Efficiency of legal restrictions on contracts in the presence of two signals

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1. Introduction

The efficiency of legal restrictions on private contracts has been analyzed by Aghion and Hermalin (1990). In their model of asymmetric information the authors assume that the informed party has only one signal. The analysis refers to a contract between an uninformed investor and an entrepreneur who needs to raise a capital to fund his project. The entrepreneur can be one of two types, who differ regarding the probability that their project fails: the investor would offer the fund at better terms if the entrepreneur is the one whose project is more likely to succeed, but he cannot distinguish between the two types. The contract is described by two variables \( (P_F, P_S) \), with \( P_F \) being the price paid in case of failure and \( P_S \) the price paid if the project succeeds. Since the good type entrepreneur has a higher probability to complete successfully the project, he would be willing to pay more in case of failure: thus \( P_F \) can be used as a signal.

What makes the free contracting inefficient is the bargaining power of the informed party, that is, the entrepreneur, who is supposed to draft and offer the contract. In fact, if the entrepreneur offers the contract and gets the whole surplus, the bad type will not internalize the cost of signaling, whereas if the investor offers contracts and gets the surplus, then he will completely internalize the cost of screening the two entrepreneurs and efficiency is maximized. Thus, with the aim to study if legal restrictions can enhance efficiency in absence of externalities, Aghion and Hermalin concentrate the analysis on the signaling situation, where the informed party with bargaining power offers the contract and the uninformed party can either accept or leave it.1

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The authors show that when the informed party disposes of a signal that is valued by the uninformed party, the effort to separate from the bad type may lead the good type to signal too much, ending with a contract that is Pareto inefficient due to the excessive risk. It follows that in such a case a limit on the capability of signaling would enhance efficiency.

The situations where legal restrictions exist that enhance efficiency are identified with respect to the type of unrestricted equilibrium. In case the unrestricted equilibrium is pooling, there always exists a subset of restrictions that are efficient. On the other hand, if the unrestricted equilibrium is separating, then some restrictions may be efficient only if the bad type is not too different from the good type (i.e., the probability of failure for the bad type is not too much higher than for the good type).

In the case of unrestricted pooling equilibrium, the set of efficient restrictions has an upper limit: if the restriction is too high and the signal is reduced to an excessively low level, the outcome is a Pareto inefficient pooling equilibrium. In the case of unrestricted separating equilibrium the set of efficient restrictions has both a superior and an inferior limit: restrictions should not be too high and not too low because outside of a particular interval the equilibrium would again be pooling at a Pareto inefficient level. More precisely, in both cases the set of efficient restrictions is a closed interval but in the unrestricted pooling equilibrium one limit is always the same (zero) while in the unrestricted separating equilibrium neither limit is known a priori.

The normative implications are indeed relevant when the unrestricted equilibrium is pooling. Since the uninformed party cannot get to know the type he is dealing with, the legislator has the chance of reducing the risk involved in the contract and thus of increasing the utility of both types. The relevant point is that it is reasonable to assume that the legislator know the efficient range of restriction, since the only problem would be not to restrict too much. To the extent that the conditions leading to an unrestricted pooling equilibrium are satisfied, there would be strong support for intervention in contract law. These conditions basically require that the two types be not very different, so that it is not too costly for the bad type to mimic the good type: the bad type is not too likely to fail, not too risk averse and his symmetric information contract already includes a high $P_F$.

This paper shows that the introduction of one more signal does not change this main result. When the unrestricted equilibrium is separating the one-signal model presents a weaker case for legal intervention because it is unlikely that the legislator knows the efficient set of restrictions. With two signals additional information is needed and the consequences of inefficient restrictions are more costly, further reducing the support for intervention. In particular, the legislator not only needs to know the right amount of the restrictions, but also the cost structures of both types of entrepreneur for the two signals. This is because in circumstances where the good type has not a cost advantage for both signals, a restriction on his cheaper signal may discard the positive relation between level of quality and amount of signaling, that is, give the bad type an absolute cost advantage in the signaling activity. This may enable the bad type to go on signaling until a separating equilibrium is reached where the bad type is confused with the good.

The main contribution of this paper is a warning about possible perverse effects of inefficient restrictions. The acknowledgment by Aghion and Hermelin that efficient restrictions on contracts do exist, even in the absence of externalities, has raised the question of
what the legislator should do given the information he has. In situations where the legislator
does not know with certainty the range of efficient restrictions, it is important to consider the
consequences of imposing inefficient restrictions. In fact, the efficient range of restrictions
changes when dealing with different contractual relationships, due to the differences in
wealth, probability of failure and risk attitude of the parties involved; applying a common
legal restriction means that in some situations efficiency is enhanced and in others reduced.
This paper suggests that when more signals are available the consequences of inefficient
restrictions are more costly than in the one-signal case and the justification for intervention
based on Pareto efficiency is weaker.

In the next section I present the model with two signals and the equilibrium that arises
under symmetric and asymmetric information. Pooling and separating equilibria are possible
when there is asymmetric information and both of them may be inefficient due to excessive
signaling. The third section is about the effects of restrictions in a situation where the good
type has lower costs for both signals, whereas in the fourth section one of them is cheaper
for the bad type. In both cases the effects of the restrictions depend on the type of equilibrium
that prevails without restrictions. The fifth section contains two tables that summarize the
results and compare them with the one-signal model, while in the sixth some interesting
extensions of the model are discussed. In the last two sections I present an application to the
market of professional services and some conclusive remarks.

2. The model

In the Aghion-Hermalin model, the expected utility functions are the following:

\[
U^i(P_F, P_S; F) = F v^i(P_F) + (1 - F) v^i(P_S)
\]

for the investor;

\[
U^e(P_F, P_S; F) = F v^e(W - P_F) + (1 - F) v^e(R - P_S)
\]

for the entrepreneur;

where \(F\) is the probability of failure, \(W\) is the initial wealth of the entrepreneur and \(R\) is the
final wealth if the project succeeds. The utility functions \(v^i\) and \(v^e\) are continuous and satisfy
the conditions for the risk averse attitude: \(v' > 0\) and \(v'' < 0\).

The framework that I use to allow for two signals is a two-period model where the project
of the entrepreneur can fail either in the first or in the second period. At the beginning of the
first period the contract is signed and the entrepreneur receives the fund \(D\). Then, if the
project fails in the first period the entrepreneur pays the amount \(P_1\) (with \(P_1 < D\)) to the
investor and if the project fails in the second period the entrepreneur pays \(P_2\) (with \(P_2 < D\)).
If the project is successful, that is it has not failed at the end of the second period, then the
investor can fully recover his credit and he gets the highest payment \(P_S\) (with \(P_S > D\)).

