Lost Profits and Unjust Enrichment damages for the misappropriation of trade secrets

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Abstract

This paper analyses civil remedies for the misappropriation of trade secrets. We study the impact of different damages doctrines on the firms' competitive behavior and on the incentives to misappropriate. We find that the owner of the trade secret is better off under the Lost Profits regime, while the rival (independently of whether he has obtained the technology by misappropriation or by independent development) is better off under the Unjust Enrichment regime. Unjust Enrichment provides less incentives to misappropriate and yields a smaller market deadweight loss. The choice between the two rules essentially depends on the lawmaker's goal.

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1 Introduction

In February 2020, a jury for the U.S. District Court for the Northern District of Illinois awarded Motorola $764.6 million after determining that Hytera, a Chinese electronics manufacturer, had used Motorola's trade secrets in its products. Motorola had sued Hytera claiming that the three engineers Hytera had hired away from its Malaysian office had stolen and brought with them thousands of confidential documents, and that Hytera had used those documents, which contained trade secrets and lines of source code, to develop a state-of-the-art digital radio that was functionally indistinguishable from its owns. Hytera had in turn sold those radios all around the world, including in the United States. The damages awarded, among the highest ever awarded for this type of claim, included $345.8 million of compensatory damages and $418.8 million of exemplary damages. Compensatory damages were calculated so as to disgorge all of Hytera's profits from the accused products from 2010 to 2019. While Hytera did not dispute that some proprietary information had been (illegally) transferred by the three engineers, it complained that Motorola had waited years after knowing about the theft to file a suit in order to profit from Hytera's business.[1]

This verdict is remarkable for two aspects. First, it highlights the sizeable dimension reached by trade secrets litigation. Damages awarded for trade secrets misappropriation have increased following the enactment of the *Defend Trade Secrets Act* of 2016 (DTSA), which has introduced a federal civil cause of action. As it was clarified in the *Motorola* decision, the DTSA also allows for the recovery of extra-territorial damages (in the

[1] In year 2010 Motorola had started to suspect the leak. In 2017 Hytera was sued.

Motorola case, they were calculated on the basis of the world turnover of the defendant). Second, the case illustrates the potential *strategic implications* of misappropriation remedies. Motorola and Hytera have been interacting in the same market for a decade, with Motorola hoping that litigation would bring back some of its lost business and Hytera knowing that a suit was impending, and that a potentially large share of its profits would be paid out in damages compensation.

This paper investigates the strategic implications of trade secrets litigation. How does the prospect of recovering damages from an unfair competitor affect the market behavior of the misappropriation victim? How aggressive will the competitor be in the face of liability that might end up disgorging its entire profits?

While these questions have general bearing on intellectual property litigation, our focus will be on trade secrets misappropriation. Trade secrets are of special interest for two reasons. First, damages for trade secrets misappropriation can be calculated according to both the Lost Profits and the Unjust Enrichment doctrines, that we intend to compare.[2] Second, trade secrets law leaves open the possibility for the rival to employ the same technology of the original owner if he develops it by proper means. So, one of the goals that damages awards can achieve is to deter the rival from employing unlawful means and instead pressure him to use lawful ones. This cannot occur under patent law, because patent infringement is, essentially, a strict liability offence.[3]

To investigate the implications of damages awards on the firms' conducts, we develop a simple model of Cournot competition between an incumbent (the original owner

[2]Since *Aro Manufacturing Co. v. Convertible Top Replacement Co.*, 365 U.S. 336 (1961), damages for utility patent infringement are calculated uniquely on the basis of the Lost Profits and the Reasonable Royalty doctrines. The Unjust Enrichment doctrine finds some application with respect to design patents. See Cotter (2013).

[3]Differently from trade secrets, patents provide an *exclusive* right: no third party can practice the patented technology without a licence, regardless of how the third party gets to the technology. While trade secrets law encourages rivals to engage in "fair competition," patent law encourages rivals to develop different ("non-equivalent") products and processes. See the literature review below.

of the technology) and a rival. Depending on the cost of developing the technology independently, which is private information, the rival will acquire the technology either by proper or improper means. When competition takes place in the market, the incumbent does not know whether she is facing an "honest" or a "dishonest" rival. If the rival is "dishonest," she will be able to recover damages at the litigation stage, and damages will be determined in accordance with either the Lost Profits or the Unjust Enrichment doctrines (explained below). The model allows us to make predictions about the rival's conduct (misappropriate or develop independently) and the firms' strategic behavior in the market. On the basis of these predictions, we will be able to draw policy evaluations.

Trade secrets law. Before discussing damages, it is useful to recapitulate the basic principles of trade secrets law. Most US states have adopted the *Uniform Trade Secrets Act* of 1985 (UTSA) which defines trade secrets as: "information, including a formula, pattern, compilation, program, device, method, technique, or process, that: (i) derives independent economic value, actual or potential, from not being generally known [...], and (ii) is the subject of efforts that are reasonable under the circumstances to maintain its secrecy" (UTSA § 1.4).[4]

In view of this definition, it is clear that the latitude of trade secrets protection is extremely broad, extending far beyond the province of the patentable inventions.

