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Entering the supplier base through certified management standards

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ABSTRACT

This paper explores the external motive (i.e., the signaling purpose) according to which small- and medium-size firms are increasingly adopting a strategy of multiple certification at international standard-setting bodies (e.g. ISO), possibly to increase their chances of being selected as suppliers by large global players. We investigate how firms select their certification strategy, choosing between no accreditation at all, and a strategy requesting one or even multiple certified management system standards. Two types of potential suppliers (the high- and low-types) are envisaged, featuring different costs of accreditation for every selected level, and yielding different utility to their customer. Our analysis suggests that, by seeking multiple certification, firms may expand the space for separation, which also goes to the benefit of the buyer. We then study how different contract provisions may alter the equilibrium outcomes, e.g. showing that contractual penalties may either expand or even shut down the space for separation between types, depending on their size.

1. Introduction

Global sourcing is increasingly being pursued as a long-term strategic goal, essentially by all the major players in today's global economy. Multinationals with long and articulated value chains are often approached by specialized small and medium-sized enterprises (SMEs), operating in a wide range of upstream industries, seeking to join their supplier base, attracted by the possibility of receiving large and valuable contracts. Aerospace companies such as Boeing and Airbus SAS or car manufacturers such as Volkswagen AG have set up dedicated websites where they present their mission statements and the basic contractual terms for a range of inputs, components and services they require. Through these platforms, interested SMEs can then express their interest in initiating a supply relationship by providing all relevant information about their activities, products and organization.[1]

This novel practice makes the entire supplier selection process open to a very wide range of potential candidates from all over the world and less tied to established local relationships. By adopting this route, global players are undoubtedly increasing competition among potential suppliers, thereby opening up new opportunities for cost savings and/or efficiency improvements; however, they fatally expose themselves to the problems caused by asymmetric information about the attributes and qualifications of candidates who are more difficult to observe, particularly in the absence of lack of prior experience with that particular supplier(s).

Against this backdrop, it is quite natural to think of certified management standards (such as the ISO 9000 series or its relatives) as a fundamental device that SMEs can use for signaling, while assuring the potential customer their conformity to minimum quality standards and consolidated practices in both their internal organization and production operations. One striking evidence in this regard is the proliferation of a host of standards (e.g., SA 8000 Labor Management Standard, Oeko-Tex Standard 100 for textile

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[1] See https://www.airbus.com/be-an-airbus-supplier.html or https://www.boeingsuppliers.com/. Another example can be found at https://portalefornitori.volkswagengroup.it, for the case of a local subsidiary, namely Volkswagen Group Italia SpA, of a large multinational group.

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industries, OHSAS 18001 Standard for Occupational Health & Safety) over the last two decades, in addition to the most common and popular one (the ISO-family Standards). Moreover, an increasing number of firms and organizations all around the world is adopting a strategy of multiple certifications, which requires to attain a canonical quality management standard (such as ISO 9000), plus *additional* certificates of compliance with other management systems standards (such as the ISO 14000 standard for Environmental systems, or the OHSAS 18001 for Occupational Health & Safety). Strategies for adopting multiple certifications are well documented in the literature, see Labodová (2004), Karapetrovic and Casadesús (2009), or Wiengarten et al. (2017).[2]

This paper explicitly addresses this aspect, studying how SMEs optimally select their accreditation policy at international standard-setting bodies (e.g. ISO) to raise their possibility of entering the supplier base of a large global player, i.e., being selected as a provider of a specific service, component or input, related to their specific characteristic activity. To account for the increasingly popular strategies of adopting multiple certifications, we consider here a triple option for each firm, represented by (*i*) a strategy of no certification at all; (*ii*) a strategy of certification of a single management standard, i.e., a 'basic' level of accreditation, for instance through the ISO 9000 family; and (*iii*) a last alternative strategy of adoption of multiple certifications, underlying a 'full' level of accreditation in which ISO 9000 is paired with additional certificates of different series, or released by other certifying institutions.

Our model assumes a fringe of SMEs, each one operating in its small local market (getting a revenue that we normalize to zero) and potentially able to certify their management systems at some international standard-setting body, upon implementing the due adjustments in its internal organization and processes, which represent the main cost of certification. Every firm is interested in applying for the participation in the supply chain of a large global player, which might grant the assignment of large and valuable work orders, yielding strictly positive revenues.[3] While entering a supply relationship with this player has the same value for all firms applying to the same contract (this value being the one appointed by the customer for such given contract), we assume that some potential suppliers are better than others in performing the requested tasks and conforming to the customer's specifications.

More specifically, we distinguish between two types of firms. The low-type is able to deliver the input, component or services of the level of quality that is pre-determined in the contract, but faces a higher cost of production, may incur in additional costs post contract formation, and also needs further assistance and support by the customer. In turn, the high-type has a lower production cost and may accomplish the task with neither incurring additional costs nor requesting external support, which brings some extra utility to the customer. Accordingly, the global players obtains a positive net surplus from the selection of the high-type, and negative net surplus from the relationship with the low-type. The model features asymmetric information on the type of each potential supplier, which corresponds to private information.

As a remedy to this problem, firms may decide to send a signal, by certifying at international standard-setting bodies and, if so, by choosing a basic or full level of accreditation. The cost of accreditation varies with the level of certification requested by the firms, conditioning on their types. We adopt as a solution concept that of Perfect Bayesian Equilibrium (PBE), thereby restricting a global player to offer a contract whenever his surplus from the relationship with the candidate supplier(s) is positive in expectation. Every interested applicant chooses her certification strategy under a standard incentive compatibility constraint, based on the anticipation of the potential customer's beliefs. Our analysis unveils the conditions under which a separating equilibrium may emerge, with the two types of firms adopting different certification strategies, thereby disclosing to the customer their different nature.

We show that pooling equilibria (such that both types of suppliers adopt the same certification strategy) are possible for any admissible level of accreditation. The emerge of one or another pooling equilibrium depends on the certification costs relative to the value of the contract at stake, including the additional charges that the low-types may incur post-contract formation to meet the requested contractual specifications. Under more restrictive posterior beliefs – i.e., conditional on the buyer being more conservative when offering supply contracts based on the observed signals, in form of firms' certification choices – separation can be achieved in equilibrium. This requires the additional costs of the low-types being sufficiently large, up to the point they cannot replicate the certification strategy adopted by the high-types, while earning strictly positive profits. In this case, the high-types have therefore incentive to invest in certification and separate through the attainment of a superior level of accreditation, thereby raising their choice to receive a contract offer.[4]

We also consider an extended version of our model, in which supply contracts prescribe penalties (of pre-determined amount) for the low-type, e.g. in case of failures such as late delivery or lack of full compliance with the product/service specifications. Our analysis shows that such penalties have the potential to enlarge the space of separation in the certification behavior of the two types of suppliers, yet on condition of being sufficiently limited. When larger, they can instead lead to a complete crowding out of separation, acting as a sort of insurance scheme (for the customer) against the risk of selecting low-types, which reduces the utility of signaling through certified management standards.[5] In this case, we show that introducing bonuses and production

[2] Another relevant contribution in this regard is Karapetrovic et al. (2010), which reports that for most organizations with more than one certified standard in their sample (93%), ISO 14000 can be regarded as an additional certificate with respect to ISO 9000; and represents the second management standard in 85% of the cases. In turn, OHSAS 18001 has a much smaller incidence. Analogous evidence comes from Hernandez-Vivanco et al. (2019).

[3] Throughout this paper, the agent (*she*) applying for the order – i.e., for a supply contract – is named specialized producer, supplier, procurer, applicant, or even candidate. In turn, the one (*he*) offering the supply contract – and corresponding to a global player/multinational corporation in our narrative – is also called customer or buyer.

[4] As far as separation is achieved, the low-types have no longer reason to waste resources in accreditation, internalizing that the customer will infer their nature and will therefore make no offer. Accordingly, admissible separating equilibria entails the low-types not to certify, whereas the high-type attain some level of certification, depending on the relative costs' configuration (and the accessibility to the various levels by the other types).

[5] By foreseeing a penalty (or, by extension, a liquidity damage clause), a buyer can relax its posterior beliefs and becomes more inclined to offer a contract for any signal observed in the market, even more so the penalty is relatively large in expectation. This inevitably reduces the incentives for the high-types to invest in accreditation, thus facilitating mimicking by the low-types. As a result, pooling equilibria are more likely to emerge.

rewards in favor of the high-types – in addition to penalties for the low-types – is unable to restore separation. In principle, these additional provisions should foster investment in certification, basically making the supply contracts at stake more appealing for the best performing suppliers. However, they prove ineffective in changing the buyer's posterior beliefs, which remains favorable to a contract offer in any case – i.e., irrespective of the applicant's certification choice – as far as penalties are in force. By contrast, bonuses (if set at a reasonable amount) tend to prompt separation whenever studied (and applied) in isolation, i.e., in the absence of contractual penalties. They induce more restrictive posterior beliefs by the customer, which then becomes less inclined to make a contract offer, unless more robust signals are observed.