This model differs in two important aspects from the political budget cycle model of
Rogoff (1990), which also has two signals. Firstly, in Rogoff the signals used by the
incumbent government (taxes and public expenditure) are such that the good type has always
lower costs for both signals, whereas in this model the existence of two independent events
makes it possible that the two types of entrepreneur have different absolute advantages for
the two signals. Secondly in Rogoff there are not wealth limits to the signals with the result
that the equilibrium is always separating; the amount of signal out of budget is to be compensated for after the election-game and in this way the cycle is generated. In line with Aghion-Hermalin’s, this model assumes that the wealth of the entrepreneur is a limit to the amount of signaling, thus making possible pooling equilibria.\footnote{10}

It is to be noticed that there is no need to introduce the interest rate since the payments already take account of time. Besides, I assume for simplicity that the rate of intertemporal preference of both the investor and the entrepreneur is null. Given these assumptions, the expected utility functions in the two-signal model are:

\[
U^i(P_1, P_2, P_S; F_1, F_2) = F_1v^i(P_1) + F_2v^i(P_2) + (1 - F_1 - F_2)v^i(P_s)
\]

\[
U^e(P_1, P_2, P_S; F_1, F_2) = F_1v^e(W - P_1) + F_2v^e(W' - P_2) + (1 - F_1 - F_2)v^e(R - P_s)
\]

**Notation**

\(P_1\) = price paid if the project fails in the first period;\(^{11}\)

\(P_2\) = price paid if the project fails in the second period;

\(P_S\) = price paid if the project is successful;

\(F_1\) = probability that the project fails in the first period;

\(F_2\) = probability that the project fails in the second period, conditional on no failure in the first period;

\(D\) = amount of debt;

\(W\) = entrepreneur’s wealth if the project fail in the first period;

\(W'\) = entrepreneur’s wealth if the project fails in the second period;

\(R\) = entrepreneur’s wealth if the project succeeds;

\(v_i\) = reservation value of the entrepreneur.

Consistently with the one-signal model, the entrepreneur’s wealth is not sufficient to repay the debt unless the project succeeds. Thus, in order to give the investor his reservation value the payment when the project succeeds is to be higher than the debt. Formally, it is: \(W < D\); \(W' < D\); \(P_1 < D < P_S\); \(P_2 < D < P_S\).

To allow for a different efficiency of the two signals, I assume that the project yields some gain at the end of the first period (i.e., \(W' > W\)), so that for an equal probability of failure the second signal is cheaper in terms of utility.\(^{12}\)

As it is explained in section three, since for both types of entrepreneur the willingness to pay is higher when the probability of failure is lower, the marginal cost of providing each signal is directly proportional to the probability of failure in the relative period. Thus, two situations are possible:

a) the good type entrepreneur has lower costs for both signals;

b) the good type entrepreneur has lower costs for only one signal.

The idea here is that the uninformed party does not have perfect information about the relationship between the cost of each signal and the level of quality, so enlarging the traditional definition of signal. In the Spence’s notion, the necessary requirement of a signal is that the cost of its production is inversely related to the quality of the signaler. This definition is proper for a situation with a unique signal but in a multisignaling context it is
excessive to require it for every signal. For the informational function of the signaling activity it is only important that the good type has lower costs for the overall signaling process. Even if for some activities with informational value the bad type might have lower costs, we can still consider those activities as signals because they contribute to the good type’s possibility to reach a separating equilibrium. This is equivalent to assuming that the uninformed party pays attention to the total amount of signaling created by each type without checking whether or not all the signals are positively related with quality.

2.1. Equilibrium with full information

In the presence of full information the entrepreneur knows the type he is dealing with and it is not possible for the bad type to pool with the good type. The entrepreneur, whether the good or the bad type, chooses among the contracts that are accepted by the investor the one which maximizes his utility. In formal terms, the problem is:

$$\max \ U_e(P_1, P_2, P_S) = F_1^e v_e(W - P_1) + F_2^e v_e(W' - P_2) + (1 - F_1^e - F_2^e) v_e(R - P_S)$$

s.t. \quad U_t = F_1^t v_t(P_1) + F_2^t v_t(P_2) + (1 - F_1^t - F_2^t) v_t(P_S) \geq \tilde{v}_i$$

with \( t = B, G \) (bad type) or (good type).

Given the assumption that all the surplus goes to the entrepreneur, in equilibrium the constraint is satisfied as an equality. The choice variables are the three terms that define a contract, that is \((P_1, P_2, P_S)\). After developing the Lagrangian function, one can see that the first order conditions are the following:

$$\frac{v'_e(W - P_1)}{v'_e(P_1)} = \frac{v'_e(W' - P_2)}{v'_e(P_2)} = \frac{v'_e(R - P_S)}{v'_e(P_S)} \quad (1)$$

$$F_1^e v_t(P_1) + F_2^e v_t(P_2) + (1 - F_1^e - F_2^e) v_t(P_S) = \tilde{v}_i \quad (2)$$

This is a system of three equations in three variables: the system is determined and thus there is a unique solution. Of course this is true both for the bad and the good type: each of them gets his favorite contract in equilibrium, which I call symmetric-information contract and indicate as:

\((\hat{P}_1^t, \hat{P}_2^t, \hat{P}_S^t)\) \quad with \( t = B, G \).

As noticed above, in the second period the marginal utility of the entrepreneur is lower if the project brings some benefit that is, if \( W' > W \). This means that, given the same probability of failure, if the monetary payment for the first and the second period were the same the second payment would be relatively cheaper in terms of utility. Condition (1) indicates that the optimal amount of the first payment is lower than the second when \( W' > W \). This effect will also be present when information is asymmetric.

In the presence of full information, neither of the two parties has any motivation to signal, so that the terms of the contract are only designed to make the bargain possible and split the
surplus. Given zero transaction costs, all contingencies are foreseen by the two parties and included in the contract in the most efficient way. Condition (1) shows that the contract reaches allocative efficiency and productive efficiency is also obtained because with full information there is no waste of resources. As a consequence any sort of regulation would be inefficient.

2.2. Equilibrium with asymmetric information and no restrictions

When there is asymmetric information, the contract is likely to have distortions due to the fact that the informed party tries to convey information to the uninformed party. Even if every contingency is foreseen and the contract is complete, the terms of the contract itself become an opportunity for the good entrepreneur to signal the low probability that his project fails and distinguish himself from the bad type. Since the terms are designed not only to reach efficiency but also to remedy the gap in the information structure, Pareto efficiency is not always reached and restrictions may be desirable.

An important difference with other signaling models, such as the pioneering model of Spence (1973), is that when the signals are terms of the contract they are not a pure waste (e.g., education in Spence’s model). Now we might think of signals as productive because they enter the utility function of the other party: the decreasing marginal utility of the two parties is the only cause of the payment-signals leading to an inefficient contract. However, if we consider as true signals the difference between the actual payments and the payments that would prevail with full information, the signals are a waste of resources. The overpayment is not productive, rather it is a redistribution of resources that takes place in an effort to separate from the other type. Even if the investor always gets his reservation value, the entrepreneur does not maximize his utility because the effort to signal leads him to change the allocation of resources among the different payments.

The loss of welfare due to asymmetric information depends on the difference between the amounts of each payment and the equivalent payment that would prevail under full information. The investor gets his reservation value in any case and only the expected utility of the entrepreneur changes.

The analysis of the efficiency of legal restrictions involves the same considerations: a restriction is Pareto efficient if both types of entrepreneurs are better off (or one is better off and the other is indifferent) with respect to a situation of asymmetric information without restrictions.

In the model it is assumed that the investor has the prior belief \( q \) that the entrepreneur is a good type. Given asymmetric information, through the signals the entrepreneur can modify the prior beliefs of the investor. Following Rogoff (1990), I parameterize the posterior beliefs as: \( \hat{q}(P_1, P_2) \).