Proprietary information is misappropriated if it is obtained by "improper means," which include "theft, bribery, misrepresentation, breach or inducement of a breach of a duty to maintain secrecy, or espionage through electronic or other means" (UTSA §1.4). Proper means of acquisition, instead, include: discovery by independent invention, discovery by reverse engineering, discovery under a license from the owner of the trade secret, observation of the item in public use or on public display, obtaining the trade secret from published literature (UTSA § 1(1) *cmt.*).[5]

[4] A similiar definition appears in the TRIPs (art. 39) and in most legal systems throughout the world (see Lippoldt and Schultz (2014)). In the US, of special relevance is also the *Restatement (third) of Unfair Competition* (1995), Ch. 4.

[5] Note that the way in which the line between "proper" and "improper" means is drawn is itself

Victims of misappropriation can seek damages and injunctive relief.[6] Injunctive relief, as in the case of patent infringement, can only be obtained under specific circumstances, bearing on the irreparability of the harm that continuing operations would entail.[7]

In turn, pecuniary damages for trade secrets misappropriation can be calculated using (at least) three different methods.[8]

1. *The Lost Profits* (LP) regime: Under this regime, damages are measured by the actual loss suffered by the victim. Typically, the victim claims the losses due to the sales reduction and the price erosion caused by the unfair competitor. This remedy is in line with standard compensatory damages, aiming at making the victim "whole," i.e., at restoring her to the position that she occupied before the tort.

2. *The Unjust Enrichment* (UE) regime: Damages fully disgorge the unfair gain (an "account of profits") made by the defendant. This remedy is in line with restitutory damages in tort and contract law, where the wrongdoer is compelled to give up the benefit obtained through the perpetration of the wrong, independently of any loss suffered by the victim.[9]

3. *Reasonable royalty* (RR) regime: It awards to the plaintiff "the price that would be set by a willing buyer and a willing seller for the use of the trade secret made by

an important policy decision (see Friedman et al. (1991)). In Franzoni and Kaushik (2016), we study the optimal scope of trade secrets protection in a game in which the probability of knowledge leakage depends on the efforts of both innovator and rival.

[6] The statute of limitations for misappropriation claims ranges from three to six years, depending on the jurisdiction (with three years for the DTSA and five years for Illinois, relevant for the Hytera case). See Digital Media Law Project (2022).

[7] *eBay, Inc. v. MercExchange LLC, 547 U.S. 388* (2006). See Menell et al. (2020), Ch. 2., for a broader picture.

[8] The same applies in Canada, China, Germany, Japan, and India. See Blair and Cotter (2005), Lippoldt and Schultz (2014), Këllezi et al. (2017), and EUIPO (2018).

[9] In general, restitution follows a double rationale: i) *deterrence,* as it deprives wrongdoers of the gain from their illegal conduct, and ii) *autonomy*, as it encourages parties to make contracts when they can, rather than imposing costs and benefits on each other and then calling for judicial valuation of them afterward. See Dari-Mattiacci (2009) and Farnsworth (2014) for a general perspective.

the defendant".[10] In other words, courts try and calculate the royalty fee that the parties themselves would have agreed to, if they had entered into a negotiation before the misappropriation took place.

In most American states (but not in New York, and certainly not in Europe), the plaintiff can also recover *Exemplary Damages* if the defendant has engaged in "wilful and malicious" misappropriation. Exemplary damages cannot generally exceed two times regular damages.

Finally, it should be noted that, in most countries, trade secrets misappropriation gives rise to criminal liability. Under the *US Economic Espionage Act* of 1996, amended by the *DTSA*, unauthorized appropriation of trade secrets is a federal crime.

From the review of a sample of federal and state civil court cases from 1950 to 2015 involving trade secrets misappropriation, Elmore (2016) has found that LP represented the most common damages regime in both federal and state cases. For federal cases, the distribution was: 53% LP, 13% UE, 18% RR, with the rest (18%) undetermined. For the state cases, the distribution was 68% LP, 28% UE, 5% RR, with the rest (18%) undetermined. The mean award (in 2015 dollars) was about $3 million for federal cases and $13 million for state cases. For both types of cases, there is a large variability in the figures. UE yielded the largest average award. LP's average award was about $4 million at federal level and $467,000 at state level. UE's average was $1.2 million at federal level and $ 44 million at state level. Finally, RR had $2.6 million at federal level and $100,000 at state level. Exemplary Damages were awarded in about a third of the cases.

In most jurisdictions, plaintiffs can chose the type of damages they intend to claim. Plaintiffs often rely on UE because, under this doctrine, damages flow directly from the violator's accounts. The victim of misappropriation can thus avoid to disclose information about her own business. For the calculation of damages based on LP,

[10] *Restatement 3*$^{\text{d}}$ *Unfair Competition*, § 45, *cmt. g.*

plaintiffs normally employ the tools developed for patent infringement cases (based on lost market shares, price erosion, incremental income, convoyed sales, etc.). The quantification of the damages, here, is more demanding (in terms of evidence), because it is based on the counter-factual reconstruction of what would have happened if the violator had not misappropriated the secret.[11] This is one of the reasons why plaintiffs often prefer to rely on UE. Clearly, another factor that can push plaintiffs towards one method or the other has to do with the size of the resulting damages. If the misappropriator can rely on substantially better manufacturing and retailing facilities, UE is likely to provide greater damages.