A key feature of our analysis is that we focus here on the external motive for seeking accreditation at international standard-setting bodies, while we disregard completely the internal motivation, i.e., the argument according to which the adoption of acceptable certifying practices (e.g. those requested by the ISO 9000 quality management standard) may positively affect firm productivity and the quality of the product or service supplied to the customer. The reason supporting this clear-cut choice is twofold. First, as a matter of fact, when pursuing a multiple accreditation strategy, firms tend to certify internal procedures, organizational solution and operational practices that – as in the case of the ISO 14000 standard for Environmental systems or the ISO 26000 standard for social responsibility – that do not directly improve firm performances or product quality, but appears to primary signal desirable attributes of the firm's *mission* and the ability of the management to put them into practice.

Second, while early studies (such as Rao et al., 1997) have detected improved operational performances of certified organizations, several follow-up contributions have raised concerns of reversed causality (see King and Lenox, 2001 or Heras et al., 2002) or pointed out a series of methodological issues.[6] Overall, evidence on this point is quite controversial and a generalized consensus on the direction of the causal effect is far from being reached. In turn, a large number of studies testifies the presence of an external motive for firms to certify their management standards. This point is clearly stressed by Terlaak and King (2006), according to whom input suppliers invest in a costly and troubled accreditation process basically as "an attempt to communicate about desirable organizational attributes to parties that cannot observe them directly", which perfectly supports our narrative. Their analysis, performed using a panel of U.S. manufacturing facilities, indeed provides clear evidence that management standards (ISO 9000, in their case) primarily act as a market signal to communicate to customers about organizational quality attributes that would, otherwise, be difficult to observe.

Our paper contributes to different strands of the economic and management literature. To the best of our knowledge, it is the first to explicitly model a signaling device through management systems standards in the context of global sourcing transactions. Moreover, it innovates in the literature of signaling by introducing a discrete choice between different levels/extents of certification through the 'basic/single' vs. 'full/multiple' certificate dichotomy, so that accreditation is no longer a binary choice of the type yes-or-no. It also contributes to the growing bulk of literature on the adoption of multiple certifications (in particular, on the integration of ISO 9000 quality management systems with ISO 14000 environmental or other standardized management systems). So far, a few authors have explained the increasing number of firms and organizations pursuing this strategy based on the internal motives for accreditation, stressing how similarities between the standards in terms of design, language and methodology of certification naturally plays in favor of such integration (see Zeng et al., 2005). In turn, we provide here a distinct and possibly complementary rationale, based on the external (signaling) motive. Simple comparative statics on our results also proves insightful to connect our theory with multi-faceted observational evidence from many industries and the patterns of management standards' diffusion reported by several papers.[7]

We introduce our signaling game in its baseline version in Section 2, while in Section 3 we derive the admissible equilibria. Section 4 portrays a social welfare analysis, based on a simple comparison among such equilibria. Section 5 proposes an extension with pre-determined contractual penalties and bonuses, to figure out how they may alter the equilibrium outcomes and affect the signaling role of certification. Conclusions are reported in Section 6.

2. Basic setup

2.1. Environment

An industry is populated by a finite number of small or medium-sized enterprises which are fully specialized in their characteristic activity. Every firm is active in a different small-scale local market, where it disposes of a local customer base with inelastic demand and therefore enjoys some monopoly rent, which justifies entry in the industry. For sake of simplicity, we assume that sale revenues are symmetric across local markets, and we normalize them to zero. We also assume that some firms are better than others in their product/service provision, in light of their superior productivity or managerial skills or stock of intangible assets. Accordingly, and in the interest of tractability, we consider two possible levels of costs at which these firms may operate. We then define as the low-type (L) a firm characterized by the highest level of production costs, denoted as $c_L > 0$; and as the high-type (H) one characterized by a lower cost $c_H \in (0, c_L)$. Nature determines the type of each firm, that we consistently index with $j \in \{H, L\}$.

[6] One example is Corbett et al. (2005). Using event-study methods, they show that the exact timing and magnitude of the effect of the first ISO 9000 certification on firm performances depends on the specification of the control group of non-certified organizations.

[7] Many studies have taken a geographical or even institutional perspective on the adoption of certified management standards, either focusing on specific certificates (mostly ISO 9000 or ISO 14000) or running a comparison across standards (e.g. studying country-level diffusion of ISO 14000 compared to ISO 9000). Other works are specifically aimed at predicting future diffusion or saturation levels, see Franceschini et al. (2010).

Every firm, irrespective of its nature, is however interested to apply for being selected as a supplier by an important final good producer in control of a global supply chain. Participating in this chain would grant superior profitability with respect to operating in the local market. In particular, we pose that entering the supplier base of the large global player (*he*) secures the appointment of a large work order – i.e., a supply contract – with value $\theta > 0$ from the perspective of a potential supplier (*she*). This can be regarded as the payment that the customer commits to make for the product or service which is the subject of the supply contract in question. It corresponds to public information at the time that potential suppliers apply for the contract. In other words, for a supplier's perspective, the value θ of the relationship with the global player is exogenously given, and constitutes the premise for the suppliers' decision to engage or not in signaling through certification at international standard-setting bodies.[8]

The utility that the global player derives from the relationship with a certain supplier depends on the type of the latter. It is therefore denoted as $v_j > 0$ with $j \in \{H, L\}$. We assume that $v_L < \theta < v_H$. Given the payoff function of the global player, namely

$$\pi^G = v_j - \theta, \tag{1}$$

this assumption implies that a positive surplus from the supply relationship accrues to the customer only when contracting a high-type supplier; in turn, a strictly negative payoff is obtained when selecting the low-type. The reason can be sought in the additional efforts that the customer makes to provide further assistance and support to the low-type in the production stage of the game, to make up for the supplier's lower level of productivity or managerial skills or stock of intangible assets.

The problem of the global player is that he cannot directly observe the profile of the firms applying for the supply contract, as their relevant qualifications are hard to check and therefore correspond to private information. This may induce the applicants to go through a costly process of accreditation of their management systems, to signal their organizational attributes to the potential customer and thus raise their chances of receiving a contract offer.

2.2. Certification

Before proceeding with the description of the signaling game that characterizes our model, it is worth stressing how certification at international standard-setting organizations might represent a possibly desirable way out for customers to the typical problem of adverse selection induced by asymmetric information. In principle, a buyer holding an informational disadvantage over the counterpart could offer a contract with a contingent payment, to be determined based on an *ex-post* evaluation of the supplier performance. These contract schemes are nonetheless of limited practical feasibility, as they are also necessarily tainted by the various shortcomings arising from contract incompleteness.

In our setting, a customer has no interest in offering different contracts to the two types of suppliers that might render less useful the certification requirement. A screening mechanism could possibly solve the problem of adverse selection, without the need for any certification process by the potential suppliers. Nonetheless, this might be costly and possibly leave some residual uncertainty. Moreover, the decision of many firms to cope with a series of troubles and additional expenses to obtain a certification of their management systems is a matter of fact; and as explained in the Introduction, a huge bulk of empirical studies (included surveys with interviews to managers and entrepreneurs) document that the signaling purpose is the main driver of this choice. It is also an established fact that a range of certification (through ISO and/or other standards) exists, which allows firms to select their degrees of certification among various possible levels.

Our model is novel in explaining, for the first time, the existence of this range of accreditation and the firm decision to invest to get either one single or multiple certificates, as suggested by observational evidence. The signaling mechanism is therefore conceived here to facilitate the selection process of the customer, basically through the separation between the high- and low-types, i.e., their choice of selecting different levels of accreditation at the equilibrium. Note that this outcome is the one desirable from the customer's standpoint, as it allows the distinction between the high- and low-types. To this purpose, the different coverage of the available certifications is summarized in the strategy set $\Omega = \{NC, BC, FC\}$ of any candidate supplier. The first option entails abstaining from any effort and cost to provide a market signal, resting with no certification (NC). The second option entails getting a basic level of certification (BC), that one might think of as the common ISO 9000 family standard. This certification corresponds to a sort of primary accreditation, through which firms may document their adequacy to management principles such as a "strong customer focus, the implication of top management, the process approach, and continual improvement" (ISO, 2020). The last option finally requires to attain a 'full' level of certification (FC), e.g. by integrating the ISO 9000 standards with additional certificates.[9]

We assume that all suppliers are capable, in principle, to meet the minimum requirements for getting the desired level of certification (either BC or FC), although the associated cost varies with the type of the applicant, namely H or L. In our notation, this cost is labeled γ_j^i, where $i \in \Omega$ identifies the type of signal sent to the potential customer (i.e., the selected level of certification), while $j \in \{H, L\}$ denotes the type of firm. A series of intuitive assumptions hold. First, given her own type, every potential supplier

[8] In Section 3.1 we show that assuming that θ is endogenously set by the buyer to serve the purpose of profit maximization would not affect the core result of our analysis.