Now the problem of the entrepreneur will be to maximize his utility given the beliefs of the investor and given the usual constraint of the reservation value for the investor:

\[
\max \quad U_e(P_1, P_2, P_S) \\
\text{s.t.} \quad U_{\hat{q}}(P_1, P_2, P_S, \hat{q}(P_1, P_2)) \geq \bar{v}_i, \quad \text{with} \quad \hat{q} \in \{0, 1, q\}.
\]
Pooling occurs when $\hat{q} = q$ and the separating equilibrium when $\hat{q} = 0$ or $\hat{q} = 1$. The maximization problem clearly shows how the entrepreneur has to consider the terms of the contract: on the one hand his utility depends directly on the payments; on the other hand the two signal-payments generate the beliefs that determine the constraint. The terms of the contract are used with two different aims: the usual one is to maximize the surplus from the exchange and the new one is to signal in order to let the investor modify his beliefs. If the equilibrium is separating the beliefs are certain and each type is revealed. In a pooling equilibrium, instead, the investor does not know which type he is dealing with and he maintains the prior beliefs.

Since the contract is made of three variables, instead of a pooling line we must define a pooling plane. This can be denoted by the function $P_S(P_1, P_2)$ which represents the contracts that are solutions to the following equation:

$$qU_i(P_1, P_2, P_S, F_G) + (1 - q)U_i(P_1, P_2, P_S, F_B) = \bar{v}_i.$$  \hspace{1cm} (3)

It is important to underline that the expected utility of the investor depends on his beliefs about the entrepreneur’s type. These beliefs are induced by the signals of the entrepreneur and we will see that in some contingencies they may be completely misleading. In the following sections the assumption is always that the distribution of probabilities of the two types are public knowledge, so that the posterior beliefs of the investor are known by the entrepreneur.\textsuperscript{15}

No matter which are the cost structures of the two types, the definition of the good type as that having an overall signaling advantage gives results that are similar to those obtained in the one-signal framework. The good type entrepreneur will signal until a separating equilibrium is reached, or until the two parties end up in a pooling equilibrium. Theoretically there could be more equilibria, but only two of them survive two reasonable refinements. As regards to efficiency, the unrestricted separating equilibrium might be inefficient (i.e., efficient restrictions might exist), whereas the pooling equilibrium is always inefficient because of excessive signaling.

2.3. Unrestricted pooling equilibrium

With respect to the pooling equilibria, all the contracts on the pooling plane would be candidate solutions of the model. However, if we consider the equilibria that satisfy the intuitive criterion, only one of them survives -precisely the one with the highest amounts of signals that are available.\textsuperscript{16} An equilibrium is not intuitive when one type, say type B (G), could never be better off in an out-of-equilibrium strategy while the other type, say type G (B), is better off in deviating from the equilibrium if the investor believes that it is type G (B) who deviates. In the model, a contract in which the signals are not fully consumed cannot be a pooling equilibrium: the good type would have an incentive to signal more if the investor believes it is him who signals. This leads the investor to believe that the entrepreneur is a bad type unless he uses the total amount of signals that is available. Given the wealth limits, this equilibrium is:

$$PE_1: \ [W, W', P_S(W, W')]$$
The parties end up in PE 1 when the bad type prefers PE 1 to his symmetric-information contract, that is, when: 

\[ U^B_e[W, W', P^S(W, W')] \geq U^B_e[\hat{P}_1^B, \hat{P}_2^B, \hat{P}_S^B]. \]  

(4)

When this condition holds the bad type has an incentive to mimic the good type and the good type has an incentive to signal until the total amount of signals is used.

### 2.4. Unrestricted separating equilibrium

As regards to the separating equilibria, only one of them is undominated and this is the one which maximizes the utility of the good type: it is the separating equilibrium with the minimum amounts of signals that are necessary for separation.

I denote \( \Omega(P_1, P_2, P_S) \) the set of contracts that lead to a separating equilibrium: the good type offers the separating contract and the bad type offers his symmetric information contract. All the separating contracts satisfy two conditions: the signals make the investor believe that the entrepreneur is a good type with probability one and the investor gets his reservation value. Formally, \( \Omega(P_1, P_2, P_S) \) is defined by the two conditions:

\[
\tilde{q}(P_1, P_2) = 1; \quad U^i_e[P_1, P_2, P_S, \tilde{q}(P_1, P_2)] = v_i. 
\]

(5)

Among the separating contracts, the entrepreneur will prefer the one with the lowest amount of signals. In this model of asymmetric information the uncertainty derives from the fact that the uninformed party does not know which type he is dealing with. However both the uninformed party and the two types can have full information about the probability of each type, with the consequence that the pattern of beliefs of the investor is public knowledge.\(^{18}\) The result is that the separating contracts are also known and the entrepreneur can choose the undominated contract. This is the contract which solves the following maximization problem

\[
\max U^i_e(P_1, P_2, P_S) \\
\text{s.t. } (P_1, P_2, P_S) \in \Omega.
\]

The first order conditions are as follows: \(^{19}\)

\[
U^i_e[P_1, P_2, P_S, \tilde{q}(P_1, P_2)] = \tilde{v}_i; \\
\frac{v'_e(W - P_1)}{v'_i(P_1)} = \frac{v'_e(W' - P_2)}{v'_i(P_2)} = \frac{v'_e(R - P_S)}{v'_i(P_S)}. 
\]

(6)

Condition (6) is the same as that which holds in the case of full information: thus in the separating equilibrium the allocation of resources between the two signals is efficient. The difference is that the amount of each payment-signal (\( P_1 \) and \( P_2 \)) is now higher and \( P_S \) is lower: this is shown by condition (5), where instead of \( q \) we have now \( \tilde{q}(P_1, P_2). \)

Thus,
productive efficiency is not reached because of the waste due to the signaling activity. I call SE 1 the undominated separating equilibrium:

SE 1: (\(\tilde{P}_1^G, \tilde{P}_2^G, \tilde{P}_S^G\)) and (\(\tilde{P}_1^B, \tilde{P}_2^B, \tilde{P}_S^B\)).

Notice that the bad type offers his symmetric information contract: given that he cannot pool, his type is revealed and so he will not use any amount of signal. This equilibrium is the solution when condition (4) is not satisfied, that is, when the bad type prefers his symmetric-information contract rather than pooling at the highest amount of signaling.

3. Legal restrictions when the good type entrepreneur has lower costs for both signals

In the model, the marginal cost for each signal is expressed in relative terms (between the two types) by the probability of failure, in virtue of the fact that there is a proportionate relationship between the expected costs of signaling and the probabilities of failure \(F_1\) and \(F_2\). To see this, consider that the marginal cost function of the first signal for the good type is equal to the loss of utility that he suffers when the first payment is a bit higher, that is: \(F_1^G v'_{s}(W - P_1)\). Identically, the marginal cost of the first signal for the bad type is \(F_1^B v'_{s}(W - P_1)\). It follows that the bad type has lower marginal costs for the first signal if the following condition is true: \(F_1^B v'_{s}(W - P_1) < F_1^G v'_{s}(W - P_1)\). Since the marginal utility for a given level of payment does not depend on the type, the condition follows: \(F_1^B < F_1^G\).

When both signals are cheaper for the good type, the main result does not change with respect to the one-signal case: restrictions on one or both signals can enhance efficiency.