In what follows, we will analyze the competitive implications of LP and UE in isolation, assuming that only one of the two methods is available to the plaintiff. This will allow us to compare the two doctrines from a policy perspective and to understand the welfare implications of policy moves that make one of the two methods relatively more appealing (at the litigation stage).

2 Overview of the results

Non-strategic analysis. Let us consider this basic setup. An incumbent firm is set to earn monopoly profits π_m thanks to her superior technology. A rival firm is interested in entering the same market. He can obtain the proprietary technology either through a licensing agreement or through misappropriation. If he enters the market, he will earn duopoly profit π_d^2, while the incumbent's profit becomes π_d^1. This situation gives rise to two basic scenarios.

In the first scenario, the rival in not bringing in superior manufacturing and retailing facilities. Essentially, the rival is just as efficient, or slightly more efficient, than the incumbent. The joint profits earned by the two firms do not exceed the monopoly profits

[11] For the complexities of the quantifications, see, for instance, Almeling et al. (2018) and Seaman et al. (2019).

previously earned by the incumbent: $\pi_d^1 + \pi_d^2 < \pi_m$. This is a situation in which the incumbent is not interested in licensing the technology to the rival. The rival, however, can misappropriate it and enter the market. Damages serve a deterrent function. Under LP, damages are equal to $D^{LP} = \pi_m - \pi_d^1$. If the rival misappropriates and is found liable, the payoff of the incumbent is $\Pi_1^{LP} = \pi_d^1 + D^{LP} = \pi_m$. The incumbent obtains the same payoff that she would get by means of an injunction. The payoff of the rival, assuming that there is no solvency constraint, is $\Pi_2^{LP} = \pi_d^2 - \pi_m + \pi_d^1 < 0$: the rival suffers a loss. Under UE, damages are $D^{UE} = \pi_d^2$, with $D^{UE} < D^{LP}$. The payoff of the incumbent upon misappropriation is now $\Pi_1^{UE} = \pi_d^1 + \pi_d^2 < \pi_m$. The payoff of the rival is $\Pi_2^{UE} = 0$. In this scenario, the incumbent is better off under LP, the rival under UE. Both damages regimes are able to deter misappropriation, with LP providing a greater sanction for the wrongdoer.

In the second scenario, the rival is substantially more efficient than the incumbent. The profits that he is able to make from the market summed to the profits left to the incumbent exceed the monopoly profits previously earned by the incumbent: $\pi_d^1 + \pi_d^2 > \pi_m$. This is a situation in which it is in the interest of the incumbent to license the technology to the rival. Damages define here the "outside options" for the licensing agreement: if negotiations break down and the rival misappropriates the technology, damages will be paid. Under LP, the payoff of the incumbent is again $\Pi_1^{LP} = \pi_d^1 + D^{LP} = \pi_m$. The rival gets: $\Pi_2^{LP} = \pi_d^2 - D^{LP} = \pi_d^1 + \pi_d^2 - \pi_m > 0$. The rival appropriates the full surplus from the (illegal) technology transfer. When negotiating the (legal) technology transfer, the rival can threaten the incumbent with misappropriation. The incumbent is in a weak bargaining position, and the licensing fee will be small.

Under UE, we have again $D^{UE} = \pi_d^2$, with $D^{UE} > D^{LP}$. The incumbent now appropriates the surplus from the illegal transfer: $\Pi_1^{UE} = \pi_d^1 + D^{UE} = \pi_d^1 + \pi_d^2 > \pi_m$, while the rival gets nothing: $\Pi_2^{LP} = \pi_d^2 - D^{LP} = 0$. Under UE, misappropriation is not a credible threat. The licensing fee will be high.[12]

[12]The "reasonable royalty" calculated on the basis of the license fee that parties would have agreed

In this scenario, damages determine the bargaining power of the parties at the licensing stage. The function of the damages award is not to exert deterrence, but rather to determine how the negotiation surplus is divided between the parties. As we intend to study the impact of damages on deterrence and market equilibrium, this is not the scenario that we focus on.[13]

The non-strategic analysis takes π_d^1 and π_d^2 as given. In reality, parties have an incentive to alter their market behavior to either reduce or increase the damages award. The rival might also decide to develop the technology by legal means, to avoid paying damages.

Strategic analysis. In the model developed below, we will assume that firms compete in quantities à la Cournot. Incumbent and rival are equally efficient in manufacturing (this rules out scenario two above). The rival can decide whether to develop the relevant technology independently, at a cost, or ferret it out from the incumbent, for free. The cost of independent development can only be observed by the rival. When the incumbent observes the entry of a rival, she will formulate a belief that the rival is either an honest firm (that has developed the technology independently) or a dishonest firm (that has misappropriated). The truth can only be known by means of a trial, at the end of which the dishonest rival will be held liable for damages. We will assume that with a small probability the dishonest firm will escape liability. This small probability is necessary to provide the rival with incentives to pursue a rational strategy in the market game (if profits were disgorged with a 100% probability, any strategy would do).

Under *LP*, the dishonest firm knows that any loss inflicted to the incumbent will show up in the damages bill. He will therefore have an incentive to engage in a non-aggressive stance. The honest rival will be aggressive as usual (under Cournot). In

upon is also affected by the level of the damages (if damages are higher, the reasonable royalty is also higher).