[9] For instance, suppliers might be interested in adding to the baseline ISO 9000 certification a certified standard of the type ISO 14000, to signal a specific attention to reduce the environmental impact of their activity; or, otherwise, a standard of the type ISO/TS 16949, which encompasses ISO 9001 by adding additional requirements (reinforcing the strength of the signal), specifically designed for the automotive sector. Other certificates, mainly related to sustainable production, are widely diffused in the textile industry. Within the ISO family, it is also worth mentioning certifications such as ISO 31000 (for resilience and "Risk Management"), ISO 26000 (for "Social Responsibility"), or even ISO 37001 (for "Anti-Bribery Management System"), that are typically paired with ISO 9000 by firms adopting a multiple certification strategy.

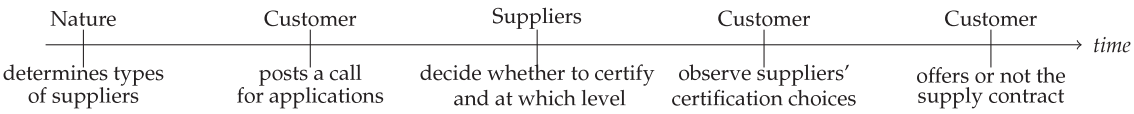

Fig. 1. Timing of the game.

faces a higher cost, the larger the extent of the certification, i.e., $\gamma_j^{FC} > \gamma_j^{BC} > \gamma_j^{NC} = 0$. The reason is quite obvious. Second, at every level of certification, the cost of accreditation is higher for the low-types than for the high-types, i.e., $\gamma_L^i > \gamma_H^i$ for both $i = BC$ and $i = FC$. This is again consequence of the lower level of productivity, managerial skills and intangible assets that characterize these suppliers, compared to the $H-$types. As a simplifying assumption, we assume here that $\gamma_L^{BC} = \gamma_H^{BC} = \gamma^{BC}$, implying that the cost of getting a basic level of certification is symmetric across types. Note that this corresponds to the worst-case scenario for suppliers to signal their types, as it restricts the overall space for separation.[10]

A couple of final remarks are required, at this stage. First, given our narrative, the bargaining power of the potential customer is overwhelming compared to that of every potential supplier, either H or L. The offer of a supply contract then takes the form of a "take-it-or-leave-it" offer by part of the buyer, which excludes any possibility for the candidate supplier to negotiate over the contract terms, included the payment due for the service or product under examination. Second, the attainment of a certain degree of certification (even the "full" one) does not affect the nature of the supplier and hence her cost structure; analogously it has no consequence on the value of the potential supply relationship with the customer. This assumption resonates well with the point raised by Belleflamme and Peitz (2014), according to whom the "ISO 9000 certification does not guarantee the quality of end products and services; rather, it certifies that consistent business processes are being applied"; and hence it "does not constitute a minimum standard on product quality". Based on these considerations, we then leave aside any aspect related to a vertical dimension of the market and a possible relationship with the adoption of certified management standards.

Coming back to our model, we finally assume that – even when fully certified, i.e., when choosing the strategy $i = FC$ – the low-types incurs additional costs in the production stage of the game, again as a consequence of their lower level of productivity, managerial skills and intangible assets, and by reasons of the more challenging production conditions faced when serving the global player, in place of the local customer.[11] This additional cost, in expectation, amounts to $\tau > 0$ and arises with some positive probability for the $L-$types only.

We can now write the supplier's payoff functions as follows. If supplier $j \in \{H, L\}$ receives a contract offer, her payoff evaluates to

$$\pi_j[o] = \theta - \gamma_j^i - c_j - \mathcal{I}_j \tau, \tag{2}$$

where $\mathcal{I}_j$ is an indicator function, that takes value one if $j = L$ (i.e., the supplier is a low-type) and zero otherwise.[12] In turn, if j receives no offer from the global player, she then falls back on the original local market, which is a sort of sloppy second. Her payoff boils down to

$$\pi_j[no] = -\gamma_j^i - c_j. \tag{3}$$

Any certification, if acquired, turns completely pointless and the cost of accreditation γ_j^i then constitutes a dead-weight loss.

2.3. Timing, solution concept and preliminary insights

The timing of the events follows. First, Nature selects the supplier types (H or L) upon entry into the industry. Second, a large global player posts a call for applications for potential supply relationships. This option creates a first-choice market for both high- and low-types, their back-up option being represented their corresponding local market. At this stage, the global player does not observe the type of the applicant but assigns a prior $\alpha \in (0, 1)$ that a candidate is a high-type. Then, every supplier decides whether to get certified or not at some international standard-setting body; and, in case, whether to attain a full or basic level of certification. The selected accreditation process takes place; the global player observes the signal sent by the applicant and, for any $i \in \Omega$, updates his beliefs to $\tilde{\alpha}_i \in [0, 1]$. Finally, he decides to offer or not a supply contract to every candidate supplier. Fig. 1 portrays this sequence.

In expected terms, the global player's payoff from each potential relationship is

$$\mathbb{E}(\pi^G) = \tilde{\alpha}_i v_H + (1 - \tilde{\alpha}_i) v_L - \theta, \tag{4}$$

when a contract offer is put forward; while it amounts to zero whenever the candidate is rejected. We apply here as a solution concept the Perfect Bayesian Equilibrium (PBE) under the so-called Intuitive Criterion (Cho and Kreps, 1987), which we define as follows[13]:

[10] All results established in this paper can then be generalized in the form of $\gamma_L^{BC} > \gamma_H^{BC}$ by assuming further conditions of the single-crossing property. We refer the reader to Lemma 1 for some hints of the general proof.

[11] One alternative interpretation could be a reputation cost, should the global payer releases bad reviews to the market about the supplier performance.

[12] A reasonable assumption implies that the value of the contract, θ, is able to cover the cost of certification γ_H^{FC}.

[13] The Divinity Criterion ($D1$) is renown to have more refining power than the Intuitive Criterion (IC) in signaling games with more than two types of sender, in which IC does not solve the multiplicity problem. In our case, adopting IC rather than $D1$ is a much more general strategy, with fewer restrictions on off-the-path beliefs.

Definition 1. In a PBE, the following holds:

(i) the customer may decide to offer the supply contract or not. His beliefs about the supplier's type $j \in \{H, L\}$ are updated upon observing the selected level of certification by the supplier. Then, a contract is offered whenever his expected return is positive.
(ii) The supplier's strategy consists of choosing the signal to send via certification, upon verifying a positive surplus from the supply contract, in expectation.

An implicit assumption of our model is that the choice of attaining a certain level of certification is actually a strategy of the candidate supplier, and not a pre-condition imposed by the customer to have any chance of receiving an offer. While some global players actually impose this restriction (see Uzumeri, 1997) many others do not, and more recent studies (e.g. Zeng et al., 2005) confirms that most of the firms voluntary choose to internationally certify their management standards.[14] Moreover, the solution concept that we apply here entails that the customer offers a contract to every applicant, whenever his expected return from the supply relationship is strictly positive. The supply contract is not unique, and more candidate firms may therefore enter his supplier base. The customer's decision on what inputs, components and/or services to outsource and how to allocate orders among the selected suppliers in equilibrium obviously falls outside the scope of our analysis.[15]

In light of Definition 1, the customer's strategy is a mapping from the signal observed $i \in \Omega$ to the binary decision of offering a supply contract or rejecting the application. In a standard two-type signaling model, IC eliminates all but one equilibrium, corresponding to the least-cost separating one, see Riley (1979). The participation and the incentive constraints of the supplier types are always satisfied in expected terms.

A natural benchmark for the PBEs arising in our game is represented by the first-best obtained under perfect information about each supplier's type. Under this circumstance, certification would turn pointless and wasteful, as no firm would ever certify its profile (unless assuming an internal motivation for accreditation) and the global player would offer a contract only to the $H-$types. To fix ideas, we lay down the following.

Remark 1. The first-best case is possible where the contract is offered only to the $H-$types without the necessity to certify. In this case, social welfare is maximized and corresponds to

$$W^{FB} = (\upsilon_H - \theta) + (\theta - c_H). \tag{5}$$

The straightforward intuition behind Remark 1 is that the global player would maximize its return from the supply relationship securing $\upsilon_j = \upsilon_H$. As the due payment is fixed and pre-determined, this would also maximize his overall surplus, through the exclusion of the $L-$types. In case of imperfect information about the suppliers' type, the signaling mechanism can be at work, provided that the *single crossing property* is valid and the right incentives of the suppliers are checked. For the low-types to acquire certification for mimicking purposes, an incentive must exist for the high-types to certify their management system standards even more. We establish such condition as

Lemma 1. *The increase in the payoff that suppliers of $H-$type obtain when upgrading the extent of their certification (i.e., when moving up from NC to BC; from BC to FC; or from NC to FC) is weakly larger than the one that suppliers of $L-$type obtain from the corresponding upgrade.*

Proof. See Appendix A. □

The key insight of Lemma 1 is that, for the $L-$types, the incentive to get certified at international standard-setting bodies is to mislead the customer by passing for a high-type. Such disguise can work if and only if also the $H-$types have a strong incentive to select the same level of certification. The result established above ensures that the incentive for the $H-$types is even stronger than for the $L-$types, provided that any upgrade in the extent of certification comes with more considerable gains from the former than the latter. The only exception is when firms move from no certificate (NC) to basic certification (BC), as the change in the supplier's payoff is the same for both types H and L. This is due to the simplifying assumption that $\gamma_H^{BC} = \gamma_L^{BC}$, introduced in Section 2.2 in regard to the basic level of accreditation. When relaxing this condition by assuming that $\gamma_H^{BC} < \gamma_L^{BC}$, Lemma 1 remains however valid.