3.1. Legal restrictions on unrestricted pooling equilibrium

If the unrestricted equilibrium is pooling, the restrictions will in general enhance efficiency because the new equilibrium is again pooling and the amount of signaling is reduced. Only if the restrictions are extremely high may the good type be worse off in the new pooling equilibrium, for the reason that the new contract requires a higher payment in case the project succeeds. Fig. 1a shows that there is a boundary beyond which the increase in \(P_S\) caused by the restrictions has a stronger effect than the reduction in signaling waste and so the utility of the good type is lower.

3.2. Legal restrictions on unrestricted separating equilibrium

In the case of an unrestricted separating equilibrium, the one-signal model held that restrictions are efficient only when the bad type is not extremely different from the good type and only if the restrictions are limited within a certain interval:21 in these conditions the cost savings of the good type are sufficient to make him better off in the new pooling equilibrium. With two signals the situation is more complex due to possible differences in their costs and to the consequences that arise from restricting only one signal.
3.2.1. Both signals are restricted

If the legal intervention affects both signals, the separating equilibrium payments are no longer available because the separating contract has the minimum amounts necessary for separation, and the same result as for the one-signal model holds. Efficient restrictions exist if the types are not too different, while the range of efficient restrictions is a closed set with inferior and superior boundaries given by combinations of the two signals (see Fig. 1b).

3.2.2. Only one signal is restricted

If only one signal is restricted, however, the good type is forced to use the other one to reach separation. This is still a consequence of the beliefs of the investor, whereby an entrepreneur who does not signal when a signal is available is considered to be a bad type. Thus if the restriction binds only one signal the parties may end up in a dominated separating equilibrium: the bad type still gets his symmetric-information contract and the good type offers a dominated separating contract. In formal terms, with a restriction on the first signal, the first possible solution is:

\[
\text{SE 2: } (\tilde{P}^1, \tilde{P}^G, \tilde{P}^S) \quad \text{for the good type;}
\]

\[
\text{and} \ (\tilde{P}^B, \tilde{P}^B, \tilde{P}^B) \quad \text{for the bad type; with } \tilde{P}^1 < \tilde{P}^G, \tilde{P}^2 > \tilde{P}^G.
\]

Since the separating contract is dominated, the equilibrium SE 2 is Pareto inferior to SE 1, thus the restriction is inefficient.

There is however another possible solution which occurs when the restriction on one signal makes separation no longer achievable; the bad type can mimic the good type with the unrestricted signal and the parties end up in a pooling equilibrium. Thus, the second possible solution is:
PE 2: \([\tilde{P}_1, W', P_S(\tilde{P}_1, W')]\), with \(\tilde{P}_1 < P^G_1\), \(W' < \min P_2; P_2 \in \Omega(\tilde{P}_1, P_2, P_3)\).

In this case the restriction is efficient only if the pooling equilibrium allows for a big reduction in the amount of signaling. The proof is immediate. The bad type is better off in PE 2 because, having the possibility to get his symmetric-information contract, he chooses to pool. The good type is better off only if the restriction allows for a significant reduction in his signaling expenditure. This is likely when the restriction is high (i.e., when \(\tilde{P}_1\) is low) and when the separating contract already involved a high amount of the unrestricted signal (i.e., when \(W' - \tilde{P}^G_2\) is low).

The interesting result is that when the unrestricted equilibrium is separating and the legislator can restrict only one signal, efficiency in enhanced only if the parties end up in a pooling equilibrium. The savings in the signaling costs due to the legal restriction more than compensate the good type for the substitution of his separating contract with the pooling contract. Thus, the question arises as to how to draft restrictions in such a way that the final equilibrium is not SE 2 but a Pareto superior PE 2. It is possible to say that the final outcome will be SE 2 when the separating level of the second signal is achievable, that is, it is lower than the wealth of the second period. Otherwise, if wealth is not enough for separation, the solution will be PE 2.

If \(W' > \tilde{P}^G_2\) then the solution is SE 2;

if \(W' < \min P_2; P_2 \in \Omega(\tilde{P}_1, P_2, P_3)\) then the solution is PE 2.

If the level of wealth is between the two values, then the solution is a separating equilibrium which is dominated by SE 2. Thus, the outcome depends on the wealth which binds the second signal and on the level of signal necessary for separation. However since the level of signal necessary for separation depends on the level of restriction \(\tilde{P}^G_2\) is a negative function of \(P_1\), it follows that the final outcome depends on the wealth that binds the second signal and on the level of restriction on the first signal.

The conclusion with respect to the unrestricted separating equilibrium is that no matter whether both signals or only one are restricted, the set of efficient restrictions has a superior and an inferior boundary. Given the level of wealth, the normative recommendation would be to reduce the amount of signal to a very low level, although not excessively low because at some point the increase in \(P_S\) would reduce the utility of the good type.

4. Legal restrictions when the good-type entrepreneur has lower costs only for one signal

If we think of high technology products or durable goods, one of the most important difference among the various products is given by their life-cycle. Not only have products a different period of life, at the end of which they can no longer be used, but the quality itself often changes during the life-cycle. In particular, some producers may be able to provide high reliability for their products in the short term while subsequently there could be a drastic
reduction in the quality. The same can happen with long term contractual relationships like the concessions to private firms for the provision of public services. In these cases a potential entrepreneur may be able to provide solid warranties for short term performances, though the level of quality would drop in the long term.

These examples suggest that some situations exist where the good producer has a lower cost for one signal but there exists another signal for which it is the bad type who has a cost advantage. In the model, the assumption that the bad type entrepreneur has lower marginal costs for the first signal is formalized as $F_1^B < F_1^G$: of course this implies $F_2^G < F_2^B$ since the good type entrepreneur is defined by the condition $F_1^G + F_2^G < F_1^B + F_2^B$. To illustrate the situation we can consider the following example:

$$F_1^G = 0.2 \quad F_2^G = 0.05 \quad (1 - F_1^G - F_2^G) = 0.75$$

$$F_1^B = 0.1 \quad F_2^B = 0.25 \quad (1 - F_1^B - F_2^B) = 0.65$$

Since the good type entrepreneur has a higher probability of completing the project (0.75 > 0.65), the investor would prefer to make the contract with him. In presence of asymmetric information, however, the investor only knows that there is one type (the good) who is more likely to succeed and that if there are no legal restrictions he can signal at lower costs than the other type. The investor does not have the crucial information about which of the two signals is cheaper for the good type. Thus, in this example a restriction on the second signal will reduce the signaling advantage of the good type entrepreneur. At first sight the restriction on the second signal seems to be a good way of intervention because the good type is the one with the incentives to signal: indeed the good type’s effort to separate leads to a situation of excessive signaling and it might appear efficient to reduce his cost advantage. As we will see however, this form of intervention has the drawback that an excessive restriction brings the economy in a tricky separating equilibrium. In fact, the adverse effect of an excessive restriction would be that the bad type is given a cost advantage in signaling: if this advantage is high enough he could go on signaling until a separating equilibrium is reached where the investor considers him to be the good type.

It is important to notice that this situation cannot occur in the absence of legal restrictions: indeed, even if the bad type entrepreneur has a cost advantage for one signal, the good type still has an overall signaling advantage if he can freely use his signal, and so the result is either a pooling or a proper separating equilibrium.

4.1. Legal restriction on the second signal: the possibility of a tricky separating equilibrium

If the legal restriction fixes the maximum amount of the second signal to the level $\tilde{P}_2$, the condition holds: $P_2 \leq \tilde{P}_2$. For the first signal the maximum amount possible is given by the wealth of the entrepreneur: $P_1 \leq W$. The efficiency results are different according to the type of unrestricted equilibrium. I consider first the case in which the equilibrium is pooling.
4.1.1. The unrestricted equilibrium is pooling.