[13] We will, however, come back to this case in the Extensions.

the market equilibrium, the incumbent and the honest rival will produce the regular Cournot quantities, while the dishonest rival will produce a lower quantity. Thus, if the rival decides to be dishonest, total market quantity is smaller and the market price higher. Damages fully disgorge the rival's profits.

Under UE, the incumbent has a stake in the profits of the dishonest rival. Thus, she will be non-aggressive if she thinks that she is facing a misappropriator. Both the honest and the dishonest rivals will be aggressive as usual. In the market equilibrium, the incumbent will produce a small quantity, while the dishonest and the honest rival, in response, will produce relatively large quantities. The total market quantity will be smaller than under traditional Cournot, but larger than under LP. Also in this case, damages will fully disgorge the dishonest rival's profits.

Under both LP and UE, misappropriation provides the rival with a payoff equal (or close to) zero. The payoff to be netted from independent discovery, instead, differs across regimes and is higher under UE, where the honest firm obtains a larger market share. This implies that, under UE, the rival firm has greater incentives to duplicate the technology by legal means.

Policy analysis. Our model provides some guidance for the choice between damages regimes. Here, several factors come into play.

If the goal of the policymaker is to provide the owner of the secret knowledge with a large payoff, as a reward for her innovative activity, the best damages regime is LP. Under this regime, the incumbent earns the largest market profits (since the dishonest rival is non-aggressive). Even if actual damages are less than under UE, the total payoff of the incumbent remains higher.

If the goal of the policymaker is to channel competition in the right direction, by disincentivizing the use of "improper means," then UE is the right regime. Under UE, the rival gets a higher reward from independent development and, consequently, misappropriates less.

If the goal of the policymaker is to balance the cost of restricted competition with the need to provide incentives to innovate, then the best regime is probably UE, since it yields the lowest deadweight loss per unit of (innovator's) profit.[14] Under UE, the prospect of a damages award has a limited distortionary effect on competition, since the rival produces a high quantity independently of whether he is honest or dishonest.

Finally, one should note that if damages were not anchored to the incumbent or the rivals' market sales, they would exert no distortionary effects on competition.[15] Damages that partially approximate this ideal regime are those based on "the value that a reasonably prudent investor would have paid for the trade secret" (investment value) or on "the development costs the defendant avoided incurring through misappropriation."[16] The determination of damages in this way, however, is likely to be quite challenging, as development costs tend to be technology-specific.

Literature. As far as we know, this paper represents the first attempt to analyze the impact of liability for trade secrets misappropriation on the firms' market behavior.

A rich economic literature, started by Schankerman and Scotchmer (2001), has focussed on the impact of damages for patent infringement on competition and entry. This literature has focussed on the cases in which the rival provides a product different from that of the original inventor, either because it represents an improvement (see, among others, Anton and Yao (2007), Hylton and Zhang (2017), and Chen and Sappington (2018)) or because if offers a different variety (Henry and Turner (2010)).[17] In

[14] The idea of using the deadweight loss to innovator's profit ratio for the evaluation of conducts that impinge on both innovation and competition is due to Kaplow (1984). It shares the same rationale as the cost-effectiveness analysis employed for the evaluation of public projects.

[15] Damages (for patent infringement) independent of firms' competitive choices have been advocated also by Friedman and Wickelgren (2019).

[16] *Bohnsack v. Varco, L.P.*, 668 F.3d 262, 280 (5th Cir. 2012). In *Ajaxo Inc. v. E*Trade Fin. Corp.*, 187 Cal.App.4th 1295, 1305 (2010), the court stated: "Where the plaintiff's loss does not correlate directly with the misappropriator's benefit . . . [a] defendant's unjust enrichment might be calculated based upon cost savings or increased productivity resulting from use of the secret." The court adds, however, that "[t]here is no standard formula to measure it."

[17] Dey et al. (2020) studies the impact of damages for patent infringement on optimal tariffs. They

these cases, damages should strike a balance between the need to incentivize the original invention (without which the follow-on would not exist) and the need to provide consumers with a version of the product that better fits their wishes. Because of this, the choice of the damages award is often intertwined with the issue of the optimal *breadth* of the patent, that is, on how different the rival's innovation should be from the original in order not to infringe (Friedman and Wickelgren (2019)). Though no clear-cut ranking of the two rules emerges, the arguments developed by Chen and Sappington (2018) suggest that LP best suits those situations in which consumers attach a greater value to the original product, while UE best suits situations in which consumers attach a greater value to the follow-on product.

Of special interest, for us, is the work of Choi (2009), who studies the case in which the rival competes à la Cournot with an inventor who holds a "probabilistic patent," that is, a patent that might turn out to be invalid.[18] He finds that, if the patent holder and the infringer face the same marginal costs (as we assume), the patent holder obtains the largest payoff under LP, while the infringer obtains the largest payoff under UE. In terms of market outcomes, the two rules prove to be fully symmetric: under LP the infringer is non-aggressive, under UE the patent holder is non-aggressive. The two rules, therefore, end up providing the same level of market welfare.

