Public Policies in Investment Intensive Industries *

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Abstract

In this paper we review some recent work on public intervention in economic environments where firms undertake investments in research or in physical assets, and then select appropriate business practices to extract profits from the outcomes of the investment process. Public policies may take different forms: the release of an authorization; the setting of fines and damages for liability; or the choice of legal standards in antitrust law enforcement. The business practices are privately profitable but may be welfare enhancing or socially harmful. When expectations are optimistic, public policies face a trade-off between ex-ante effects on investment, that suggest hands off, and ex-post control of practices when harmful, that requires intervention. Our general result suggests that public policies should be softer when innovation is an important source of welfare improvements.

1 Introduction

When private activities may generate negative externalities, it is generally recognized that some form of public intervention may be desirable.[1] The most appropriate policy may be selected within a wide range of different regimes that differ in terms of timing – intervening before or after the relevant activities have been undertaken – and in terms of the tools at the public agent's disposal, from releasing an authorization to levying fines.

So far, the literature has studied this issue looking at environments where technologies were given and public intervention consisted in affecting the behavior of private agents who

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[1] This claim is justified as long as the Coase Theorem does not apply, due for instance to transaction costs, difficulties in coordination, imperfect information. We argue that in many instances some of these elements characterize the economic environments we are interested in.

produced externalities.[2] This Chapter, instead, presents a simple framework to survey the effects of different public policies in research intensive industries. In this setting, the current practices of agents interact with the long run decision to invest in R&D. We refer to an economic environment where firms first invest in research and then, if research is successful, undertake business practices to exploit the profit potentials of the innovation. Firm's practices, in turn, while privately profitable, may be *ex-ante* welfare enhancing or detrimental. In this framework a stricter public intervention, reducing the profits *ex-post*, discourages the investment in research although it may better control *ex-post* behavior. There is therefore a potential tension between the *ex-ante* and *ex-post* effects of the policy that works in all the regimes considered.

We mainly draw on our recent work: Immordino, Pagano and Polo (2011) focus on the choice between *ex-post* liability and *ex-ante* authorization of innovative products as genetically modified (GM) organisms, or new drugs. They identify when each policy is optimal. In Immordino and Polo (2012), instead, we compare per-se and discriminating legal standards, within the *ex-post* law enforcement regime, referring to antitrust intervention against abuse of dominance. Hence, the two papers can be read as complementary.

A key feature of our approach is that the effects of the practices, when applied to the new technologies, are unknown at the time the investment is sunk and the policy is set. This uncertainty may be rooted in the very nature of the research activity, so that the features of the innovation are unknown until discovery. For instance, a new GM seed may promise higher yields but may also pose unknown risks to public health, risks that can be properly verified only once the research has been concluded. This setting reminds the class of problems that we address in Immordino, Pagano and Polo (2011) and which are reviewed in Section 4 of this Chapter.

In other instances, uncertainty may be due to the interaction of the innovation, whose properties may have been controlled and planned by the firm with sufficient confidence, with the economic or social environment at the time the innovation will be introduced. The features of this environment at this later stage, in turn, will depend on the decisions of other agents and cannot be assessed *ex-ante* with certainty. To illustrate, consider the example of a dominant software company that may invest in research to tie a new software application into a new personal computer operating system, a setting that refers to the competition policy issues addressed in Immordino and Polo (2012) and reviewed in Section 5 of this Chapter. Beyond the initial intent of the company, the efficiency and foreclosure effects of tying this new software packages will depend, at the time of its commercial introduction, on the alternative packages and applications available from competitors, which may be only imperfectly foreseen at the time of the research investment.

We derive a full range of normative results that depend on the private and social effects of the practices, and on the likelihood that they will cause social harm. Our general result

[2] The literature of Public Economics and Law and Economics has further pointed out that the optimal form of intervention should trade-off the social benefits of the different regimes with their enforcement costs. See, on the public economics side, among others, Krueger (1974); Rose-Ackerman (1978); Banerjee (1997); Acemoglu and Verdier (2000); Glaeser and Shleifer (2003); Immordino and Pagano (2008). Similar arguments can be found in the literature on the optimal design of regulation: see Laffont and Tirole (1993) and Armstrong and Sappington (2007). The law and economics literature, such as Becker (1968), Becker and Stigler (1974) and Polinsky and Shavell (2000), has dealt with similar issues arising from the optimal enforcement of norms.

suggests that the more optimistic the expectations of the practices' social effects the laxer the policy. When comparing *ex-ante* authorization and *ex-post* liability (Section 4), *laissez-faire* initially prevails, for very optimistic expectations, and is then replaced by an *ex-post* liability regime. When damages are capped, because of a limited liability constraint, a (strict) *ex-ante* authorization is finally selected when the probability of social harm is very high. In the analysis of different legal standards (Section 5), per-se legality initially prevails, then replaced by a discriminating (effect-based) rule, while per-se illegality is introduced for very pessimistic expectations on the effects of the practice, when fines are capped.

The remainder of this chapter is organized as follows. Section 2 discusses the relevant literature. Section 3 sets up the baseline model. Section 4 compares *ex-ante* regulation to *ex-post* liability. Section 5 compares different legal standards in antitrust. Section 6 concludes.