I have called PE 1 the unique equilibrium that survives the intuitive criterion: 

$$\text{PE 1: } [W, W', P_s(W, W')]$$

With the restriction $$P_2 \leq \bar{P}_2$$ on the second signal, the one for which the good type has an absolute advantage, the new equilibrium can only be another pooling equilibrium: 

$$\text{PE 2: } [W, \bar{P}_2, P_s(W, \bar{P}_2)]$$

Proof

The fact that the unrestricted equilibrium is pooling means that the bad type prefers to offer the pooling contract rather than his symmetric-information contract. Since PE 1 was preferred by the bad type to his symmetric-information contract, the new pooling equilibrium PE 2 will also be preferred because it involves a lower amount of the signal that is more costly for him. Separation was not possible for the good type in the unrestricted equilibrium and so it’s not possible now either. By the same token, even if the restriction is so high that the bad type is given a cost advantage in signaling, the good type will always be able to mimic the bad type and avoid a tricky separating equilibrium. This is again a consequence of the condition that the good type prefers pooling at the maximum amount of signals rather than getting the symmetric-information contract of the bad type.\(^{24}\)

Since the investor has to receive his reservation value, the reduction in the payment of the second period is compensated for by an increase in the payment when the project succeeds. Thus although the good type prefers PE 2 to the symmetric-information contract for the bad type, he may be worse off than in PE 1 if the legal restriction is too severe.

The conclusion that follows is that when the unrestricted equilibrium is pooling and wealth is limited, a restriction on the signal of the good type will lead to another pooling equilibrium. This new equilibrium will be more efficient, since it involves a lower amount of signaling, except for extremely severe restrictions.\(^{25}\)

The result is the same if the restriction is put on the signal for which the bad type has a cost advantage. Even if now the good type gets a larger signaling advantage, the bad type will always prefer pooling because he used to prefer pooling with the maximum amount of signals ($$W, W'$$).

Thus, when the unrestricted equilibrium is pooling and the legislator targets only one signal the results are consistent with those obtained in a one-signal framework: in order to introduce efficient restrictions the only concern of the legislator should be not to restrict too much. As we will see in the next paragraph, instead, when the unrestricted equilibrium is separating the results are different and for the legislator it is important not to ignore the existence of the other signal.

4.1.2. The unrestricted equilibrium is separating

In absence of restrictions the separating equilibrium is allocative efficient as the first order condition of the full information case (condition 6) is satisfied. I have called this equilibrium SE 1:
SE 1: \( (\tilde{P}^G_1, \tilde{P}^G_2, \tilde{P}^G_S) \) and \( (\tilde{P}^B_1, \tilde{P}^B_2, \tilde{P}^B_S) \).

SE 1 will be solution of the model when the bad type prefers his symmetric-information contract to the pooling contract.

Given this separating equilibrium as outcome in the case of no restrictions, we can examine what happens when the second signal, for which the good type has lower costs, is restricted. I consider the case in which the restriction is so high that the good type cannot separate any more:\(^{26}\)

\[ \tilde{P}_2 < \tilde{P}^G_2. \]

It is assumed anyway that the restriction still allows the bad type to get his symmetric-information contract:

\[ \tilde{P}_2 < \tilde{P}_2 < \tilde{P}^G. \]

Now both pooling and separating equilibria exist, but the separating equilibrium may be such to mislead the investor. This is because an excessive restriction may give a signaling advantage to the bad type: the supply of signals would become equivalent to a cost structure in which \( F^G_1 + F^G_2 > F^B_1 + F^B_2 \). In such a situation the bad type is the one who pushes for separation and if he succeeds in separating the investor is led to wrongly believe that the bad type is the good type. Hence I call this equilibrium a tricky separating equilibrium.

So let’s now suppose that the restriction is so high as to give a signaling advantage to the bad type. Of course a possible outcome is that the good type is able to mimic the bad type into a pooling equilibrium:

PE 3: \( [W, \tilde{P}_2, \tilde{P}_S(W, \tilde{P}_2)] \)

This will be solution of the model when the good type prefers PE 3 to the symmetric-information contract of the bad type. Indeed in this situation the signaling race is driven by the bad type and so for a pooling equilibrium to occur the requirement is that the good type has an incentive to mimic the bad type (and not vice-versa). Since in case of separation the good type can only get the contract designed for the bad type, the condition follows:

\[ U^G_e(W, \tilde{P}_2, \tilde{P}_S(W, \tilde{P}_2)) > U^G_e(\tilde{P}^B_1, \tilde{P}^B_2, \tilde{P}^B_S). \] (7)

If condition (7) is not satisfied then the parties end up in the so-called tricky separating equilibrium:

SE 3: \( (\tilde{P}^B_1, \tilde{P}^B_2, \tilde{P}^B_S) \) for the bad type,

\( (\tilde{P}^B_1, \tilde{P}^B_2, \tilde{P}^B_S) \) for the good type.

In this case the good type does not find it convenient to mimic until \( P_2 = W' \) and he prefers to accept the symmetric-information contract for the bad type. Such a situation may occur when there is a big difference in the costs of the signals for the two parties and at the same time the restriction on the signal of the first party is very large; for the good type the second signal becomes so costly that he prefers to be considered as the bad type, rather than
pooling. The signaling activity becomes completely misleading and the investor is fooled in signing the contract for the good type with the bad type. In an ex-ante perspective the investor gets his reservation value because he updates the prior beliefs in the wrong way: only if he knew the real probabilities he could see that he is accepting a contract which does not provide him his reservation value.

Thus, when the unrestricted equilibrium is separating, a legal restriction on the first signal may reverse the signaling advantage and lead to one of two possible equilibria. One is a pooling equilibrium and the other one is the so-called tricky separating equilibrium. Instead, if the restriction is preserving the signaling advantage of the good type, then either the restriction is not binding (if $P_2^B < \tilde{P}_2$, the parties remain in the separating equilibrium) or there is a new pooling equilibrium (when $P_2^B \geq \tilde{P}_2$).

The tricky separating equilibrium will never be Pareto efficient because the good type is worse off; he is offering a contract which was available but not offered in the unrestricted equilibrium. The pooling equilibrium instead might be efficient if it allows for great savings in the signaling expenditure.

This result suggests that in a two-signal framework the policy recommendation for contract regulation should be more cautious than in a one-signal context. If there is only one signal, imposing an inefficient restriction will shift the parties from a pooling or a separating equilibrium to a pooling equilibrium, whereas in presence of two signals a bad restriction may generate a tricky separating equilibrium.

5. A summary of the results

I summarize now the results that have been found in the previous sections. A comparison is made with the result obtained by Aghion and Hermalin in the one-signal context. The indications for drafting efficient restrictions do not change significantly: in both models if the unrestricted equilibrium is pooling the restrictions shall not be too high and if the unrestricted equilibrium is separating the restrictions shall be neither too high nor too low. What does change with two signals is the amount of information needed by the legislator to know the efficient set and the consequences of putting inefficient restrictions.