Our model retains the spirit of Choi (2009), with the important difference that we focus on trade secrets misappropriation. We study the choice of a rival that has the opportunity to compete either in a lawful or in an unlawful way (as explained above, this is not possible when the innovation is protected by a patent). The possibility that the rival develops the technology by proper means breaks the market symmetry between the regimes. Under LP, the dishonest rival is non-aggressive because he knows that he will be liable for damages. Under UE, the incumbent is somewhat non-aggressive be-

find that LP invites import tariffs, while UE invites import subsidies. Chopard et al. (2014) analyzes the case in which the innovation allows the rival to reduce its production costs.

[18] In practice, the prospect that the patent is declared invalid provides strong incentives to the parties to settle out of court. These incentives are missing in trade secrets litigation.

cause she believes that the incumbent *might* be dishonest, and thus liable for damages. Because of this asymmetry, the UE regime ends up providing higher market welfare and a greater reward to honesty.

3 The Model

In order to enter a market occupied by an incumbent, a competitor has two options: he can either develop the technology independently or ferret it out illegally from the incumbent. Independent development entails a cost, while misappropriation entails the risk of litigation and payment of damages. The calculation of damages is based either on the lost profit (LP) or the unjust enrichment (UE) doctrines.

The cost of independent development has cumulative probability distribution $G(c)$. The actual cost is known only to the rival. If the cost happens to be low, the rival will develop independently, otherwise he will opt for cost-free misappropriation.

When the incumbent observes the entry of a new firm, she formulates a (consistent) belief about the nature of the rival: with probability θ the rival has misappropriated (is "dishonest"), with probability $1-\theta$ the rival has developed independently (is "honest"). The incumbent and the rival engage in quantity competition (à la Cournot) in the market, knowing that - if the technology has been misappropriated - the dishonest rival is liable for damages. In order to provide the rival with some incentives to engage in misappropriation, we assume that adjudication is imperfect: a dishonest rival will have to pay damages with probability $\alpha \leq 1$. Our focus will be on the case in which α is close to 1.

The market inverse demand is assumed to be linear: $p = 1 - Q$, where Q is the market quantity.[19] The incumbent will be labeled "firm 1," the dishonest rival "firm 2d", and the honest rival "firm 2h". So, market quantity will be $q_1 + q_{2d}$ with probability θ, and $q_1 + q_{2h}$ with probability $1 - \theta$. The marginal cost of production is assumed to

[19] Our results apply to generic linear demand functions with shape $p = a - bQ$.

be zero for all firms.[20]

Firms decide their quantities simultaneously. Market profits of the incumbent are denoted $\pi_1(q_1, q_{2d})$ when it competes with the dishonest rival, and $\pi_1(q_1, q_{2h})$ when it competes with the honest rival. Market profits of the dishonest rival are $\pi_{2d}(q_1, q_{2d})$, while the market profits of the honest rival are $\pi_{2h}(q_1, q_{2h})$. Finally, monopoly profits, used in the calculation of LP damages, are equal to $\pi_m = \left(\frac{1}{2}\right)^2$.

As usual, we proceed by analyzing the last stages of the game first.

3.1 The Lost Profits Regime

Under the LP regime, damages are calculated on the basis of the actual loss for the incumbent:

$$D^{LP} = \pi_m - \pi_1(q_1, q_{2d}).$$

When the incumbent decides her market strategy, she does not know whether she is facing a dishonest rival, from which she will recover damages with probability α, or an honest rival, from which she cannot recover.

The expected payoff of the incumbent is:

$$\begin{aligned}\Pi_1^{LP} &= \theta\left[\pi_1(q_1, q_{2d}) + \alpha D^{LP}\right] + (1-\theta)\pi_1(q_1, q_{2h}) \\ &= \theta q_1(1 - q_1 - q_{2d}) + (1-\theta)q_1(1 - q_1 - q_{2h}) + \theta\alpha\left(\frac{1}{4} - q_1(1 - q_1 - q_{2d})\right) = \\ &= q_1(1 - q_1 - \theta q_{2d} - (1-\theta)q_{2h}) + \theta\alpha\left(\frac{1}{4} - q_1(1 - q_1 - q_{2d})\right). \qquad (1)\end{aligned}$$

With probability θ the incumbent is facing a dishonest rival that will play q_{2d} and that will be liable for damages with probability α.[21] With probability $1-\theta$ she is facing

[20] Since firms are equally efficient, under all circumstances joint duopoly profits cannot exceed monopoly profits. This implies that, if the incumbent were free to choose the damages regime at the litigation stage, he would opt for LP. In the analysis, we assume that the damages regime is fixed in advance and that it cannot be changed.

[21] If Exemplary damages are considered, then damages might increase up to 3 times D^{LP}. So, α

an honest rival that will play q_{2h}. Clearly, damages increase if the incumbent makes a smaller profit.

The optimal quantity for the incumbent should meet

$$\frac{\partial \Pi_1^{LP}}{\partial q_1} = 1 - 2q_1 - \theta q_{2d} - (1-\theta)\, q_{2h} - \theta\alpha\,(1 - 2q_1 - q_{2d}) = 0,$$

and thus

$$q_1 = \frac{1 - \alpha\theta - q_{2d}\,(1-\alpha)\,\theta - (1-\theta)\, q_{2h}}{2\,(1-\theta\alpha)}.$$

Note how the prospect of compensatory damages affects the incumbent's behavior. Against a rival that is dishonest for sure ($\theta \to 1$) or honest for sure ($\theta \to 0$), the incumbent plays the Cournot best reply. When the rival can be either honest or dishonest, the incumbent focusses her reply mostly on the choice of the honest rival, for a share of the profits she loses to the dishonest one, she gets back at the litigation stage.