2 Related literature

Several strands of the literature are relevant for our work. Starting with the Law and Economics literature, our papers have some common elements with the so called "activity level" model (see, for instance, Shavell, 1980 and 2007 and Polinsky and Shavell, 2000). According to this approach, private benefits and social harms depend on two different decisions of private agents: a level of activity (how long the individual drives) and a level of precaution (the speed at which the agent drives). This literature focusses mainly on comparison of different liability rules (strict vs fault-based). In our model the innovative effort resembles the activity while the choice of new actions parallels precaution. However, in our setting, the time and information structure are different, since innovative effort is taken before uncertainty is resolved and before actions are chosen, while in the activity level model activity and precaution are chosen together and uncertainty plays no role.

The analysis performed in Immordino Pagano and Polo (2011) is related to Shavell (1984), who analyzes four determinants of the choice between an authorization and a liability regime, in his context respectively labeled as safety regulation and liability: (i) difference in risk knowledge; (ii) incentive or ability to enforce penalties; (iii) magnitude of administrative costs, and (iv) magnitude of maximal fines. In our analysis, we hold determinants (i) to (iii) constant across regimes. This is done to focus on the role of innovation in the choice between regimes, eliminating other sources of differential effectiveness between them.

Immordino, Pagano and Polo (2011) compare different policy regimes based on *ex-ante* versus *ex-post* intervention. A model that analyzes similar issues is Schwartzstein and Schleifer (2012), who investigate when and how the optimal policy combines *ex-ante* regulation and *ex-post* litigation in the activity model. They consider a setting where safe and unsafe firms decide whether to produce and may take precautions. Firms face uncertainty as to the liability for damages that will apply to them, due to the assumption that courts can make errors: a judge may mistake a safe firm for an unsafe one, which creates a disincentive effect for safe firms. If the regulator can identify safe firms *ex ante*, it is optimal for regulation to set these firms free from liability for damages, since the social benefits of their activity exceeds the expected harm from taking too few precautions. This parallels our finding that regulation should be softer when social harm is unlikely. But our analysis differs from Schwartzstein and Schleifer (2012), as we model uncertainty as inherent to the

social effects of firms' research activity, rather than as arising from judicial errors. As such, it applies uniformly to any form of policy intervention, and does not *per se* favor any regime over others.

Immordino and Polo (2012) introduce in the analysis the role of judicial errors. Judicial errors and their reduction, i.e. accuracy, are a central concern in law enforcement: they have been analyzed in the standard model of law enforcement proposed by Kaplow (1994), Kaplow and Shavell (1994, 1996), Polinsky and Shavell (2000) and Png (1986) among others, which focusses on the (negative) impact of such errors on marginal deterrence. In this framework, accuracy is always desirable, and it is chosen optimally balancing the marginal benefits and costs. In our framework, errors affect not only *ex-post* (marginal) deterrence, but also *ex-ante* deterrence: type I errors, inducing over-deterrence, discourage investment, while type-II errors affects positively the research effect due to underdeterrence. The effects of accuracy, therefore, are richer in our setting than in the traditional law enforcement literature.

The impact of antitrust enforcement in innovative industries, at the core of Immordino and Polo (2012), is analyzed also in a paper by Segal and Whinston (2007). Considering a sequence of innovations, the authors analyze the trade-off between protecting the incumbents, by so doing increasing the rents of the winner and the incentives to invest in innovation, and protecting the innovative entrants, that increases the rate of technical progress. They derive conditions under which the latter effect is the dominant one.

Segal and Whinston (2007) offer interesting results on law enforcement when innovative activity is a crucial component, but they do not consider different legal standards, which instead play a central role in Immordino and Polo (2012). In Katsoulakos and Ulph (2009) a welfare analysis of legal standards is developed, comparing per-se rules and discriminating (effect based) rules characterized by a lower probability of errors, in a setting where no innovative investment is required. The authors identify some key elements that can help deciding the more appropriate legal standard and the cases in which type-I or type-II accuracy is more desirable, but do not consider the additional effects arising when decisions on research investment and on the practices interact. The discussion on legal standards has occupied also an important place in the recent debate on the enforcement of competition policy in preventing foreclosure and monopolization, comparing per-se or form-based rules and discriminating or effect-based rules (see on this point Gual et al., 2005 DG Competition, 2005 and 2008 and Department of Justice, 2008).

Finally, Chang (1995), Green and Scotchmer (1995) and Erkal (2005) consider the interaction of different forms of public intervention, namely antitrust and patent policy, in a setting of sequential innovations. They show that different licensing agreements may have an impact on the incentives to further discover the second innovation as well as on market coordination.

3 A simple set up

Consider a profit-maximizing firm that chooses whether to invest in R&D activity or not. If the firm invests and fails, or if it does not invest at all, it can only implement the status-quo action, $a = 0$, e.g. familiar technologies, and the resulting profit and welfare are normalized to zero. If instead the firm invests and succeeds in its research effort, it discovers how to

implement a set of new actions $A = (0; 1]$, with associated profits $\Pi = \pi a$, where $\pi > 0$. In this case, the firm is also assumed to learn the state of nature $s \in \{b; g\}$, where the bad state b occurs with probability β and the good state g occurs with probability $1 - \beta$. In the bad state b, the innovation is socially harmful, and the new actions decrease welfare according to $W_b = -w_b a$, with $w_b > 0$. In the good state g, the innovation raises welfare by $W_g = w_g a$, with $w_g > 0$. That is, in the bad state, private incentives conflict with social welfare since a new action a yields profit but reduces welfare, while in the good state g, new actions raise welfare as well as profits

The resources I that the firm invests in research determine its chances of success: for simplicity, I is assumed to coincide with the success probability, so that $I \in [0, 1]$. The cost of learning is increasing and convex in the firm's investment; for concreteness, we assume it is given by $c(I) = c\frac{I^2}{2}$. After choosing I and learning its outcome, the firm selects the most profitable action a among the feasible actions under the constraints imposed by public policy.