[14] More specifically, Uzumeri (1997) reports that in the late '90s, a few large industrial buyers in the U.S. market – including DuPont and Eastman Kodak – were requesting ISO 9000 accreditation to their suppliers, and a similar policy was in place by part of some large European companies (see Corbett, 2006). However, the survey analysis by Zeng et al. (2005) indicates that at least 65% of the respondents opted for a voluntary implementation of ISO 9001. Moreover, in the websites (mentioned in the Introduction) through which multinational companies post their calls for suppliers and gather self-applications by interested candidate, no mention is made of mandatory or compulsory certified standards, which can therefore be regarded as supplementary documentation that firms may send in support of their application. Rather, much emphasis is given in these websites on the system of procurer's liabilities, which has led us to consider the model extension with contract penalties, developed in Section 5.1.

[15] In this perspective, contracting more suppliers upon satisfying the participation and incentive-compatibility constraints may appear as a reasonable risk diversification strategy for a risk-averse buyer.

3. Equilibrium analysis

3.1. Separating equilibria

We can now start discussing the equilibrium outcomes that our game admits. We first consider the case of a *separating equilibrium*, such that suppliers sort according to their type (H or L) in different certification strategies. Only two admissible cases qualify as Perfect Bayesian Equilibria (PBEs) of our game, which both entails no certification (NC) by the $L-$types.

This result is summarized below, as

Proposition 1. *A separating equilibrium surviving the Intuitive Criterion (Cho and Kreps, 1987) is characterized as follows:*

(1) The suppliers of $H-$type choose the most complete certification level (FC) and the suppliers of $L-$type decide not to certify (NC), conditional on $\theta \leq \gamma_L^{FC} + \tau$, with posterior beliefs given by $\tilde{\alpha}_{FC} = 1$, $\tilde{\alpha}_{NC} = 0$ and $\tilde{\alpha}_{BC} \in (0, 1)$.

(2) The suppliers of $H-$type choose the basic level of certification (BC) and the suppliers of $L-$type decide not to certify (NC), conditional on $\theta \in (\gamma^{BC} + \tau; \gamma_L^{FC} + \tau)$, with posterior beliefs given by $\tilde{\alpha}_{BC} = 1$, $\tilde{\alpha}_{NC} = 0$ and $\tilde{\alpha}_{FC} \in (0, 1)$.

Proof. See Appendix B. □

Let us assume first that the value of the contract is $\theta \leq \gamma_L^{FC} + \tau$.[16] The supply contract is not sufficiently rich to cover all expenses that a $L-$type faces to attain full certification. The main reason is the relatively large expected cost τ that arises in the production stage of the game, which is then added to cost γ_L^{FC} incurred for full accreditation. The $L-$types have therefore no longer interest in attaining this level of certification, which remains instead viable to the $H-$types. Should the $L-$types choose the lower level of certification – i.e., a basic level of accreditation (BC) – the $H-$types will however be able to separate by choosing the full certification strategy (FC), hence precluding any chance for the $L-$types to receive an offer.[17] Any money spent on accreditation results in a dead-weight loss, which explains why they necessary opt for a strategy of no certification (NC). At this point, for the $H-$types it suffices to get a basic level of certification (BC) to make sure to be contracted, saving on the accreditation costs (as $\gamma^{BC} < \gamma_H^{FC}$).[18]

The second circumstance to consider is such that $\theta \leq \gamma_L^{FC} + \tau$ holds, but the (expected) additional cost τ incurred by the $L-$types post contract formation is sufficiently limited to have $\theta > \gamma^{BC} + \tau$. The value of the supply contract at stake, namely $\theta \in (\gamma_L^{BC} + \tau, \gamma_L^{FC} + \tau)$, turns sufficiently high to support the choice of the $L-$types to get a basic level of certification (BC).[19] Accordingly, the $H-$types must undertake a larger investment in accreditation – thus accessing the higher level FC, not sustainable by the low-types – to separate from the latter. The $L-$types have no other option than choosing NC to avid unnecessary costs, as the possibility to receive an offer is nil anyway, under both $i = NC$ and $i = BC$.

The analysis conducted so far should make it clear that, in our setting, the presence of two (or by generalization, multiple) levels of certification tend to increase the space for separation between types, to the benefit of the global player. This is a novel aspect to our approach, compared to a more conventional environment with only one possible level of certification which constraints the supplier choice to a binary option, i.e., whether to get certified or not. With only one level of certification, the range of θ over which separation can be attained would be reduced to one specified in Point 1 of Proposition 1.

This point is crucial to get better insights on the more recent trends observed in the market for management systems certifications. We have already pointed out that the popular ISO 9000 family standards simply certifies that consistent business processes are applied by firms (again, we refer to Belleflamme and Peitz, 2014), and hence cannot be regarded as proper minimum quality standards, at least in the sense of Leland (1979) or Ronnen (1991). Most importantly, they provide a simple indication that certified firms' procedures comply with the adoption of the best practices, but does not specify the extent to which every firm goes beyond the bar. In this regard, the adoption of a strategy of multiple certification bu an increasing number of firms could be interpreted as an attempt by part of best performing organizations to create new spaces for separation, thereby preserving and giving strength to the external (signaling) motive for seeking accreditation at international standard-setting intuitions.

Going back to the separating equilibria described in Proposition 1, we observe that both the admissible outcomes allow for a further refinement under the Intuitive Criterion. The least-cost separating equilibrium is indeed possible in both cases, when the conditions on θ are satisfied at the margin.[20] Any contract offer by the global player must cover the cost of the appointed supplier's accreditation, plus the additional cost τ. In this case, the advantage for the customer lies in the fact of being able to select the $H-$types while excluding the $L-$types, thus preventing any loss from the establishment of a supply relationship. This means that

[16] Under this condition, the global player offers a contract upon observing BC (i.e., $\tilde{\alpha}_{BC} = 1$) and rejects the applicants when observing NC (i.e., $\tilde{\alpha}_{NC} = 0$). Should FC be observed, he will offer a contract for any off-the-equilibrium beliefs $\tilde{\alpha}_{FC} \in [0, 1]$.

[17] With separation, posterior beliefs would be $\tilde{\alpha}_{FC} = 1$ and $\tilde{\alpha}_{BC} = 0$, with contract offers conditioned to $i = FC$.

[18] Any off-equilibrium signal $i = FC$ will induce an offer, as far as the only possible sender would be a $H-$type.

[19] In this case, a contract offer is conditioned on the signal $i = FC$ (i.e., $\tilde{\alpha}_{FC} = 1$), whereas $i = NC$ results in no offer (i.e., $\tilde{\alpha}_{NC} = 0$). If the observed signal is $i = BC$, no offer is put forward for $\tilde{\alpha}_{BC} < \hat{\alpha} \equiv (\theta - \upsilon_L)/(\upsilon_H - \upsilon_L)$.

[20] This would imply that the contract offer covers, at least, the cost of the selected level of certification plus the expected cost incurred by the low-type post contract formation, i.e., $\theta = \gamma_j^i + \tau$ with $i = \{FC, BC, NC\}$ and $j \in \{H, L\}$. Such condition is necessary for the customer to sustain separation and avoid further losses.

the H-types gain a position rent. For satisfying the incentive of the L-types not to certify, the customer must pay for the supply provision at least a price $\theta = \gamma_j^i + \tau$, which refunds a cost, namely τ, that the selected supplier (of type H) does not actually incur.

The least-separating equilibrium case proposed in Proposition 1 can prove to correspond exactly to the calculation of the "optimal value" of the supply contract (i.e., the optimal level of θ) that maximizes the customer's payoff. Provided that separation is key to avoid the loss implied by the selection of the $L-$types, it is easily proved that this optimal (least-cost separating) value of θ perfectly coincides with the solution of a standard profit maximization problem. Assuming that θ is endogenously set by the global player to serve the purpose of profit maximization would however require to satisfy the participation constraint of the high-types, precisely as under our assumption of a pre-determined value of θ. In brief, nothing would change with respect to the existence of a space for separation, and its boundaries.

The least-cost separating equilibrium also makes the whole story perfectly compatible with an alternative setting in which we consider competition (either perfect or imperfect) among suppliers to obtain one single contract at stake (e.g. based on a mechanism of descending price auction typical of price competition models, in which the lowest price seller conquers the entire market). To model this, it suffices to update the timing depicted in Fig. 1 by including an additional stage in which suppliers have the chance to compete, right after the suppliers' decision whether to certify or not. This would increase further the bargaining power of the global player *vis-à-vis* all candidate suppliers, inducing a lower level of θ, with a limit value perfectly compatible with the least-cost separating equilibrium under the Intuitive Criterion.[21]

Finally, we note that for relatively low levels of τ, the only admissible PBE would be a pooling equilibrium in which all types choosing a strategy of no certification (NC), as illustrated in the next section.[22] As separation is no longer possible, we observe the following.