Let us consider the dishonest rival. We have

$$\begin{aligned} \Pi_{2d} &= \pi_{2d}(q_1, q_{2d}) - \alpha(\pi_m - \pi_1(q_1, q_{2d})) \\ &= q_{2d}\,(1 - q_1 - q_{2d}) - \alpha\left(\frac{1}{4} - q_1\,(1 - q_1 - q_{2d})\right), \end{aligned} \tag{2}$$

from which we obtain the optimal quantity:

$$\begin{aligned} (1 - q_1 - 2q_{2d}) - \alpha q_1 = 0, \text{ or} \\ q_{2d} = \frac{1 - q_1\,(1+\alpha)}{2}. \end{aligned}$$

Note that the optimal quantity of the dishonest rival is reduced by the prospect of the damages award: if she produces a large quantity, the resulting reduction in price harms her twice: her own products are sold with a lower margin and, due to price erosion, damages increase. For $\alpha \to 1$, the dishonest rival ends up maximizing joint profits: she

would have to be multiplied by k, with $k \in [1, 3]$.

sets $q_2 = \frac{1}{2} - q_1$ and the market price converges to monopoly price.

Let us consider the honest rival. We have

$$\Pi_{2h} = q_{2h}\left(1 - q_1 - q_{2h}\right), \tag{3}$$

and thus:

$$q_{2h} = \frac{1 - q_1}{2},$$

as in a standard Cournot game.

By combining the three best reply functions, we get:

$$q_1^{LP} = \frac{1 - \theta\alpha}{3 - \alpha\theta\left(4 - \alpha\right)},\ q_{2d}^{LP} = \frac{2 - \alpha - \theta\alpha(3 - 2\alpha)}{6 - 2\theta\alpha(4 - \alpha)},\ q_{2h}^{LP} = \frac{2 - \theta\alpha(3 - \alpha)}{6 - 2\theta\alpha(4 - \alpha)}, \tag{4}$$

with

$$q_1^{LP} \geq q_{2h}^{LP} \geq q_{2d}^{LP},$$

and

$$\pi_1^{LP} \geq \pi_{2h}^{LP} \geq \pi_{2d}^{LP} \geq 0.$$

As θ increases, the probability that the incumbent is facing a non-aggressive dishonest rival increases and q_1^{LP} increases. As a consequence, both q_{2d}^{LP} and q_{2h}^{LP} decrease.

The payoffs of the parties are

$$\begin{aligned}
\Pi_1^{LP} &= \frac{4 - 3\theta\alpha - 6\theta^2\alpha^2(2 - \alpha) + \theta^3\alpha^3(12 - 8\alpha + \alpha^2)}{4(3 - \theta\alpha(4 - \alpha))^2}, \\
\Pi_{2d}^{LP} &= \frac{(1 - \alpha)(4 - (1 + 12\theta)\alpha + 3\theta(2 + 3\theta)\alpha^2 - 7\theta^2\alpha^3 + \alpha^2\theta^2)}{4(3 - \theta\alpha(4 - \alpha))^2}, \\
\Pi_{2h}^{LP} &= \frac{(2 - \theta\alpha(3 - \alpha))^2}{4(3 - \theta\alpha(4 - \alpha))^2},
\end{aligned}$$

with

$$\Pi_1^{LP} \geq \Pi_{2h}^{LP} \geq \Pi_{2d}^{LP} \geq 0. \tag{5}$$

With perfect adjudication ($\alpha \to 1$), we get:

$$q_1^{LP} = q_{2h}^{LP} = \frac{1}{3}, \quad \text{and} \quad q_{2d}^{LP} = \frac{1}{6}.$$

The incumbent and the honest rival produce standard Cournot quantities, while the dishonest rival produces a quantity small enough to yield a monopolistic market price. The market price will thus be equal to $\frac{1}{2}$ with probability θ, and $\frac{1}{3}$ with probability $(1-\theta)$. Figure 1 illustrates.

