outcome. Price taking, price setting or quantity setting models may lead to different conclusions about the efficiency of standards (e.g., Valletti 2000). Firm's collusion may be a relevant variable, because of the downstream structure of food value chains (e.g., Ecchia & Lambertini 1997).

The relative efficiency of mandatory and voluntary standards is difficult to ascertain from a theoretical standpoint. However, based on existing literature and the illustrative model in Chapter 3, Table 4-1 provides a crude summary of the findings. The results in the table must be considered as rough and imprecise approximation offering just general suggestions and are not intended as an accurate policy guide. All decisions must rely on an accurate market evaluation. It must be noted that Table 4-1 refers to the efficiency in promoting the transition to sustainable production, without considering the overall effects on social welfare.

Table 4-1: Crude summary of factors affecting the relative efficiency of mandatory and voluntary standards in promoting the transition to sustainable food production.

	Crude assessment of conditions for relative efficiency of:	
Factors affecting efficiency	Mandatory Standards	Voluntary Standards
Increase in margin from sustainable production	Low	High
Value of externalities	High	Low
Share of inefficient firms	High	Low
Share of consumers with high WTP	Low	High

The margin from sustainable food production is defined as the difference between the consumers' willingness to pay for sustainable food and its average cost of production. The increase is computed with respect to the unit margin of conventional production, and it measures the market benefits that firms can capture from the transition to sustainable production (in the absence of subsidies). **If the gain from sustainability is low, the appealing for firms of voluntary standards is low. The rate of adoption is expected to be low, and the effect on the sustainability of the food system to be limited. In this case, mandatory standard can be more efficient in promoting the transition to sustainable food production. However, in the absence of compensative subsidies, mandatory measures result in a strong exclusion effect if the increase in margin is small (or even negative).**

The value of externalities refers to the benefits that sustainable food production brings to society and are not captured by a price increase. Examples may include environmental benefits, mitigation of climate change, or social cohesion in rural areas. **Mandatory standards may be more effective in producing externalities because they ensure that production is allocated to efficient firms only, excluding the others from the market.** Voluntary standards, instead, facilitate efficient firms only.

It must be noted that if markets are heterogeneous, the distribution of the variables is important for policy design. A market with a large share of efficient firms and a limited number of inefficient ones can benefit from a voluntary approach. On the opposite, if efficient firms are few, voluntary standards may be ineffective. Similarly, in a market where only a small number of consumers are willing to pay a premium for sustainable food, voluntary standards may have limited effect.

1.17 What are the advantages and drawbacks of voluntary and mandatory standards from firms' behavior and strategic choice perspectives relevant for the transition to sustainable agri-food system?

The review of the literature pointed out few critical issues that must be considered in the design of sustainability standards.

1.17.1 The trade-off between sustainability requirement and exclusion or adoption.

High requirements may result in the exclusion of a large share of firms or in a low rate of adoption. The cost of standards for firms is a major drawback. Costly sustainability standards may harm firms' ability to compete in domestic and international markets. The problem can be attenuated with subsidies, but trade issues and information rents may emerge as unintended consequences.

High requirements under mandatory standards may result in a severe damage for inefficient firms. Instead, under voluntary standards inefficient firms may keep their business (although with a possible profit reduction if the standards depress the demand for conventional products). **Mandatory standards are more effective in promoting sustainable food production in inefficient firms than voluntary ones, but their consequences for inefficient firms may be severe.**

Voluntary standards promote sustainability in efficient firms only, the ones that are more likely to adopt private standards if available. However, their impact on inefficient firms is limited.

1.17.2 Incentive to opportunism.

The introduction of standards may originate a moral hazard problem and public monitoring may be required to ensure consumer protection. For a regulator, monitoring systems are expensive and may have a political cost as well (imposing high fines to producers, more bureaucracy, reducing entrepreneurial freedom etc.) that must be considered. Also, high expected penalties for opportunism that are necessary to discourage moral hazard may be perceived as disproportionate.

The comparison of the incentives to opportunism between voluntary and mandatory standards is not easy, and it depends on several variables including the value of conventional production and the benefits from participation to the standards. In general**, inefficient firms facing mandatory standards may have incentive to opportunism in order to avoid negative profits and exit. Instead, the opportunistic behavior of firms facing voluntary standards is driven by the extra-profits that the label or certification may give**. This difference may affect the public perception of standards and monitoring activities.