Corollary 1. *Separation between types is attainable only if the expected additional cost τ that the $L-$types face post-contract formation is sufficiently high, i.e., $\tau \geq \theta - \gamma_L^{FC}$.*

Proof. As shown in points 1 and 2 of Proposition 1, a strict requirement for a separating PBE is that $\theta \leq \gamma_L^{FC} + \tau$. When the additional cost τ expected by the $L-$type is sufficiently small, such constraint is more difficult to satisfy. As a limit case, assume that no cost arises in the post-contract stage of the game, i.e., $\tau = 0$. Without this additional edge, a separating PBE cannot exist, provided that γ_L^{FC} cannot be larger than the value of the contract, θ. □

3.2. Pooling equilibria

We can now focus on the admissible *pooling equilibria* of our game, in which all suppliers opt for the same certification strategy, unconditionally from their type. A pooling PBE can be admitted for any possible level of certification, based again on the relative size of θ and τ and the posterior beliefs (denoted as $\tilde{\alpha}_i$, with $i = \Omega$) of the global player offering the supply contract. We detail our theoretical result as

Proposition 2. *A pooling equilibrium surviving the Intuitive Criterion (Cho and Kreps, 1987) exists in the following cases:*

1. *Both types of suppliers choose a full level of certification (FC) if $\theta \geq \gamma_L^{FC} + \tau$ and the global player offers a contract if $\tilde{\alpha}_{FC} \geq \hat{\alpha}$ and $\tilde{\alpha}_{BC}, \tilde{\alpha}_{NC} \leq \hat{\alpha}$.*
2. *Both types of suppliers choose a basic level of certification (BC) if $\theta \geq \gamma^{BC} + \tau$ and the global player offers a contract if $\tilde{\alpha}_{BC} \geq \hat{\alpha}$ and $\tilde{\alpha}_{NC} \leq \hat{\alpha}$, irrespective of the level of $\tilde{\alpha}_{FC} \in [0, 1]$.*
3. *Both types of suppliers choose not to certify (NC) and the global player offers a contract if $\tilde{\alpha}_{NC} \geq \hat{\alpha}$ and $\tilde{\alpha}_{FC}, \tilde{\alpha}_{BC} \in [0, 1]$; alternatively, he does not make any offer if $\tilde{\alpha}_{NC} \leq \hat{\alpha}$ and $\tilde{\alpha}_{BC}, \tilde{\alpha}_{FC} \leq \hat{\alpha}$.*

Proof. See Appendix C. □

To make sense of Proposition 2, we consider first the case in which $\theta \geq \gamma_L^{FC} + \tau$, so as to reconnect with the arguments put forward in the discussion of the separating equilibria in Proposition 1. When the value of the supply contract is that large, even the $L-$types may afford the cost of attaining the highest degree of certification (FC), without undermining their possibility to engage in a profitable supply relationship with the customer. The $H-$types could then try to separate from the $L-$types by downgrading their level of accreditation (from FC to BC, or even to NC) but their chances to get a contract offer would remain unaffected, or would even reduce, based on the posterior beliefs of the customer. We can therefore envisage a first pooling PBE of our game such that all suppliers adopt full certification, provided that $\theta \geq \gamma_L^{FC} + \tau$ is matched with posterior beliefs such $\tilde{\alpha}_{FC} \geq \hat{\alpha}$ and $\tilde{\alpha}_{BC}, \tilde{\alpha}_{NC} \leq \hat{\alpha}$, that is, a contract offer is possible only upon observing the signal $i = FC$.

[21] This claim is easily proved by noting that the participation constraints of the various suppliers is satisfied on the condition that, in expectation, θ is at least able to cover the investment cost of accreditation, namely γ_j^i, and the cost arising for the $L-$types in the eventual production stage, namely τ.

[22] Whenever the $H-$types choose no certification (NC), the $L-$types have no incentive to stick to $i = BC$ or $i = FC$ and prefer to deviate, so as to save on the cost of accreditation and exploit mimicking under pooling. In turn, whenever one type of supplier chooses BC and the other type choose FC, a profitable deviation can always prove to exist for one of the two types, leading again to a pooling equilibrium.

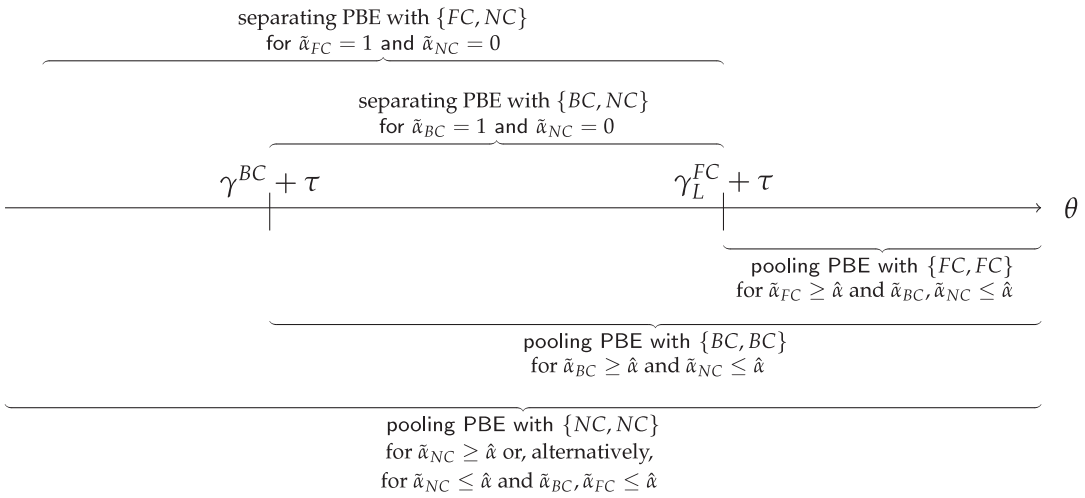

Fig. 2. Admissible PBE of the game, as a function of the contract value.

Let us suppose now that $\theta \geq \gamma^{BC} + \tau$. A supplier of type L may get a positive surplus from the relationship with the global player, conditional of sticking to a level of accreditation not higher than BC. After the revision of the beliefs, the customer offers a contract to any candidate sending the signal $i = BC$, while rejecting any applicant with signal $i = NC$. Should this be the case (so that $\tilde{\alpha}_{BC} \geq \hat{\alpha}$ and $\tilde{\alpha}_{NC} \leq \hat{\alpha}$), then no firm will ever decide to pay additional costs to get fully certified (FC), anticipating that this strategy does not increase the chance to receive an offer. In other words, separating from the L-types through the choice of a higher level of certification (FC) would leave the $H-$types with the same probability of being selected as under the alternative (and more parsimonious) strategy of basic certification (BC). Given $\gamma_H^{FC} > \gamma^{BC}$, the option BC is then preferred over FC, leading to a pooling equilibrium in which all supplier select this strategy.

Finally, we note from Proposition 2 that a pooling equilibrium with no certification (NC) may emerge from two different sets of posteriors. If $\tilde{\alpha}_{NC} \geq \hat{\alpha}$, the global player is willing to contract any applicant, irrespective of the type $j \in \{H, L\}$. This takes away any incentive for firms to invest in accreditation, as a signaling mechanism loses its meaning. All firms decide not to certify, whatever the global player's off-the-equilibrium beliefs $\tilde{\alpha}_{FC}, \tilde{\alpha}_{BC} \in [0, 1]$. A second, trivial case of pooling PBE with no certification (NC) is the one with $\tilde{\alpha}_i \leq \hat{\alpha}$ for any $i = \{FC, BC, NC\}$. The posterior beliefs induce the customer to reject any candidate, unconditionally from the observed signal, which prompts all firms to abstain from investing in the certification of management system standards.

All admissible equilibrium outcomes of our game (both pooling and separating one) are summarized in Fig. 2, along with the corresponding necessary posterior beliefs. As the figure reveals, there are regions of the space of θ over which multiple PBEs are admitted, in which case a refinement is needed to narrow down the solutions. Based on the Intuitive Criterion (Cho and Kreps, 1987), we have proved that the lost-cost separating equilibrium is feasible to propose. A similar comment can be made in regard to the interval in which only pooling equilibria arise.

Based on the revision of beliefs in $\tilde{\alpha}_i$, we can have all equilibria mapped through the signaling process of certification. Interestingly, we can go further by looking at which of the pooling versus separating equilibria can ensure a higher level of welfare.