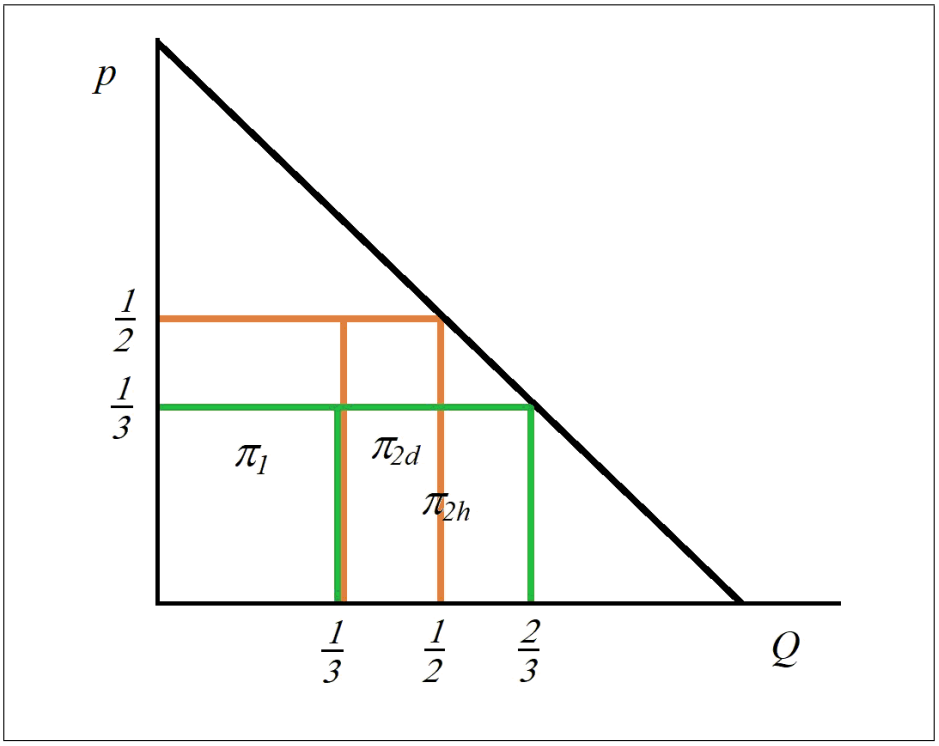

Fig. 1. The price is $\frac{1}{2}$ if the rival is dishonest, and $\frac{1}{3}$ if the rival is honest.

The damages awarded are

$$D_{\alpha=1}^{LP} = (q_m - q_1)\, p_m = \left(\frac{1}{2} - \frac{1}{3}\right) \frac{1}{2} = \frac{1}{12}. \tag{6}$$

The rival is liable for the diverted sales, but not for price erosion.

The payoffs of the players are:

$$\Pi_1^{LP} = \frac{1}{9} + \frac{5}{36}\theta, \qquad \Pi_{2d}^{LP} = 0, \quad \text{and} \qquad \Pi_{2h}^{LP} = \frac{1}{9}.$$

Under perfect adjudication, the profits of the incumbent increase with the probability of misappropriation θ. The incumbent is better off without rivals. But if she has to have a rival, better to have a non-aggressive one, liable for damages.

3.2 The Unjust Enrichment Regime

Under the UE regime, the incumbent can recover the profits made by the dishonest rival.[22] Thus,

$$D^{UE} = \pi_{2d}\left(q_1, q_{2d}\right).$$

The expected payoff of the incumbent is:

$$\begin{aligned}
\Pi_1^{UE} &= \theta\left[\pi_1(q_1, q_{2d}) + \alpha D^{UE}\right] + (1-\theta)\pi_1(q_1, q_{2h}) \\
&= \theta\pi_1(q_1, q_{2d}) + (1-\theta)\pi_1(q_1, q_{2h}) + \theta\alpha\pi_{2d}\left(q_1, q_{2d}\right) \\
&= q_1\left(1 - q_1 - \theta q_{2d} - (1-\theta)\, q_{2h}\right) + \theta\alpha q_{2d}\left(1 - q_1 - q_{2d}\right). \qquad (7)
\end{aligned}$$

The optimal quantity of the incumbent should meet:

$$\frac{\partial \Pi_1^{UE}}{\partial q_1} = 1 - 2q_1 - \theta q_{2d} - (1-\theta)\, q_{2h} - \theta\alpha q_{2d} = 0,$$

and thus

$$q_1 = \frac{1 - q_{2d}\theta\left(1+\alpha\right) - (1-\theta)\, q_{2h}}{2}.$$

The incumbent is highly concerned about a reduction in the market price, because this affects both her own revenue and the revenue of her rival, which she can appropriate

[22] In an alternative interpretation of the model, UE represents the case in which recoverable damages are constrained by the level of the rival's profits.

through the damages award. So, it is the incumbent now who pursues a non-aggressive strategy.

The expected payoff of the dishonest firm is:

$$\Pi_{2d}^{UE} = (1-\alpha)\pi_2(q_1, q_{2d}) = (1-\alpha)\, q_2\, (1 - q_1 - q_{2d})\,. \tag{8}$$

The dishonest rival can only hope to escape judgement. His payoff is just $(1-\alpha)$ of standard duopoly profits. The optimal quantity is therefore

$$q_{2d} = \frac{1-q_1}{2},$$

as in a standard Cournot game.

The payoff of the honest rival is

$$\Pi_{2h}^{UE} = \pi_2(q_1, q_{2h}) = q_{2h}\,(1 - q_1 - q_{2h})\,, \tag{9}$$

which yields again the standard Cournot best reply:

$$q_{2h} = \frac{1-q_1}{2}.$$

By combining the best replies, we get:

$$q_1^{UE} = \frac{1-\theta\alpha}{3-\theta\alpha},\ q_{2d}^{UE} = \frac{1}{3-\theta\alpha},\ q_{2h}^{UE} = \frac{1}{3-\theta\alpha}, \tag{10}$$

with

$$q_{2d}^{UE} = q_{2h}^{UE} \geq q_1^{UE},$$

and

$$\pi_{2d}^{UE} = \pi_{2h}^{UE} \geq \pi_1^{UE}.$$

Under UE, the incumbent plays a non-aggressive market strategy against a dishonest rival. As the probability of misappropriation increases, the optimal quantity of the

incumbent decreases. In turn, the quantity produced by the rival, honest and dishonest, increases.