4 Ex-ante authorization vs. ex-post liability of innovative products

We start our comparison of policy regimes by considering a firm that invests in research projects, for instance on genetically modified (GM) seeds, potentially able to improve farming, yet exposed to unknown risks to public health; similar issues arise in the nanotechnology industry (Editors, 2010), or in the pharmaceutical and chemical industries (Philipson and Sun (2008)). To contain the potential hazards posed by innovative activity, public policy may constrain the actions of successful innovators either by subjecting them to an *ex-ante* notification and authorization requirement (*authorization*) or to an *ex-post* liability regime (*liability*), where the firm can be condemned to pay damages. Under the authorization regime, the firm notifies to a public agency (such as the Food and Drugs Administration) the action it plans to undertake based on the results of its research (e.g., the sale of GM seeds), and the agency, after carrying out an investigation on the potential implied harm, decides whether the firm is allowed to go ahead. In contrast, under a liability regime the firm is free to choose any new action made possible by its research findings (in our example, sell any new GM seed), but may have to pay a fine or damage *ex-post* if this action causes social harm. Public policies must trade off the social gains arising from the firm's innovation (a larger harvest) against their potential social harm (a public health hazard). The key issue to be explored is how this trade-off shapes the optimal design of the policy in each regime, as well as the choice between regimes.

4.1 *Ex-ante* Authorization

In the authorization regime, after a firm notifies the action that it wishes to undertake, the authorizing agency investigates whether the notified actions are socially harmful or not, and obtains decisive evidence about their social effects with probability $p \in [0, 1]$, while it finds no evidence in either direction with probability $1-p$. If the evidence is decisive, the authorization is given if and only if the evidence is favorable. If, instead, it is not decisive, the agency can

opt for one of two rules: a "lenient authorization" (LA) rule, whereby when in doubt the firm is authorized, or a "strict authorization" rule (SA), whereby in such circumstances the authorization is denied. Hence, under the LA regime the firm is authorized as long as no social harm is proved, while under the SA rule new actions are permitted only if proved to be socially beneficial.

If the preliminary review were always to produce decisive evidence ($p = 1$), the two regimes would be equivalent; but if it may fail to yield hard evidence ($p < 1$), the lenient and strict rules differ. LA leads to under-enforcement, since with probability $\beta(1-p)$ it gives green light to a harmful action, while SA entails over-enforcement, by blocking with probability $(1-\beta)(1-p)$ a beneficial action. When the authorization is denied, the firm must take the *status-quo* action $a = 0$.

The timing of the game is as follows. At $t = 0$ the agency chooses between the LA and the SA rule, committing to the chosen rule for the entire game. At $t = 1$ the firm chooses its innovative activity I and with probability I discovers the new actions A and the state of nature s. At $t = 2$, under the rules LA and SA the firm notifies the agency of the new action it wishes to undertake. At $t = 3$ the agency obtains evidence on the social effects of the proposed action with probability p, and decides whether to authorize it or not. At $t = 4$ the firm carries out the authorized action (if any), and the corresponding private and social payoffs are realized.

Since by assumption the new actions in A are more profitable than the *status-quo* action $a = 0$, if research is successful the firm always applies to be authorized to carry out the highest (most profitable) new action $a = 1$. If the LA rule is in place, the firm anticipates that the agency will always authorize it in the good state (with probability $1-\beta$) and will authorize it only with probability $1-p$ in the bad state (with probability β). Hence, under the LA rule, the firm will take action $a = 1$ with probability $(1-\beta)+\beta(1-p) = 1-\beta p$. Then, the expected profits at the time the level of investment is chosen are $E(\Pi_{LA}) = I(1-\beta p)\pi - c\frac{I^2}{2}$.

Under the SA rule, instead, the agency will authorize action $a = 1$ only if it uncovers favorable evidence (with probability p), which happens only in the good state (with probability $1-\beta$). Hence, the action 1 will be authorized with probability $(1-\beta)p$ and the expected profits are $E(\Pi_{SA}) = I(1-\beta)p\pi - c\frac{I^2}{2}$.

Since the firm is allowed to take the most profitable action more often ($1-\beta p > (1-\beta)p$), the lenient rule, leaving greater expected profits to innovators, is associated with greater investment in innovation than the strict one. Indeed, we have

$$I_{LA} = \frac{(1-p\beta)\pi}{c} > I_{SA} = \frac{(1-\beta)p\pi}{c}.$$

Comparing the different authorization rules, Immordino Pagano and Polo (2011) conclude that the LA rule, being associated to under-deterrence, boosts innovative investment more than the SA rule. When there is a low probability β that the new actions reduce welfare, the former is preferable to the latter.[3] This happens for a larger set of values of the probability β when enforcement becomes more effective (higher p): when the probability of social harm

[3]This result is obtained by comparing the expected welfare under the LA rule, $E(W_{LA}) = I_{LA}\left[(1-\beta)w_g - \beta(1-p)w_b\right] - c\frac{I_{LA}^2}{2}$, with the one under the SA rule, $E(W_{SA}) = I_{SA}(1-\beta)pw_g - c\frac{I_{SA}^2}{2}$, where the profit maximizing investments have been described above.

increases, the agency sticks to the lenient rule only if the ability to detect harmful innovations is high enough as to compensate the under-deterrence of this rule.