4. Welfare evaluation

Here, we carry out a simple comparison among the various equilibrium outcomes listed in Propositions 1 and 2 at the aim of establishing their ranking in terms of social welfare. First, let us call the first separating equilibrium (with the high-types choosing FC) in Point 1 of Proposition 1 as $s1$; and the second separating equilibrium in Point 2 of the same proposition (i.e., the one with the high-types choosing BC) as $s2$. Analogously, with respect to Proposition 2, we define the pooling equilibrium with the highest level of certification for both types (FC) as $p1$; the pooling equilibrium with basic certification (BC) as $p2$; and finally, the one with no accreditation (NC) as $p3$. In this brief analysis, social welfare is captured by the sum of the surplus of the three players – i.e., the global producer and the two types of potential suppliers, H and L – as quantified based on the conditions of the underlying equilibrium. We summarize our results in the proposition that follows,

Proposition 3. *Under the conditions specified in Propositions 1 and 2, we observe that*

- *Social welfare in $s2$ is larger than the one in $s1$;*
- *Social welfare in $p3$ is larger than the one in $p2$, which is in turn larger than the one in $p1$;*
- *Social welfare in $s1$ is larger than the one in $p1$;*
- *Social welfare in $s2$ is larger than the one in $p1$ and $p2$;*
- *Social welfare in $p3$ is the largest one.*

Proof. See Appendix D. □

We first note the highest level of social welfare is associated with $p3$, i.e., the pooling PBE with no certification, essentially as a result of the fact that both types of supplier avoid facing the cost of getting certified. Nonetheless, even this equilibrium is unable to attain the first-best condition, since it includes a component of welfare loss that would not be present under perfect information on the suppliers' types, that is, the fact that a supply contract is proposed also to the L-types in $p3$.[23] Second, we know from Corollary 1 that a positive and sufficiently large value of τ is needed to secure the social welfare benefits induced by separation between types. This strongly penalizes separation from a pure social welfare's perspective, although separating equilibria have the merit of leaving the customer with a strictly positive payoff, at odds with the $L-$type supplier that incurs a loss from the lack of contract offers and her subsequent forced reversion to the small local market. With the emergence of a pooling equilibrium, the strictly positive surplus that the customer obtains under separation is traded off with the positive surplus accruing the $L-$types that are selected. The customer's utility from the relationship with the $H-$type is offset by the negative surplus originating from the selection of the $L-$types; and also the payoff of the $H-$types declines, as the latter are no longer able to separate from the other candidate suppliers.

Quite obviously, the ranking established in Proposition 3 could considerably change if we were introducing specific assumptions on the exact proportion between high- and low-type suppliers in the market, which could possibly drive our welfare analysis even in a direction more favorable to separating equilibria. Even more so, however, the first-best condition could never be attained, provided that certification of management standards is costly.

5. Extensions and discussion

5.1. An extension with penalties and liquidated damages clauses

We now change the design of the supply contract with respect to the baseline specification analyzed so far, at the aim to assess whether additional contract provisions may alter the incentives of the candidate suppliers to choose one certification strategy over the others.

We start by introducing penalty and liquidated damages clauses, that often appear in the contractual relationships between procurers and customers (particularly when the contract offer, as postulated here, is of the type *take-it-or-leave-it* and is made by a large multinational corporation, with overwhelming bargaining power over the counterpart). Penalties in their essence are generally aimed to deter a supplier from not complying with the provisioning norms, such as non-observance of the due delivery terms. We assume here that any supplier failure is verifiable by a third party (a judicial court or an arbitrator) which makes contractual penalties fully enforceable. A money transfer of a pre-determined amount then takes place in favor of the customer by way of damages for breach. We study here the case of lump-sum penalties, which appears the most relevant for the purpose of our analysis, although liquidated damages clause (commensurate to the magnitude of the harm caused by the supplier) can be even a possibility.[24] An alternative interpretation could be that the penalty prescribes that, in case of failures, the supplier must rework part of the production or supply addition units, so that the customer can however obtain a positive value from the supply relationship, even when selecting a $L-$type supplier.

To introduce this new element in our setting, it suffices to interpret now the additional cost τ as the expected value of the contractual liability that a low-type supplier will incur *ex-post* for infringements of its contractual obligations with the customer. Only the $L-$types are subject to the penalty's payment, as we assume they are the only with a strictly positive probability of failure in the supply relationship. In expectation, the penalty therefore corresponds to the pre-determined money transfer agreed upon in the contract, discounted by the probability of breaching. With respect to Eq. (4), the *ex-ante* return of the global player modifies as follows,

$$\mathbb{E}(\pi^G) = \tilde{\alpha}_i \upsilon_H + (1 - \tilde{\alpha}_i)(\upsilon_L + \tau) - \theta, \tag{6}$$

while the payoffs of both suppliers H and L remain the same as in the baseline model.

Intuitively, the penalty acts a sort of insurance device for the customer against the risk of selecting a low-type, and hence obtaining negative surplus *ex-post* from the supply relationship. When the value of the contractual penalty is relatively low in expectation, i.e., $\tau \leq \theta - \upsilon_L$, such insurance scheme proves ineffective, provided that the global player derives a utility $\upsilon_L - \theta$ (with $\upsilon_L \leq \theta$) from the relationship with the $L-$types and hence continue to suffer losses in case of bad calls. At the same time, the incentives for the $L-$types to get certified for mimicking purposes remains much the same as those in the baseline version of our model. As a result, the admissible equilibria of the game are still those outlined in Propositions 1 and 2, just with a few minor adaptations in the corresponding underlying conditions.

By contrast, when the expect value of the penalty becomes larger, i.e., $\tau \geq \theta - \upsilon_L$, a separating PBE does no longer exist. Only the pooling equilibria listed in Proposition 2 survive, also in this case, with a few minor adaptions. The underlying intuition is that, for high values of τ, the global player shuts down completely any risk of incurring losses when selecting an $L-$type. His surplus from the relationship with the low-types indeed turns strictly positive, provided that $\upsilon_L + \tau > \theta$. This makes certification of management systems (at any possible level) much less relevant for the selection decision by part of the customer, thereby reducing the incentives

[23] This is easily observable by comparing Eq. (5) of Remark 1 to the welfare conditions implied by the pooling equilibrium $p3$ described in Appendix C.

[24] The result derived under contractual penalties of pre-determined amount can however be extended to the more general class of compensation tools for damages.

for all candidate suppliers to undertake the costly process of providing signals. In brief, separation is broken basically due to the customer's propensity to offer a contract even to the $L-$types, by reason of the positive surplus he gets anyway from the participation of these firms in his supply chain (although lower than the surplus accruing from the relationship when the $H-$types). We establish this novel result as

Proposition 4. *When a cash transfer (refund) is admissible and relatively large, i.e., $\tau \geq \theta - \upsilon_L$, then offering a contract to the L-types is profitable. Both separating PBEs that emerge in the baseline model without contractual penalties disappear, whereas all pooling PBEs survive, conditional on adjusting the posterior beliefs, namely $\hat{\alpha}^{\star} \equiv (\theta - \upsilon_L - \tau)/(\upsilon_H - \upsilon_L - \tau)$, in place of $\hat{\alpha}$.*

Proof. The first part of the proof, related to the separating PBEs, is reported in Appendix E. The proof of the second part, relative to the pooling PBEs, follows similarly the steps proposed in the proof of Proposition 2 in Appendix C, using Eq. (6) in place of Eq. (4). □

As the introduction of the penalty induces the customer to be overall less selective upon observing the signal, saving on the cost of accreditation becomes a significant concern of the $H-$type suppliers. The argument holds for any level of certification, either BC or FC, that these candidate suppler where selecting in the previous separating PBEs of the game. As a further confirmation, we note that the buyer's posterior beliefs now sustaining pooling equilibria are defined in Proposition 4 with respect to a new threshold, namely $\hat{\alpha}^{\star}$, which is less restrictive than the corresponding threshold applying in the baseline model with no contract penalties, i.e., $\hat{\alpha}^{\star} < \hat{\alpha}$. The space for a contract offer by the buyer expands, whatever the signal observed in the market under any of three circumstances listed in Proposition 2.

5.2. Additional contract provisions

As a final extension, we introduce now *additional* contract provisions, on top of penalties and/or liquidated damages clauses, to assess whether they have the potential to restore a space for separation between types, conditional on $\tau \geq \theta - \upsilon_L$. In particular, we analyze here the case of bonuses and production rewards that the global player might be willing to pay to the $H-$types, in association with the penalty for the $L-$types already introduced in the previous Section. In other words, we consider in this extension a scheme of promised rewards and threats, established *ex-ante*, for a contingent payment based on an *ex-post* evaluation of each supplier performance. In principle, a customer might be willing to grant a bonus in order to increase the overall appeal of the supply contract for the high-type suppliers and thus foster their investment in certification with the aim to differentiate from the $L-$types, escape their mimicking behavior and make the whole process of supplier selection much smoother.

The payoff of the global player can now be written as

$$\pi^{G} = \upsilon_j - \theta + \mathcal{I}_j \tau - (1 - \mathcal{I}_j)\varepsilon, \tag{7}$$

where $\mathcal{I}_j$ is again an indicator function, that takes value one if $j = L$ and zero otherwise. In expectation, the player's payoff turns out to be

$$\mathbb{E}(\pi^{G}) = \tilde{\alpha}_i(\upsilon_H - \varepsilon) + (1 - \tilde{\alpha}_i)(\upsilon_L + \tau) - \theta. \tag{8}$$

In contrast with the previous extension with penalty only, in this new version of the game the payoff functions of the two types of suppliers change substantially with respect to the baseline model. When the supplier receives a contract offer, her payoff amounts to the price of the contract θ net of production and possible certification costs, minus the penalty τ (meant as a refund for the global player) for the $L-$types; and plus a premium ε for the $H-$types. In other words, when the contract is offered, supplier j obtains

$$\pi_j[o] = \theta - \gamma_j^i - c_j - \mathcal{I}_j \tau + (1 - \mathcal{I}_j)\varepsilon, \tag{9}$$

whereas, in case of no offer, her payoff evaluates to

$$\pi_j[no] = -\gamma_j^i - c_j. \tag{10}$$

The extensive form of the game is then the one depicted in Fig. 3.