In the next tables I keep using the symbols $G$ and $B$ to indicate the good and the bad type. As we can see from the tables, the differences from having one or two signals are limited to the consequences of drafting inefficient restrictions. Although efficient legal restrictions exist both in the case of one and of two signals and adding one signal does not change the configuration of the efficient set (i.e., whether it is upwards or downwards limited), it is important to consider that the legislator will have to take into account the likelihood that some inefficiencies may arise. These are due both to the limited information possessed by the legislator and to the fact that commonly the same legal provision applies to different contractual relationships, each one having a different efficient set.

As I mentioned, the information necessary to the legislator is in general more costly in the presence of two signals because he has to work along two dimensions. This is not particularly relevant in case of unrestricted pooling equilibrium, when the restrictions are only upper-limited; adding one signal does not always require more information to enhance efficiency.
since a minimum amount of restrictions on one or on both signals is always efficient. In case of unrestricted separating equilibrium, instead, in addition to a superior limit there is also an inferior limit to the efficient set and thus the legislator needs to know these values before setting the restrictions.

With respect to the effects of an inefficient restriction, Table 1 shows that when the good type has lower costs for both signals the results change only when the unrestricted equilibrium is separating; with two signals an inefficient restriction may leave the parties in a separating equilibrium, though a dominated one. Instead in the case of unrestricted pooling equilibrium the conclusions are the same: inefficient restrictions leave the two types in a pooling equilibrium which is inefficient due to the excessive payment when the project succeeds. This is due to the fact that the good type does not like an excessive reduction in the amount of the signals because he has a low probability of failure.

Table 2 shows that when the good type has lower costs for only one signal the results do not change if the restrictions affect both signals in a proportional way or in such a way as to preserve the signaling advantage of the good type. Like in the previous case, where the good type has lower costs for both signals, the result of inefficient restrictions can either be an inefficient pooling equilibrium or a dominated separating equilibrium. The difference is that now the restrictions may also be such as to invert the signaling advantage of the good type: this happens when the restriction on the signal of the good type is proportionally larger than the restriction on the signal of the bad type. To illustrate these contingencies I have been
considering the case where only the signal of the good type is restricted and the legal amount of it is reduced to a very low level: in this situation a tricky separating equilibrium may arise.

6. Extensions

6.1. Relaxing the assumption that the distributions of probability are public knowledge

In the model it is assumed that the probabilities of failure of the project of each type are known by the other type and by the investor. If this assumption is relaxed, we are in a situation where each type of entrepreneur knows his probabilities of failure but he has no information on the other type. As regard to the investor, he formulates the beliefs over the two types in order to design the pooling plane and the symmetric information contracts; since nothing would change in the interaction, we can keep the assumption that his beliefs are equal to the true probabilities of the two types.

Thus the pooling plane and the symmetric information contracts remain the same and what changes is the set of the separating contracts. Now the good type entrepreneur does not know the relative cost of the signals for the bad type (given by his probabilities of failure) and so he does not know with certainty which contracts are part of the separating set. This means

<table>
<thead>
<tr>
<th>Efficient restrictions:</th>
<th>UNRESTRICT. POOLING EQ.</th>
<th>UNRESTRICTED SEPARATING EQ.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ONE SIGNAL</td>
<td>Efficient restrictions always exist. The set of efficient restrictions has a superior limit.</td>
<td>Efficient restrictions do not always exist. The set of efficient restrictions has an inferior and a superior limit.</td>
</tr>
<tr>
<td>TWO SIGNALS</td>
<td>Efficient restrictions always exist. The set of efficient restrictions has an upper boundary.</td>
<td>Efficient restrictions do not always exist. The set of efficient restrictions has a lower and an upper boundary.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Consequences of inefficient restrictions:</th>
<th>UNRESTRICT. POOLING EQ.</th>
<th>UNRESTRICTED SEPARATING EQ.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ONE SIGNAL</td>
<td>Excessive restriction (the amount of the signal is too low): pooling equilibrium where G is worse off.</td>
<td>Insufficient restriction (the amount of the signal is not reduced enough) or excessive restriction: pooling equilibrium with G worse off.</td>
</tr>
<tr>
<td>TWO SIGNALS</td>
<td>Excessive restriction on the signal of the good type: inefficient pooling equilibrium (G is worse off).</td>
<td>1) Restriction on the signal of G that gives a signaling advantage to B: —Tricky separating equilibrium —Pooling equilibrium where G is worse off. 2) Restriction on the signal of G that preserves the signaling advantage of G: —Dominated separating equilibrium —Pooling equilibrium where G is worse off.</td>
</tr>
</tbody>
</table>

Table 2
The good type has lower costs for only one signal
that the chances of the good type to separate are positively dependent on the amount of his signaling activity: all separating equilibria are now possible solutions and the parties may end up in a dominated one. In such a situation restrictions become more likely to be efficient since excessive, wasteful signaling is present not only in the unrestricted pooling equilibria but also in the unrestricted separating equilibria.

6.2. A battery of signals

In many contractual relationships it is often the case that one party can use several signals to show the quality of his product to the other. The success of a deal is normally affected by different contingencies, some of which are fairly concrete and others more intangible. Not only are entrepreneurs committed to strategies of advertising and commercial promotion but most of them pay attention to how they look when they go to a business meeting, they take care of the way customers are treated in their firms, they may also consider as an important signal the level of education of the managers. Together with the terms of a specific contract, all these factors might play a role in deciding the success or the failure of a bargain. It would then be interesting to examine how the interaction of all the signals impact on the efficiency of the exchange.

The consideration made in the previous subsection for the case of two signals remains true also when there are \( n \) signals: if the two types do not have information over the probabilities of each other, we cannot exclude that dominated separating contracts are possible equilibria of the model. Indeed the lack of information may lead the good type to offer a separating contract with an inefficient allocation of the signals or a contract which uses all the signals when only some of them would be sufficient for separation. Thus, the case for having legal restrictions would be stronger for more signals: in particular, the more signals that are available the bigger the potential for waste in the unrestricted separating equilibrium.

If the two types have knowledge about each other’s distribution of probability, the set of separating contracts \( \Omega(P_1, P_2, \ldots, P_N, P_S) \) is known. In this case, the first order condition would again require the equality of costs for all signals and that would bring the optimal separating contract. All the signals available would be used in the most efficient way. Thus, the same conclusions of the two-signal case hold and there would be less support for legal restrictions.

However, the situation changes when the types are not very different and the bad type is able to mimic the good type. In a pooling equilibrium the two types will use all the signals and the prohibition of some of them would enhance efficiency. The excessive amount of signaling is once again the consequence of the beliefs of the uninformed party: if the entrepreneur does not use all the signals and each of them for the entire amount available, then the investor would believe that he is a bad type.

This may illustrate the real situation in markets where the products are not much differentiated. Since the consumers cannot distinguish the quality of each of them, the parties find themselves in a pooling equilibrium with a huge amount of signals. For example, the levels of advertising through the various channels (television, newspapers, commercial promotions) happen to be highest for some products with a low level of differentiation. Among all plausible explanations, one that provides real life evidence of the intuitive
criterion is that the typical consumer considers a product to be the bad type when it is not heavily advertised, forcing the producers to an inefficient pooling. The prohibition of some channels of advertising or a restriction on the amount of it would make the producers pool with less signals or with a lower amount for each of them. Efficiency would be enhanced by a measure equal to the savings in the signaling expenditure.

6.3. The case with infinite wealth

In situations where the wealth limits are not binding, the unrestricted pooling equilibrium is no longer possible. Given the intuitive criterion the good type will always separate: in any pooling situation both types would signal a bit more in order to get the good type contract and this process ends only when separation occurs.