4.2 *Ex-post* Liability

Having characterized the optimal authorization regime, we now consider the optimal implementation of the liability regime. In this latter case, the successful innovator can implement any action $a \in A$, but anticipates that he may be sanctioned if the action is found to have caused social harm. This occurs when the agency obtains evidence that the chosen action was socially harmful, which happens with probability p as in the authorization regime. Under liability, an action $a \in A$ that causes social harm is punished according to a fine (or damage) schedule $f(a)$ chosen in the interval $[0, F]$ and non-decreasing in social harm:

$$f(a) = \begin{cases} 0 & \text{if } a = 0 \\ \underline{f} \geqslant f & \text{if } 0 < a \leqslant a_f \\ \overline{f} \leqslant F & \text{if } a > \widetilde{a}. \end{cases}$$

In the liability regime, the timing of the game is as follows: at $t = 0$ the agency commits to the fine schedule $f(a)$. If the agency sets its fines at zero for any new action $a \in A$, it effectively opts for a *laissez-faire* regime. At $t = 1$, the firm chooses innovative activity I and with probability I discovers the set of new actions A and the state of nature s. At $t = 2$ it decides which action a to take. At $t = 3$ the private and social payoffs are realized. At $t = 4$ the agency investigates the action a, finds decisive evidence about its social effects with probability p and, if it does, levies the fine $f(a)$.

The influence of law enforcement and penalties on firms' behavior is twofold: it affects both the choice of the *action* when the new actions are discovered and are socially harmful, and the *research investment* in the first place, when the firm computes the expected profits from the new actions. The first effect plays *ex-post*, and we can label it as *ex-post deterrence,* that is, the ability of fines to guide private choices among unlawful actions.[4] The second effect, which is absent in standard models, stems from the impact of law enforcement on innovative activity, and therefore on the probability that any new action will be taken. For this reason we can label this second effect *ex-ante deterrence*. The policy will be chosen considering both effects on private choices and ultimately on welfare.

The choice of actions at $t = 2$ depends on the outcome of the firm's innovative activity at $t = 1$ and on the fine schedule $f(a)$ designed by the agency at $t = 0$. When innovative activity is unsuccessful, the firm carries out the *status-quo* action $a = 0$. Instead, when successful the firm can also take new actions $a \in A$. If these are socially beneficial, no damage can be imposed, so that the firm picks the most profitable action in the good state, i.e. $a_g = 1$. If instead the new actions $a \in A$ are socially harmful they might be sanctioned, and the firm chooses the action that maximizes profits net of the expected fine: $\widetilde{a}_b = \arg\max_{a \in [0,1]} [\pi a - p f(a)]$. Referring again to our example, if innovative activity is unsuccessful, the firm sells traditional seeds ($a = 0$), while if successful it markets the most profitable type of seeds if that poses no concern for public health ($a_g = 1$), while it selects a

[4] This effect is known in the Law and Economics literature as marginal deterrence. See Stigler (1970) and Mookherjee and Png (1994).

less profitable variety ($\widetilde{a}_b$) if it is dangerous, taking into account the corresponding damages it may be called to pay.

At $t = 1$ the firm chooses the innovative activity I so as to maximize its expected profits, anticipating the optimal actions to be taken at $t = 2$. In terms of our example, the biotech firm chooses its investment in R&D, taking into account which GM seeds it will sell if successful. The expected profits of the firm under liability when choosing the level of investment I, given the action, $\widetilde{a}_b$, are

$$E(\Pi_L) = I\left[(1-\beta)\pi + \beta(\pi\widetilde{a}_b - pf(\widetilde{a}_b))\right] - c\frac{I^2}{2}.$$

The profit maximizing investment is therefore:

$$I_L(\widetilde{a}_b) = \frac{(1-\beta)\pi + \beta[\pi\widetilde{a}_b - p\underline{f}]}{c}.$$

Finally, we can write the expected welfare that the agency maximizes:

$$E(W_L) = I_L(\widetilde{a}_b)\left[(1-\beta)w_g - \beta w_b\widetilde{a}_b\right] - c\frac{I_L^2(\widetilde{a}_b)}{2}.$$

The (incentive compatible) action $\widetilde{a}_b$ and investment I_L depend on the fine schedule (the parameters $\underline{f}$, $\overline{f}$ and a_f). A convenient way to describe the optimal penalty schedule is to consider its design as equivalent to (indirectly) implementing an action $\widehat{a}_b$ in the bad state - and a corresponding investment $I_L(\widehat{a}_b)$ - that maximizes expected welfare, among all (profit-maximizing) actions $\widetilde{a}_b$ which the firm will want to pick in the bad state.