Following the same lines as above, a new result is derived, in form of

Lemma 2. *In presence of a cash-transfer penalty (τ) sufficiently high to inhibit separation in the market (i.e., $\tau \geq \theta - \upsilon_L$), bonuses or production rewards are not able to restore separating equilibria, as the global player has still incentive to offer a contract also to the $L-$types.*

Proof. Given Eq. (8), suppose that $\mathbb{E}(\pi^{G}) \geq 0$ for any $i \in \Omega = \{FC, BC, NC\}$. At any level of certification, the bonus must satisfy the constraint $\varepsilon < \upsilon_H - \theta$, otherwise a paradox would be present, the buyer incurring losses when contacting the $H-$types. At the same time, a penalty $\tau > \theta - \upsilon_L$ prevents the buyer from incurring losses when selecting a $L-$type. Having said this, the proof is very similar to ones of the previous propositions. If the customer's beliefs of selecting a $H-$type are $\tilde{\alpha}_i = 1$ for a certain $i \in \Omega$, then one of the two alternative signals $j \neq i \in \Omega$ will be assigned to the beliefs of selecting a $L-$type. The buyer's payoff is strictly positive for $\tilde{\alpha}_j = 0$, provided that $\tau > \theta - \upsilon_L$. When the cash-transfer penalty is set large enough, it is always possible to offer a contract to supplier L, which creates larger incentives to select these types indeed. As a result, a contract offer is made even in the case of off-the-equilibrium beliefs $\tilde{\alpha}_k \in [0, 1]$, with $k \neq i, j \in \{FC, BC, NC\}$, as the buyer's payoff remains positive with both types of supplier. Certification is then no longer meaningful. □

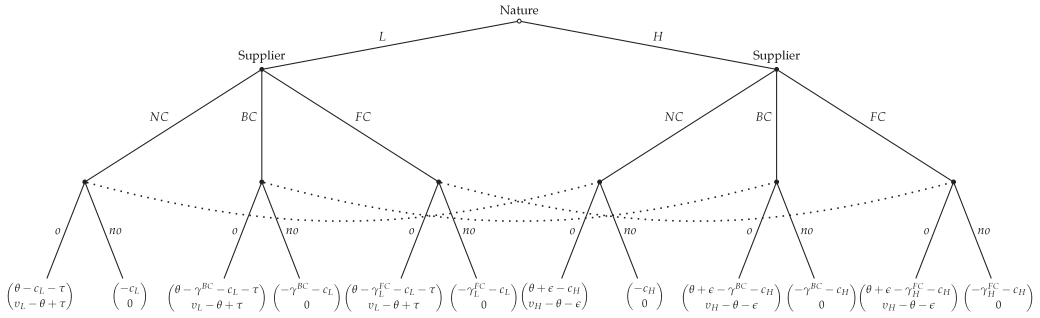

Fig. 3. Extensive form of the signaling game under additional contract provisions.

Lemma 2 can be interpreted as follows. As hinted above, the award of a production bonus may, in principle, prompt the $H-$types to invest more in accreditation, to seek separation via signaling. However, this proves not sufficient to create a new space for separating PBEs, at least until a contractual penalty for the $L-$types is active, or better, until such penalty is relatively large in expected terms, i.e., $\tau > \theta - \upsilon_L$. The incentive of the $H-$types to invest in accreditation is then frustrated, as the customer's posterior beliefs remain unaffected as far as a large penalty fully insure against the risk of selecting a $L-$type. Any possible production reward then turns into a pointless expenditure for the buyer.[25]

Faced with this conclusion, one might wonder whether bonuses or production rewards paid to the $H-$types are always ineffective to sustain separation, or they have some impact when studied *in isolation*, i.e., when they apply in the absence of contractual penalties (either in form of lump-sum cash transfers or liquidated damages clauses). Taking this route, we remove τ from the supply contract, and we observe that the buyer's expected payoff becomes

$$\mathbb{E}(\pi^M) = \tilde{\alpha}_i(\upsilon_H - \varepsilon) + (1 - \tilde{\alpha}_i)\upsilon_L - \theta, \tag{11}$$

whereas the payoff functions of both suppliers L and H are still those in Eqs. (2) and (3).

It is easily proved that, in this case, the bonus ε has the potential to enlarge the space for separation between types. A separating PBE is in fact possible in regions of the space of parameters where a pooling equilibrium would emerge otherwise. This is because the high-types now take much more advantage from separation, as their considerably increase their probability of receiving an offer and, with this, a post contract formation bonus that substantially mitigates their saving motive to abstain from certification. The increased probability of a contract offer originates from the fact that the bonus induces a more selective behavior by part of the customer, which considerably reduces the space of contract offers. The high-type suppliers respond to the incentive, by investing more in signaling in search for separation, which naturally widens the region of the space of parameters over which a separating PBE can be sustained. We lay down our last proposition as

Proposition 5. *Without a cash-transfer penalty, bonuses or production rewards may increase the space of separating PBEs identified in Proposition 1, as the $H-$type suppliers may have more incentive to separate. This is possible by adjusting beliefs, $\tilde{\alpha}_i \geq \hat{\alpha}' \equiv (\theta - \upsilon_L)/(\upsilon_H - \upsilon_L - \varepsilon)$, with $\hat{\alpha}' \geq \hat{\alpha}$.*

Proof. The proof follows exactly the same steps of the proof of Proposition 1 in Appendix B. The only difference is that, now, the buyer's expected payoff includes the bonus ε and hence to the expression in Eq. (11). Accordingly, given $\varepsilon < \upsilon_H - \theta$, we have $\mathbb{E}(\pi^M) \geq 0$ for any $i \in \Omega = \{FC, BC, NC\}$. Given the customer's beliefs about supplier H, namely $\tilde{\alpha}_i = 1$, we observe that $\upsilon_H - \theta - \varepsilon > 0$ holds for $\varepsilon < \upsilon_H - \theta$. Any alternative signal $j \neq i \in \{FC, BC, NC\}$ induces $\tilde{\alpha}_j = 0$, implying no contract offer, provided that $\upsilon_L < \theta$. We also note that $\mathbb{E}(\pi^M) \geq 0$ for any $k \neq i, j \in \{FC, BC, NC\}$ such that $\tilde{\alpha}_k \geq \hat{\alpha}'$. It is straightforward to show that $\hat{\alpha}' \geq \hat{\alpha}$, which means that $\hat{\alpha}'$ is actually to a more restrictive threshold than the one identified in the baseline model without the bonus. As the supply contract offered to the applicants is now more expensive for the customer, the range of beliefs over which this contract is offered necessarily shrinks. This opens up the possibility of separating PBEs in which the $H-$type choose either FC or BC, while the $L-$types choose NC. We then revert to the same circumstances specified in Proposition 1, with the only difference that the range of opportunities to offer the supply contract in the off-the-equilibrium beliefs decreases, provided that $\hat{\alpha}' \geq \hat{\alpha}$. □

5.3. Discussion

The theoretical results that have emerged from our analysis can provide a few relevant insights on patterns and stylized facts that have been documented by the most recent literature on the adoption of the ISO family standards, or similar management system standards by part of SMEs in different regions of the world.

[25] Note that whenever $\tau < \theta - \upsilon_L$, the conditions for separation resume, as the global player is left with a strictly negative payoff when contracting a $L-$type.

Before going into a more detailed discussion of this specific point, it is worth coming back to the premise made in the introduction, that our theory builds on the external, rather than internal, motives for certification. As already explained, this choice is supported by the upshot of a large number of survey studies that the most crucial factor to invest in certification is the "improvement of the company's image and social impact" (e.g. Karapetrovic et al., 2010), as reported by the majority of persons in charge of quality and environmental management systems in their organizations. Government and customer pressure are generally indicated as of lesser importance, whereas considerations related to improved efficiency and control or even reduction of problems and accidents play, overall, a rather nuanced role.[26] Moreover, even for environmental management standards such as ISO 14000 – that, compared to ISO 9000, should be less appealing for firms in search of product quality or process efficiency improvements –, the documented evidence suggests that a clear correlation (and not causal relationship) exists between firm performances and the adoption of the standards, lending further support to the relevance of the external motive for certification.[27] Having said this, even if SMEs were actually prompted to seek certification based on a strong internal motive, the narrative of our paper would remain mostly consistent. Improving firm performances by adopting standardized management practices would indeed be an essential step for participation in global supply chains; and it is well-known organizations with documented foreign activity display a higher propensity towards international certification.