1.17.3 Reduction of product differentiation

"By its very nature, a minimum quality standard limits the range in which producers can differentiate quality" (Ronnen 1991, p. 491). For example, if sustainable and not-sustainable food product coexists in a market, after the implementation of mandatory standards sustainable products only remain. In price-competition models, the reduction of differentiation may lead to more fierce price competition among producers because price is the only competitive advantage that is left.

Vertical quality models suggests that mandatory standards may result in lower prices for firms using sustainable production processes, because they are not perceived by consumers as selling superior quality goods. On the other hand, if all producers in the market comply with the mandatory standards, certified sustainable production may be perceived as a prerequisite for market access and consumers and intermediaries may not be willing to pay a premium

(e.g., Menard & Valceschini 2005 about private safety standards). If the implementation of mandatory standards results in lower-than-expected prices, the exclusion effect can be stronger than expected as well.

1.18 Concluding remarks

Table 4-2 summarizes the comparison of voluntary and mandatory public sustainability standards, based on the findings in previous chapters. Few conclusive remarks can be drawn from the discussion.

Table 4-2: Comparison of voluntary versus mandatory standards

	Mandatory standards	Voluntary standards
Effects on inefficient firms (firms with *high* cost of implementing sustainable food production)	• Increase sustainability • Profit loss • Possible exclusion from the market	• No change in sustainability • Possible profit reduction (if labels/certifications lower consumer demand for conventional products)
Effects on efficient firms (firms with *low* cost of implementing sustainable food production)	• Increase sustainability only under asymm. information • Ambiguous effects on profits	• Increase in sustainability • Profit increase for adopting firms.
Subsidy (payments enhancing the effectiveness of the standards)	• Compensative subsidies to: o Attenuate exclusions and profit losses o Sustain high sustainability requirement • Cons o Possible rents (overcompensation) o Incentive to opportunism	• Incentive subsidies to: o Promote adoption o Sustain high sustainability requirement • Cons o Possible rents (overcompensation) o Incentive to opportunism
Conditions for relative efficiency (one type of standards being preferred to the other)	• Low margins from sustainable production • High values of externalities • High shares of inefficient firms • Low consumers' willingness to pay for sustainability	• High margins from sustainable production • Low values of externalities • High shares of efficient firms • High consumers' willingness to pay for sustainability
Conditions for high impact on sustainability of food production (the regulation is effective in facilitating the transition to sustainable food production)	• High shares of inefficient firms • High minimum sustainability requirements, requiring either: o High consumers' willingness to pay for sustainability o Compensative subsidies	• High shares of efficient firms • High minimum sustainability requirements, requiring either: o High consumers' willingness to pay for sustainability o Incentive subsidies
Conditions for efficient regulation (public sustainability standards are preferable to private governance)	• High values of externalities	• High values of externalities and asymmetric information • Asymmetric information and high coordination costs (private standards too costly)

1. The efficiency of public standards is expected to increase as public concern for environmental and social sustainability of food production grows.
    a. Mandatory and voluntary standards can facilitate the transition toward sustainable food production in the presence of relevant positive externalities, although in different ways. If the value that society

attach to these externalities increase (for example, because of climate change or resource depletion), public standards become more desirable socially.

b. In theory, information asymmetry alone is not sufficient rationale for public regulation, because private standards could address the issue. Public standards may be efficient in solving asymmetric information problem if:
    i. The cost of coordination of private firms is high
    ii. Consumers have limited trust in private certification and trust public ones more

2. The choice between mandatory and voluntary public sustainability standards depends on (i) the actual characteristics of the market, and (ii) the objective of public action. Cost, demand, and competition variables must be considered when designing the optimal policy (Table 4-2). Mandatory standards are more efficient when a change in food production by least efficient firms is needed. Voluntary standards are more efficient when the goal is to support efficient firms in exploiting their potential for sustainable food production. This implies that
    a. A sectoral approach to the regulation may be preferable, so that standards can be adapted to market conditions.
    b. Revision of the standards must be possible as market conditions change.
3. If a market exhibits heterogeneity in (i) firms' cost of implementing sustainable food production, and/or (ii) consumers' willingness to pay for sustainability, voluntary and mandatory standards are complementary in promoting sustainable food production. In a complementary setting, mandatory standards focus on least efficient firms and on the demand segment with lowest willingness to pay. Instead, voluntary standards support the most efficient firms in meeting the demand of consumers with high willingness to pay for sustainability.
    a. Public standards can be complementary with private standards as well. In this case, it must be considered that private standards do not take fully into account the value of externalities.

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List of abbreviations

MS	Mandatory standards
S	Standards
SI	Sustainable initiatives
VS	Voluntary standards

List of tables

List of figures

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