Two different effects interact in the selection of the optimal action $\widehat{a}_b$ in the bad state: *ex-post* deterrence requires to implement a low action to reduce social harm, whereas a higher and more profitable action is desirable to sustain investment, as long as the expected welfare is *ex-ante* positive. Indeed, the first partial derivative of the expected welfare with respect to the action implemented in the bad state, $\widetilde{a}_b$ is

$$\frac{\partial E(W_L)}{\partial \widetilde{a}_b} = \left[(1-\beta)w_g - \beta w_b\widetilde{a}_b - cI_L\right]\frac{\beta\pi}{c} - \beta w_b I_L,$$

where the first term corresponds to the indirect effect through the impact on investment (*ex-ante* deterrence), while the second refers to the direct impact of the action on welfare (*ex-post* deterrence). This latter is always negative, requiring to reduce the action when socially harmful. The sign of the first one depends on the parameters and on the level of the implemented action $\widetilde{a}_b$. When innovation has potentially large social benefits ($w_g > w_b + \pi$) and social harm is sufficiently unlikely ($\beta < \frac{w_g - w_b - \pi}{w_g + w_b}$), the first term is positive and large even at $\widetilde{a}_b = 1$. In this case, in order to foster investment in innovation, the firm should be allowed to choose the most profitable action even in the (very unlikely) bad state. The liability regime should be suspended, in favor of a *laissez-faire* regime. When β is high ($\beta > \frac{w_g - w_b - \pi}{w_g + w_b}$), instead, the firm must be constrained by setting a fine $\overline{f}$ large enough so as to implement the action $\widehat{a}_b(\beta) < 1$ in the bad state.[5] The implemented action $\widehat{a}_b(\beta)$ varies continuously from

[5] In this case we have an internal solution for $\widehat{a}_b < 1$. The first term of the partial derivative is kept positive by reducing $\widetilde{a}_b$ when β increases.

the most profitable one ($a = 1$) to the *status-quo* action ($a = 0$) as the probability of the bad state β, as well as the marginal social loss w_b, increase. The new actions are completely deterred only in the limiting case $\beta = 1$, while for $\beta < 1$ some welfare-decreasing actions $\widehat{a}_b(\beta) > 0$ are accepted. This pattern describes the optimal implementation of a liability rule.

4.3 Optimal Policies

The final step is the selection of the optimal policy through the comparison of the expected welfare associated with each regime. The optimal regime depends on the parameters (w_g, w_b and π) that describe the private and social effects of the new actions, and on the likelihood of the bad state, β. We describe the optimal policies in terms of the likelihood of social harm, β, and the thresholds that affect the shift in regime in terms of the parameters w_g, w_b and π. Immordino, Pagano and Polo (2011) find that public intervention becomes increasingly stringent as the likelihood of social harm increases: as β goes up, the optimal policy changes from *laissez-faire* to a liability regime, while the authorization regime is always dominated. This is because penalties can be fine-tuned to the likelihood of social harm, whereas authorizations are more rigid, being a "yes-or-no" decision that does not affect at the margin the choice of the action.

When the maximum feasible fine is capped at some upper bound, for instance due to a limited liability constraint on the damages that can be levied, however, the optimal policies become considerably richer. With capped fines, indeed, also the authorization regimes play a role for sufficiently large values of the likelihood of social harm β. More specifically, the constraint on maximum fines hampers the effectiveness of the liability regime for values of β exceeding a certain threshold. For an interval of values above this threshold, the liability and the lenient authorization regimes become equivalent, while for even larger values of β the strict authorization regime dominates both of them. Intuitively, when social harm is very likely and fines are capped at a maximum, the incomplete deterrence of the liability regime becomes too costly for society. At that point, the strict authorization regime dominates, being safer though less sophisticated. Hence, for increasing likelihood of the social harm, β, all the policy regimes are selected, starting from *laissez-faire*, moving to liability, shifting to lenient authorization and closing with strict authorization when β is very high.

5 Abuse of dominance: the optimal legal standards

We now discuss the implementation of competition policies in innovative industries. We maintain a similar set up, with the firm initially investing in research and then undertaking a practice to extract profits from the innovative technology. In this section, however, we explicitly refer to antitrust intervention on unilateral, or monopolization, practices. More precisely, we want to analyze the selection of the optimal legal standards, comparing per-se rules, where a practice itself may be classified as unlawful, with a discriminating rule, that considers a practice anticompetitive only if its effects reduce welfare. Compared with the previous section, we focus here on *ex-post* intervention.

We argue that the choice of legal standards and the antitrust enforcement against abuse of dominance in investment intensive industries capture two ingredients that have

played a central role in competition policy in the last decade. In recent years the debate on competition policy has explored in depth the role played by economics in improving the analysis of anticompetitive conducts. The discussion has raised issues concerning the substantial arguments as well as the legal standards that should be adopted in cases involving anticompetitive practices. Following the important reforms on cartel cases (article 101) and merger control, in 2009 the DG Competition of the European Commission has reshaped the enforcement of article 82 (now 102) on abuse of dominance, pursuing an approach that rests on a deeper and more intelligent use of the new findings of economic analysis in the enforcement against unilateral practices.[6] The received view from modern Industrial Organization is quite mixed, depending on the specific environments and models. While some economists argue that dominant firms adopt socially harmful practices to maintain their market power, others consider this possibility skeptically, stressing instead the pursuit of superior efficiency as the driving force explaining the emergence of market leaders.[7] Hence, among the Industrial Organization researchers and antitrust practitioners there is no general consensus that certain business practices always produce desirable or negative welfare effects, while a more articulated view based on the specific conditions seems to prevail.