It is thus to be considered what happens when the unrestricted equilibrium is separating and wealth is infinite. Restricting only one signal will always lead to another separating equilibrium which is dominated by the unrestricted one. To see this, consider a situation where both parties offer a contract in which one signal is already at the maximum limit. Given that the other signal is not bound by wealth, a marginal increase in its amount could allow separation: actually both parties would find it convenient to increase that signal a marginal amount and get the good type contract rather than pooling. Again this process finishes only when separation occurs. In particular, if the bad type has a cost advantage for one signal and only the other signal is restricted then the solution is a tricky separating equilibrium.

Only if both signals are restricted can the new equilibrium be pooling and thus efficiency is enhanced if there are major reductions in the amount of the signals.

7. An application: advertising by lawyers

A striking illustration of these results comes from the market of professional services, which are characterized by asymmetric information between the consumers and the providers of the service. In particular if we consider doctors or lawyers, in many countries the professional associations prohibit any form of advertising. Ignoring other effects of the prohibition, here we can simply consider truthful advertising as a signal that could allow doctors and lawyers to show their type to the market. The rest of the signals that are available may be aggregated in the trust that the practitioner has been able to get from the market, what is commonly known as reputation. What is relevant is that professional services are credence goods and since reputation does not reveal the type of the practitioner it can be considered just like a signal.

Thus, with advertising and reputation as the two signals, the model suggests some considerations about the effects of the prohibition of advertising. If we consider only young practitioners, in many small, local markets the good type is likely to have higher costs for the signal of reputation because these costs depend on the number of friends, acquaintances and other qualities that are not strongly related with the quality of the service. If the good practitioner has an absolute advantage for advertising and the bad one an absolute advantage
for building a reputation, the prohibition on advertising eventually leads to a tricky separating equilibrium. Only without the ban is the good type able to pool or even to separate from the bad type.

With respect to the experienced practitioners, who have long been in the market and have already built a reputation, the situation is not the same because the signal of reputation is more likely to be positively related to quality. The good and the bad type have each their reputation and thank to the prohibition of advertising they keep signaling using only that signal: their cost of signaling is the cost of preserving the reputation and keeping from opportunistically reducing the level of quality. Whether this is efficient or not depends on the result of allowing both signals: if with advertising the good type is able to separate then the ban may be inefficient, but if advertising only increases the amount of signaling, then its prohibition in a market of experienced practitioners would be supported by efficiency considerations. Since the professional associations are dominated by experienced practitioners, this helps to explain why prohibition of advertising has long been an indisputable norm.

8. Conclusions

The main contribution of this paper is the acknowledgment of an adverse effect that may arise when legal restrictions are set on the terms of a contract. Using a broader definition of signal I stated that when more signals are available, the cost of each is not necessarily negatively correlated with the level of quality: the implication is that a tricky separating equilibrium can arise from an inefficient level of restrictions.

I suggested that some situations, like the market of legal services for young practitioners, can be interpreted in the terms of a tricky separating equilibrium while others, like the market for homogeneous industrial products, are very similar to an inefficient pooling equilibrium. In the first case the restriction is not needed and might be inefficient, whereas in the pooling case a restriction would reduce the excess of signaling and so be efficient.

This points to the position of the legislator, who has to decide whether or not to draft the legal restrictions when his information is limited, more signals are available to the informed party and different contractual relationships imply different sets of efficient restrictions. As Aghion and Hermalin acknowledge, modeling a single contractual relationship provides too strong a case for restrictions, whereas a general provision which applies to more species of contracts should take into account the inefficiencies that are eventually generated in some of the contractual relationships. This paper underlines that these inefficiencies may indeed be relevant when more signals are available; not only might there be an inefficient pooling equilibrium like in the one-signal case, but also dominated separating equilibria. In particular, in the tricky separating equilibrium the misleading beliefs of the uninformed party can last for several contractual agreements if the quality is defined through a distribution of probabilities.

The policy recommendation that follows is that the legislator is to be sure that there is only one signal to be targeted because if he restricts one signal and another one exists for which the bad type has a cost advantage, then a tricky separating equilibrium may occur. When the
existence of more signals is acknowledged, it is important to find out which of them are cheaper for the good type and avoid putting high restrictions on them.

The critical point is to find out to what extent quality and cost of a signal are inversely related. If statistical measures are available and the signals can be ordered according to the strength of this link (for example using the coefficient of correlation) then the legislator should start the restrictions from the signal with the weakest correlation.

The framework used in this model is open to enlargements. An interesting one is to specify a utility function and analyze efficiency through the Kaldor-Hicks criterion. This would allow the finding of precise values for the set of efficient restrictions and would strengthen the case for intervention.36 Given different efficient sets for different relationships, the key point is always to find out to what extent rigid laws can incorporate flexible restrictions, so that the number of inefficiencies is minimized. Thereafter the magnitude of the inefficiencies and of the welfare improvements can be estimated and the choice between specific rules and vague standards can be made on a cost-benefit basis.37

As we saw, in a multisignal framework it is important for the legislator to find out all the signals that are available to the informed party. An interesting theme for empirical research could be to test how the terms of a contract change according to the degree of asymmetry in the information structure. If we consider for example a big market which is formed by many local markets, considering how the level of a penalty clause changes with the frequency of purchases, with the strength of reputation effects or with the size of third party certification, can bring evidence as to whether or not that penalty clause is used with signaling purposes.

Notes

1. Sometimes the distinction between signaling and screening is not fully appreciated. Here we just remind the reader that in signaling models the informed party takes the initiative to signal his type while in screening models the uninformed party drafts contracts in such a way that he can get to know the two types through their choices.
2. In a pooling equilibrium both types offer the same contract whereas in a separating equilibrium each type offers a different contract, so that the uninformed party can distinguish between the two types.
3. This is due to the fact that when the two types have very different probabilities of failure, the symmetric information contract of the good type has already a signaling function and it allows the good type to separate. See Aghion-Hermalin (1990).
4. In contrast with the signaling model of Spence (1973), where the signal is a pure waste, in this framework the signal should not be reduced below a certain amount because the other payment would necessarily increase and thus, given decreasing marginal utility, it would reduce utility.
5. I use the term legislator with reference to civil-law systems in which contract law is codified by legislatures. The argument goes the same way for other systems in which law-making is the task of special committees, authorities or courts.
6. If the signal assumes binary values, like it could for education in the model of Spence
(1973), the effect of an increase in the difference between types is different. In such a case, given the quality of the bad type, when the quality of the good type is higher the incentive for the bad type to mimic the good type is also higher because there is a larger gain from pooling. See Rasmusen (1990), chapter nine.

7. In the model quality is defined as the probability that the project succeeds.

8. The hypothesis of a distinction between failure in the first period and failure in the second period is equivalent to assuming a project which is made of two subprojects. The payments in case of failure of each subproject may be used as signals and the good entrepreneur is the one with the higher probability of completing both subprojects.

9. The technology is such that the probability of failure in the first period is independent of the probability of failure in the second.

10. In the specific relationship between an investor and an entrepreneur the assumption of infinite wealth would be meaningless because in such a case there would be no need for funds. However the same framework can be applied to other sorts of market relationships where wealth could be infinite. This is the case for example of the job market, where the unemployed can use the years of studies and the years of experience to signal his type to the employer.