A few patterns emerged from the empirical literature on ISO certification that is worth being discussed here through the lens of our theoretical model. A considerable amount of research has studied the diffusion of the various management systems standards (see Corbett, 2006; or Corbett and Kirsch, 2009) and even the effects of such distribution on international trade outcomes (see Clougherty and Grajek, 2008, 2014; Galina and Maskus, 2009. Albuquerque et al. (2007) report that in later-adopting countries, standards tend to diffuse faster. Kollman and Prakash (2002) show that the payoff for certified organizations may vary according to differences in national institutional settings. In turn, Franceschini et al. (2010) detect three different regions in Europe, this being the world region where the ISO family standards are more diffused. In Eastern Europe, Italy, Spain and Portugal certification still has a rapid growth phase; in Central Europe, a saturation point has been reached; finally, in the 'Island' area, the number of certifications is slowly decreasing after having reached a peak.

One might think that many organizations, especially in Eastern Europe, have largely reaped the benefits of the European integration process, raising their productivity levels and thus qualifying as credible candidates for entering the supplier base of Western European companies. Firms in these countries have more need to provide market signals than competitors located in Western regions, particularly if interested to enter the supplier base of the large multinational corporations located in Western Europe. Moreover, the large number of domestic competitors in search of accreditation via ISO 9000, forces the best performing firms in these countries to reinforce their market signal through the adoption of multiple standards, so as to achieve separation. This further accelerates the growth rate of diffusion of management system standards in this region of the world. We have also seen that separation is more difficult to obtain, the larger is the value of the supply contract at stake. In countries such as Italy, Spain or Portugal, low rates of GDP growth over the last few years may have induced of a larger need for cost reduction, that might have induced lower incentive for low performance firms to mimic the behavior of the high performance firms, resulting in different certification strategies and thereby facilitating separation. In turn, in countries with better or simply more consolidated contracting intuitions (such as those in Northern Europe or the 'Island' area, increased reliance on the contractual system of suppliers' liability may have substantially reduced the incentive of the more productive firms to embark upon the costly process of certification.

6. Conclusion

We have proposed a very simple model of signaling in which small- and medium-sized firms may decide to invest in the certification of their management system standards to communicate about desirable organizational attributes at the aim of being awarded a supply contract by a large global player. According to our analysis, by adopting a strategy of multiple certification, high-type firms may expand the space for separation from the low-types, even though for sufficiently large values of the supply contract, only pooling equilibria arise, in which both types choose the same level of accreditation.

Our theory has built on a series of specific assumptions, e.g. the fact that supply contract terms are known by firms at the time they select their certification strategy. Indeed, we have provided anecdotal evidence that large global players (such as Boeing, Airbus or Volkswagen) have dedicated sections on their official websites meant for potential suppliers that want to apply for work orders. These websites not only provide a wealth of information about the company's procurement policies, practices and expectations, but also a list of pre-determined terms and conditions of a potential relationship (including payment terms and even invoicing and payment methods).

Based on the evidence that management system standards do not constitute a standard of minimum quality, in our model we have abstracted from any consideration based on the quality of the input, component or series supplied by the two types of firms, assuming that the quality of the supply provision is pre-determined, and both types are capable to meet this level, even though at different costs and requesting (or not) further support by the customer. As a possible avenue for further research, it might be interesting to propose a more sophisticated setting featuring a vertical dimension related to product quality (either the quality of the final good or the one of component, input or service procured by the supplier) to study how differences in the quality provision by the different types may alter their incentives to invest in certification of their management system standards for signaling purposes.

[26] Further evidence in this regard can be found in Georgiev and Georgiev (2015) or Christmann and Taylor (2001) although, in this case, limited to the ISO 14000 environmental management standards.

[27] Based on data for nearly 1000 firms located in California (U.S.), Levine and Toffel (2010) find, for instance, that ISO 9001 adopters feature higher survival rates in the market and higher growth rates for sales, employment, payroll, and average annual earnings among surviving employers. This confirms the findings of earlier studies, e.g. Montabon et al. (2000).

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.inteco.2023.02.003.

References

Albuquerque, P., Bronnenberg, B., Corbett, C., 2007. A spatiotemporal analysis of the global diffusion of ISO 9000 and ISO 14000 certification. Manage. Sci. 53 (3), 451–468.
Belleflamme, P., Peitz, M., 2014. Asymmetric information and overinvestment in quality. Eur. Econ. Rev. 66 (C), 127–143.
Cho, I., Kreps, D., 1987. Signaling games and stable equilibria. Q. J. Econ. 102 (2), 179–221.
Christmann, P., Taylor, G., 2001. Globalization and the environment: Determinants of firm self-regulation in China. J. Int. Bus. Stud. 32 (3), 439–458.
Clougherty, J., Grajek, M., 2008. The impact of ISO 9000 diffusion on trade and FDI: A new institutional analysis. J. Int. Bus. Stud. 39 (4), 613–633.
Clougherty, J., Grajek, M., 36, 2014. International standards and international trade: Empirical evidence from ISO 9000 diffusion. Int. J. Ind. Organ. 70–82.
Corbett, C., 2006. Global diffusion of ISO 9000 certification through supply chains. Manuf. Serv. Oper. Manag. 8 (4), 330–350.
Corbett, C., Kirsch, D., 2009. International diffusion of ISO 14000 certification. Prod. Oper. Manage. 10 (3), 327–342.
Corbett, C., Montes-Sancho, M., Kirsch, D., 2005. The financial impact of ISO 9000 certification in the United States: An empirical analysis. Manage. Sci. 51 (7), 1046–1059.
Franceschini, F., Galetto, M., Maisano, D., Mastrogiacomo, L., 2010. Clustering of European countries based on ISO 9000 certification diffusion. Int. J. Qual. Reliab. Manag. 27 (5), 558–575.
Galina, A., Maskus, K., 2009. The impacts of alignment with global product standards on exports of firms in developing countries. World Econ. 32 (4), 552–574.
Georgiev, S., Georgiev, E., 2015. Motivational factors for the adoption of ISO 9001 standards in Eastern Europe: The case of Bulgaria. J. Ind. Eng. Manag. 8 (3), 1020–1050.
Heras, I., Dick, G., Casadesús, M., 2002. ISO 9000 registration's impact on sales and profitability: A longitudinal analysis of performance before and after accreditation. Int. J. Qual. Reliab. Manag. 19, 774–791.
Hernandez-Vivanco, A., Domingues, P., Sampaio, P., Bernardo, M., Cruz-Cázar, C., 2019. Do multiple certifications leverage firm performance? A dynamic approach. Int. J. Prod. Econ. 218, 386–399.
Karapetrovic, S., Casadesús, M., 2009. Implementing environmental with other standardized management systems: Scope sequence, time and integration. J. Clean. Prod. 17 (5), 533–540.
Karapetrovic, S., Casadesús, M., Heras, I., 2010. Empirical analysis of integration whitin the standards-based integrated management systems. Int. J. Qual. Res. 4 (1), 25–35.
King, A., Lenox, M., 10, 2001. Lean and green? An empirical examination of the relationship between lean production and environmental performance. Prod. Oper. Manag. 244–256.
Kollman, K., Prakash, A., 2002. EMS-based environmental regimes as club goods: Examining variations in firm-level adoption of ISO 14001 and EMAS in U.K., U.S. and Germany. Policy Sci. 35, 43–67.
Labodová, A., 2004. Implementing integrated management systems using a risk analysis based approach. J. Clean. Prod. 12, 571–580.
Leland, H., 1979. Quacks, lemons, and licensing: A theory of minimum quality standards. J. Political Econ. 87 (6), 1328–1346.
Levine, D., Toffel, M., 2010. Quality management and job quality: How the ISO 9001 standard for quality management systems affects employees and employers. Manag. Sci. 56 (6), 978–996.
Montabon, F., Melnyk, S., Sroufe, R., Calantone, R., 2000. ISO 14000: Assessing its perceived impact on corporate performance. J. Supply Chain Manag. 36, 4–16.
Rao, S., Ragu, T., Solis, L., 1997. Does ISO 9000 have an effect on quality management practices? An international empirical study. Total Qual. Manag. 8, 335–346.
Riley, J., 1979. Informational equilibrium. Econometrica 47 (2), 331–359.
Ronnen, U., 1991. Minimum quality standards, fixed costs, and competition. RAND J. Econ. 22 (4), 490–504.
Terlaak, A., King, A., 2006. The effect of certification with the ISO 9000 quality management standard: A signaling approach. J. Econ. Behav. Organ. 60, 579–602.
Uzumeri, M., 1997. ISO 9000 and other metastandards: Principles for management practice? Acad. Manag. Exec. 11, 21–36.
Wiengarten, F., Humphreys, P., Onofrei, G., Fynes, B., 2017. The adoption of multiple certification standards: Perceived performance implications of quality, environmental and health & safety certifications. Prod. Plan. Control 28 (2), 131–141.
Zeng, S., Tian, P., Shi, J., 2005. Implementing integration of ISO 9001 and ISO 14001 for construction. Managerial Auditing J. 20, 394–407.