These developments have suggested a change in the view legal standards should be selected in antitrust enforcement. A new approach has emerged, labelled "effect-based" as opposed to the traditional form-based approach.[8] The novelty of these proposals refers to identifying anticompetitive practices through a careful analysis of the foreclosure effects of the conducts, beyond their formal description.

The debate on antitrust enforcement against unilateral practices has overlapped with the handling of several landmark cases of abuse of dominance that involved technological market leaders or incumbents in network industries: the US and EC cases against Microsoft, covering a full range of business practices, from bundling to exclusive dealing; the record fine to Intel for loyalty rebates; the recent cases involving Google and Apple. All those cases have posed new and complex issues where business practices and innovative investments are strictly entrenched. Liberalized public utilities in Europe are another arena where incumbents, with a legacy on the monopolistic network infrastructures, have been prosecuted for abuse of dominance. This has happened for the major telecom companies of many European countries, or for the incumbent operators in the electricity and gas markets.[9]

Although the cases mentioned above were specifically addressing the anticompetitive use of certain business practices, in the debate following the decisions, it has been argued that the impact on the incentives to invest in research should be considered. And, similarly, some commentators pointed out that an excessively severe antitrust policy against the established public utility incumbents could reduce their investment incentives in a phase where new

[6] See Gual et al. (2005) and DG Competition (2005) and (2008).

[7] See Evans and Padilla (2005) for a brilliant summary of the evolution of economic thinking in antitrust from the traditional view to the Chicago critique to the post-Chicago approaches.

[8] We have several, almost equivalent, definitions in both views. The effect based approach is often defined as a discriminating rule, since it is contingent on the effects, and closely reminds the rule of reason adopted in the US on certain practices. The form-based is also called per-se rule, as it considers unlawful a practice per-se, with no consideration of its effects.

[9] See the cases of margin squeeze that have involved in the last decade Deutche Telecom, British Telecom, France Telecom, Telecom Italia and Telefonica, or the German electricity incumbents and the Italian gas incumbent.

important projects should be realized to improve the energy or telecom networks.

How these concerns should be addressed, and what might be the implication for the selection of the appropriate legal standards are still an open issue. In Immordino and Polo (2012) we explore this issue, using a framework similar to the benchmark model we discussed in the previous section. However, we slightly modify the payoff functions in order to allow for an independent positive effect of the new technologies. This effect works together with the one produced by the business practices chosen to develop and commercialize the innovative products. The private profits are therefore given by $\Pi(a) = \Pi + \pi a$, where Π represents the stand alone positive effect of the innovation on profits, while the second term captures the extra profits due to the adoption of the practice a. Social effects as well can be described through a (positive) stand alone effect on welfare, W, and the additional impact of the practice, that may be positive or negative. Therefore, in the good state total welfare if the innovation is successful is $W_g(a) = W + w_g a$, while the socially harmful case corresponds to $W_b(a) = W - w_b a$.

This framework can be applied, for instance, to the design of a new operating system and the related applications, where these latter may be bundled together with the OS. The action a, in this case, may represent the degree of compatibility of the new OS with competitors' applications, a lower compatibility (a higher a) corresponding to larger private benefits for the innovator. Welfare effects of different degrees of compatibility may be negative ($W_b(a)$) if, this way, competitors are foreclosed. But we may also have a case where low compatibility increases welfare ($W_g(a)$), if bundling the OS and applications improves the performance of the software while competitors can still market their on packages using alternative OS or middlewares, with no restriction on their ability to compete.

The framework adopted allows to consider not only the optimal legal standards, but also the interaction of competition and patent policy. The effectiveness of this latter, in our framework, can be captured by the level of private benefits Π appropriated by the innovator, for given social value W: when patent protection is effective Π is close to W, while the innovator hardly receives a return when competitors can easily imitate the new technology and/or the social benefits are transferred to consumers, a case corresponding to a low Π for given W.

Antitrust legal standards, in this setting, differ in the way unlawful practices are defined, in the informational requirements that are needed to implement them, and in the probability of committing judicial errors in their implementation. Per-se rules establish the legality or unlawfulness with reference to the practice itself, no matter how large is the degree a of its implementation, nor the effects that are produced. Per-se legality, in this framework, states that the practice is always legal, and cannot be sanctioned, whereas per-se illegality, that, for instance, considers as unlawful any tying of the OS and apps, gives the enforcer the power to fine the practice at any degree $a > 0$ it is undertaken. Conversely, a discriminating (or effect-based) legal standard considers a practice as unlawful as long as it reduces welfare: compatibility, in this case, can be sanctioned only in case it is a vehicle to foreclosure.