11. Or if both subprojects fail. To maintain the analogy with the biperiodal framework, the second subproject should never succeed if the first subproject fails.

12. This will be evident from the first order conditions of the equilibrium under perfect information, which also show the optimal allocation of the two signals when the good type reaches a separating equilibrium. These conditions show that if wealth does not change after one period \( W' = W \) then the optimal choice implies an equal level of payment-signals \( P_1 = P_2 \). See Section 2.1.

13. Differently, the unrestricted separating contract, though allocative efficient, is not productive efficient because the payments are partly wasted with signaling purposes.

14. Although the entrepreneur is only one, his type is not known. Since there is a chance that he might be either type, a Pareto improvement requires that both types are better off.

15. The investor updates the prior beliefs (given by the distribution of probabilities) according to the Bayes rule.

16. See Rasmusen (1990) for a formal explanation of the intuitive criterion and Aghion-Hermalin (1990) for its application to signaling models.

17. For the proof of this proposition see Aghion-Hermalin. The intuition is that separation is not possible because the bad type always prefers to pool, even when the level of signals is maximized.

18. In the case that one type does not know the distribution of probability of the other and the beliefs of the uninformed party are not known, any separating contract can be a possible equilibrium. In such a case, since the separating equilibrium itself might be a dominated one, restrictions are more likely to enhance efficiency. See section 6.1.

19. Since we have a system of three equations in three variables, the undominated
contract is unique: see the appendix for the details. Rogoff (1990) provides a proof of this proposition in a dynamic context.

20. When the condition on the beliefs is satisfied by the symmetric information contract, then the unrestricted separating equilibrium is efficient and restrictions are always inefficient.

21. Efficient restrictions have not only a maximum limit but also a minimum limit.

22. In the set of efficient contracts there is no contract with the value $\hat{P}_1$ for the first payment.

23. On the signal, the restriction has the same effect of an increase in the probability of failure in the second period.

24. In PE 1 it is true that: $U_e^{2G}[W,W',P_S(W,W')]=U_e^{2G}(\hat{P}_1,\hat{P}_2,\hat{P}_S)$ and if $\hat{P}_2 < W'$ it follows that $U_e^{2G}[W,\hat{P}_2,P_S(W,\hat{P}_2)]>U_e^{2G}(\hat{P}_1,\hat{P}_2,\hat{P}_S)$; where $P_S(W,\hat{P}_2) > P_S(W,W')$.

25. As in the one-signal case, the restriction is inefficient only when it reduces the signal to an excessively low level. See section 3.1 and Fig. 1a.

26. If the restriction keeps allowing the good type to separate, it is always inefficient because separation is reached with a more costly combination of signals.

27. This situation is common for production processes with economies of scale and learning processes. In the example of two subprojects, the good type entrepreneur might be involved in a lot of activities with subproject 1, having just a few with subproject 2: thus the probability of failing in the first subproject is very low, while the probability of failing in the second is much higher. If the opposite is true for the bad type, a heavy restriction on the first signal gives the bad type an overall signaling advantage.

28. In a simple signaling game the tricky separating equilibrium is a final result, but in a repeated game the investor can adjust his beliefs. In the equilibrium of a repeated game the beliefs are required to be self-confirming and so the possibility of a tricky separating equilibrium is ruled out. Notice however that in order to correct his beliefs the investor needs to remain for a long time in the market: this is because after a single contract he can only see if the project failed or succeeded but he cannot infer the probability of failure. Only after several contracts with the same type can he get to know the probability of failure with a reasonable interval of confidence.

29. The problem would arise if the legislator can only reduce heavily the signals, for example because of a discontinuity in the amount of signals. In such a case it is important to know the maximum limit of the efficient restrictions and more information is required when two signals are at stake.

30. Distortions arise only when signals are not available in a continuum, but at discrete or binary values. For example while the level of advertising can be chosen in a continuum, the decision that managers should drive a Mercedes is a zero-one choice. If a signal is not used in a separating equilibrium, it means that the cost of its lowest amount is above the cost of the efficient level of the other signals.

31. The service provider knows the relative quality of the service while the client does not.

32. Credence goods are those for which the level of quality cannot be known with
certainty even after consumption. For a description of credence goods see Darby and Karny (1973).

33. In the model the two signals belong to the terms of the contract while strictly speaking advertising and reputation cannot be thought of as parts of the contract. However the effect of the restrictions is the same because the cost of the two signals could in theory be split among all the contracts that are offered. The model’s assumption that may be unreasonable is the market power to the informed party since lawyers are often unable to make take-it or leave-it offers.

34. Even if reputation never allows the two types to be distinguished with certainty, it reduces the asymmetry of information as the number of transactions increases.

35. For more on advertising and professional services see Posner (1993).

36. The set of Pareto efficient restrictions is a subset of the Kaldor-Hicks efficient set.

37. More suggestions for further developments and research are in Aghion-Hermalin (1990).

Acknowledgments

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Appendix

The undominated separating contract

When there is asymmetric information, the maximization problem of the entrepreneur is as follows:

\[
\begin{align*}
\max & \quad U_e(P_1, P_2, P_S) \\
\text{s.t.} & \quad U_i[P_1, P_2, P_S, \hat{q}(P_1, P_2)] = \bar{v}_i.
\end{align*}
\]

The Lagrangian function is:

\[
L = U_e(P_1, P_2, P_S) + \lambda[\bar{v}_1 - U_i(P_1, P_2, P_S, \hat{q}(P_1, P_2))].
\]

Given that the variables of choice are \( P_1, P_2 \) and \( P_S \), the first order conditions are:

\[
\begin{align*}
U_e & - \lambda U_{1i} - \lambda \hat{q}_1 = 0 \\
U_e & - \lambda U_{2i} - \lambda \hat{q}_2 = 0 \\
U_e & - \lambda U_{Si} = 0 \\
U_i[P_1, P_2, P_S, \hat{q}(P_1, P_2)] & = \bar{v}_i
\end{align*}
\]

where
In every separating equilibrium the investor believes that the entrepreneur is the good type with probability one. Thus also the undominated separating contract is such that \( \hat{q}(P_1, P_2) = 1 \). This means that an increase in the amount of either of the two signals does not increase the posterior beliefs of the investor (\( \hat{q} \) cannot be greater than one) and we have: \( \hat{q}_1 = \hat{q}_2 = 0 \).

With these conditions the first order conditions for the undominated separating contract become:

\[
\begin{align*}
U_1^c - \lambda U_1^i &= 0 \\
U_2^c - \lambda U_2^i &= 0 \\
U_S^c - \lambda U_S^i &= 0 \\
U_i^c(P_1, P_2, P_S, \hat{q}(P_1, P_2)) &= \bar{v}_i
\end{align*}
\]

The last system is the same obtained in the case of full information, with the only difference being the constraint. Thus the first order conditions are:

\[
\frac{v_e'(W - P_1)}{v_i'(P_1)} = \frac{v_e'(W' - P_2)}{v_i'(P_2)} = \frac{v_e'(R - P_S)}{v_i'(P_S)}
\]

\[
U_i^c(P_1, P_2, P_S, \hat{q}(P_1, P_2)) = \bar{v}_i
\]

The first condition shows that in the undominated separating equilibrium allocative efficiency is reached, as in the case of full information. However, since the constraint is now different and includes the beliefs of the investor, the payments are higher and productive efficiency is not reached.

References