Operationally, per-se rules require to observe only whether the practice is adopted (if $a > 0$), a much simpler task than assessing the social effects (whether $W(a)$ is larger or lower than W), a process where we assume the enforcer may commit errors.[10] Type-I errors,

[10] More precisely, we assume that the enforcer receives an informative but noisy signal σ that interprets as

then, arise when the enforcer mistakenly evaluates the practice as socially damaging while it is welfare enhancing, leading to over-enforcement, whereas type-II errors and under-enforcement occur in the opposite case. We measure how seriously errors affect enforcement by the probability ε^I and ε^{II} of committing type I or type II errors. Then, enforcement tools in a discriminating regime add to the usual fine schedule $f(a)$ the possibility to costly reduce the probability of errors (accuracy) by collecting additional information. To sum up, we model legal standards according to two dimensions: flexibility and accuracy. In this perspective, discriminating rules are more flexible than per-se, adapting enforcement to the effects of the practice, but are more prone to errors, requiring more information to be implemented. In this framework, Immordino and Polo (2012) analyze two issues: first, optimal enforcement policies for per-se and discriminating regimes are characterized; second, the outcomes are compared to select the optimal legal standard.

5.1 Per-se Rules

Per-se rules, by their very nature, do not discriminate the practice according to its effects, and therefore cannot induce a different behavior in the bad or the good state. While the firm, under per-se legality, is never fined, and therefore chooses always action $a = 1$, under per-se illegality the firm will select the action that maximizes the net profits, $\widetilde{a} = \arg\max_a \Pi + \pi a - f(a)$. The expected profits when the investment is chosen are therefore $E\Pi_{PS} = I(\Pi + \pi\widetilde{a} - \underline{f}) - \frac{I^2}{2}$ and the profit maximizing investment is

$$I_{PS} = \Pi + \pi\widetilde{a} - \underline{f}. \tag{1}$$

Finally, expected welfare under per-se illegality is

$$EW_{PS} = I_{PS}\left[W + ((1-\beta)w_g - \beta w_b)\widetilde{a}\right] - \frac{(I_{PS})^2}{2}. \tag{2}$$

We show that when the prior β on social harms is sufficiently low, a per-se legality regime is selected, committing not to intervene in order to boost the innovative investment. For more pessimistic priors, a per-se illegality regime is introduced, giving the enforcer the power to fine the practice. In this case, by appropriately shaping the fine schedule, the enforcer can implement an action $\widehat{a}$, reducing, or even completely deterring, the practice itself. For increasing values of the probability of social harm β, the optimal policy initially still implements the action at the highest level ($\widehat{a} = 1$), as in the per-se legality regime, but reduces the investment through the fine $f(1) > 0$, and then turns to progressively reducing the action $\widehat{a}$ until full deterrence is implemented.

5.2 Discriminating Rule

Turning to the discriminating rule, the enforcer sets the fine schedule conditional on the social effects, and therefore never fines the practice when receiving a good signal, while properly

corresponding to social harm when above a certain threshold x.

implementing through the fine schedule $f(a)$ the action $\widehat{a}_b$ when the signal is bad. Since the signal is noisy, the firm is fined also when the true state is good. The expected profits under the discriminating rule when the investment is chosen are therefore

$$E\Pi_D = I\left\{\Pi + (1-\beta)\left[\pi - \varepsilon^I \overline{f}\right] + \beta\left[\pi\widetilde{a}_b - (1-\varepsilon^{II})\underline{f}\right]\right\} - \frac{I^2}{2}.$$

The optimal investment given the enforcement policy is then:

$$I_D = \Pi + (1-\beta)\left[\pi - \varepsilon^I \overline{f}\right] + \beta\left[\pi\widetilde{a}_b - (1-\varepsilon^{II})\underline{f}\right].$$

We can notice that type-I errors imply over-deterrence, and, indeed, reduce the investment, while type-II errors have an opposite impact through under-deterrence. The enforcer, then, designs the optimal policy using the fine schedule and the level of accuracy to maximize the expected welfare:

$$EW_D = I_D\left[W + (1-\beta)w_g - \beta w_b\widetilde{a}_b - \frac{I_D}{2}\right] - \frac{\gamma}{2}(\overline{\varepsilon} - \varepsilon^I)^2 - \frac{\gamma}{2}(\overline{\varepsilon} - \varepsilon^{II})^2,$$

where the last two terms refer to the cost of reducing type-I and type-II errors by refining accuracy.

The optimal enforcement policy, for increasing values of the probability of social losses β, works as follows: when β is sufficiently low the most profitable action is implemented even in the bad state ($\widehat{a}_b = 1$), setting the fine $\underline{f}$ at the lowest level. Then, as long as the fine $\underline{f}$ may be set to zero, the discriminating rule collapses into a per-se legality regime for low β. In the potential conflict between *ex-ante* deterrence, that suggests to reduce fines to boost investment when the social loss is unlikely, and *ex-post* deterrence, that instead always requires to fine the practice when socially harmful, the former effect prevails. For higher values of the probability of social harm, instead, the enforcer progressively reduces the action $\widehat{a}_b$ in the bad state. In this case, moreover, type-I accuracy is refined, reducing type-I errors and over-deterrence, as a complementary way to sustain the investment while controlling the action $\widehat{a}_b$.

5.3 Optimal legal Standards

These results shed lights also on the optimal legal standards that are selected, according to different values of the likelihood of social harm, β. Per-se legality prevails for low values of β, as a way to boost investment by committing not to intervene *ex-post* when the practice is harmful. Per-se rules are then abandoned, in favor of the discriminating rule, when social harm becomes more likely, balancing *ex-ante* and *ex-post* deterrence.

Moreover, the legal standards and associated enforcement policies are adjusted to the effectiveness of patent policy, that we measure through the stand alone profits of the innovator, Π, for given social welfare W. In Immordino and Polo (2012) we show that per-se legality is preferred to a discriminating rule for

$$\beta \leq \frac{W - \Pi + w_g - \pi - w_b\frac{\Pi+\pi}{\pi}}{w_g + w_b},$$

and the upper bound moves to the right when Π decreases (for given W). Moreover, we show that the implemented action in the bad state under a discriminating rule, $\widehat{a}_b$, increases as well, making the antitrust enforcement less stringent. Both adjustments make the antitrust enforcement laxer, improving the incentives to invest in research whenever the patent policy becomes less effective. Antitrust policy, therefore, acts as a substitute to patent protection in our framework.

When fines are capped, for instance because of limited liability, the optimal enforcement policies are further enriched. Since a higher probability of social harm requires to implement a lower action $\widehat{a}_b$ and to increase the fine for $a > \widehat{a}_b$, for sufficiently high β the limited liability constraint becomes binding. The enforcement policy is modified accordingly, choosing a combination of fines, type-I and type-II accuracy that make enforcement more and more costly. When β becomes very high, then, a more rigid but less costly per-se illegality rule is preferred to save on enforcement costs. Hence, depending on the prior β and the parameters W, Π, w_g, w_b and π (that enter into the expression of the different thresholds), the full range of legal standards is adopted.

The results in Immordino and Polo (2012) then contribute to the debate on the desirable form of antitrust enforcement of unilateral practices by showing that form-based (per-se) rules may be desirable in some cases, while effect-based (discriminating) rules may be desirable in others. In particular, when no investment issue is involved, and the only concern of law enforcement is to control the practice (*ex-post* deterrence), then it is shown that the discriminating rule is dominant, even when β is very low, supporting the view of those that claim in favor of a generalized effect based approach. This result applies to sectors where there is no major issue of research investment interacting with business strategies, as in mature industries where no innovation is expected to replace the current technologies. The desirability of a discriminating over per-se rules emerges also when the enforcement policy is chosen, or can be redesigned, after the investment is sunk (no commitment case).

Flexible, discriminating rules, however, are not always the dominant legal standard when investment matters and the enforcer can commit to a given legal standard. Indeed, when the practice undertaken on the innovative products is unlikely to harm consumers (low β), a more rigid per-se legality rule is preferred. This rule ensures no *ex-post* intervention when social harm arises, and thereby it strengthens the *ex-ante* incentive to invest. In this case, the enforcer faces a time inconsistency problem that can be solved through guidelines or precedents, restoring the ability to commit. However when β is large, a discriminating rule dominates the per-se legality regime, as it preserves the flexibility to implement an enforcement policy when the action is socially harmful. Finally, the discriminating rule displays a second weakness when β is very large, and fines are capped. Then, the only way to control a harmful action is to rely on accuracy.[11] This makes the simpler, but less costly, per-se prohibition a more appealing regime.[12]

[11] We have seen that type-II accuracy can improve deterrence on actions, while the reduction of type-I error may sustain innovative investments. The possibility of refining type-I or type-II accuracy rests on the following argument. A practice may be welfare enhancing (good state) or detrimental (bad state). Each of the two possibilities can be analyzed within an appropriate model, and their empirical predictions suggest a set of observables. As long as the two sets of predictions are, at least in part, distinct, we can obtain identifying restrictions that allow to validate either of the two explanations. See Polo (2010) for an application to selective price cuts.

[12] The role of commitment and flexibility of a legal system in affecting growth has been recently studied by

Finally, Immordino and Polo (2012) show that, with minor changes, the same results occur when the firm has to run a preliminary phase of deterministic investments in physical assets, rather than of uncertain investments in research. In this sense, therefore, the prescriptions on the optimal legal standards apply in our framework to a wide range of (research or physical capital) investment intensive industries, capturing the two classes of technological champions and public utility incumbents that have been at the center of landmark antitrust cases in recent years in Europe.

6 Conclusion

In this Chapter we discuss a research agenda where the agents first have to invest resources in learning – what we call research – and then, if successful, they are able to choose a new action that *ex post* may be welfare enhancing or reducing. Public policies, determining the instances when the firm is subject to a restrictive policy treatment, affect both the *ex-post* profits from the new actions and the *ex-ante* incentives to invest in research. The optimal policy comes out of the interplay between the *ex-ante* effect on investment and the *ex-post* effect on actions, and depends on the priors of the enforcer on the likelihood and magnitude of the positive and negative private and social effects of the new practices.

We compare several policy options: in the first part of the paper, we analyze the choice between *ex-ante* authorization and *ex-post* liability of innovative products, as genetically modified seeds, or new drugs. In the second part of the paper, different legal standards (per-se vs. discriminating rules) are compared in the enforcement of antitrust intervention against abuse of dominance in investment intensive industries.

When the social effects of the new practices are likely to be positive, in both cases the optimal policy prescribes not to intervene, as a way to commit no to penalize the new practices *ex-post* when socially harmful: this result is driven by the goal to sustain the innovative investment. When expectations are more mixed, liability, or a discriminating rule, are selected in the two environments. Finally, for pessimistic expectations, authorization, or per-se illegality are selected.

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