Due to her reliance on damages, the incumbent earns the lowest market profits among the three firms. This outcome is in sharp contrast to the LP regime, in which the incumbent earns the largest market profits.

The firms' payoffs are

$$\Pi_1^{UE} = \frac{1}{(3-\theta\alpha)^2},\ \Pi_{2d} = \frac{1-\alpha}{(3-\theta\alpha)^2},\ \Pi_{2h} = \frac{1}{(3-\theta\alpha)^2},$$

with

$$\Pi_1^{UE} = \Pi_{2h}^{UE} \geq \Pi_{2d}^{UE}.$$

Again, the dishonest rival obtains the lowest payoff, since he has to disgorge his profits.

Note that the payoffs of the dishonest and the honest rivals both increase with θ : as the incumbent takes a less aggressive stance, both rivals earn larger profits.

With perfect adjudication ($\alpha \to 1$), we get:

$$q_1^{UE} = \frac{1-\theta}{3-\theta}, \quad \text{and} \quad q_{2d}^{UE} = q_{2h}^{UE} = \frac{1}{3-\theta}.$$

The dishonest and the honest rival produce quantities larger than the Cournot quantity, while the incumbent produces a quantity lower than the Cournot quantity. If the incumbent were sure to face a dishonest rival, she would produce a zero quantity and she would just extract the rival's monopolistic profits in the form of damages. Figure 2 illustrates.

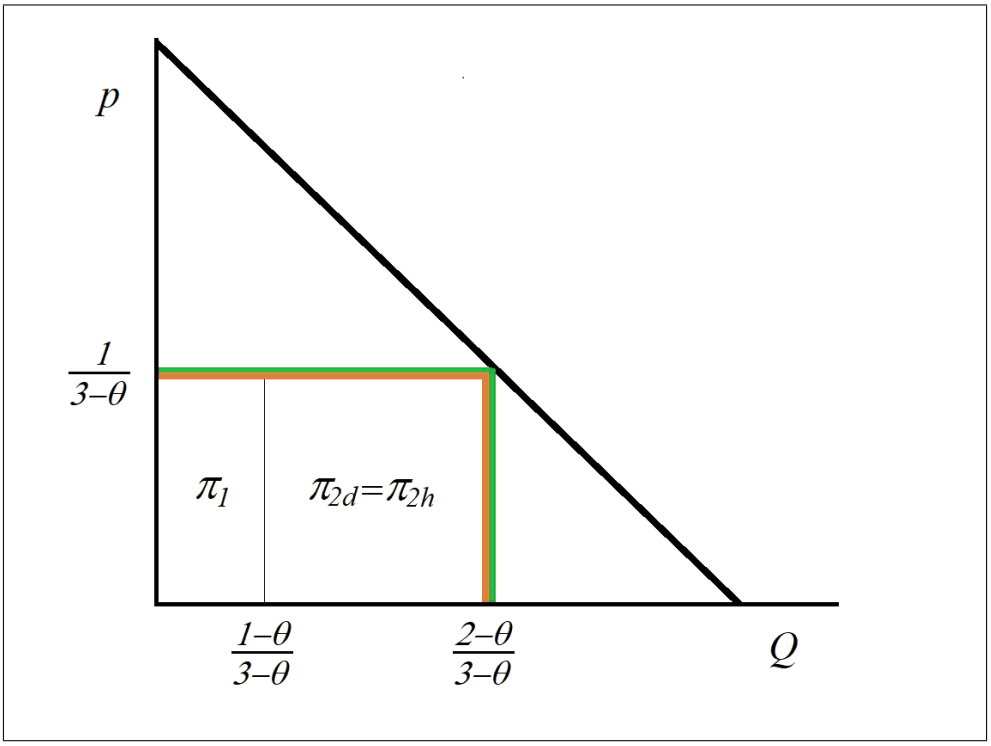

Fig. 2. The price is $\frac{1}{3-\theta}$ with both types of rival.

Damages are now:

$$D^{UE}_{\alpha=1} = q^{UE}_{2h}\left(1 - q^{UE}_{1} - q^{UE}_{2h}\right) = \frac{1}{3-\theta}\left(1 - \frac{1-\theta}{3-\theta} - \frac{1}{3-\theta}\right) = \frac{1}{(3-\theta)^2}. \tag{11}$$

Under UE, the profit of the dishonest rival - and thus damages - are higher if the probability of misappropriation is higher and the incumbent plays a less aggressive strategy.

The parties' payoffs are now

$$\Pi^{UE}_{1} = \frac{1}{(3-\theta)^2},\ \Pi_{2d} = 0, \quad \text{and} \quad \Pi_{2h} = \frac{1}{(3-\theta)^2}.$$

The honest rival gains if θ increases and the incumbent becomes less aggressive.

3.3 Lost Profits vs. Unjust Enrichment

Independent discovery of the technology used by the incumbent requires an investment equal to c. This cost is distributed on $[0,1]$ with cumulative distribution function $G(c)$. From now on, we focus on the case with $\alpha \to 1$.

Under LP, the ex-ante payoff of the rival is

$$\begin{array}{ll} \widehat{\Pi}_{2d}^{LP} = 0 & \text{if he misappropriates,} \\ \widehat{\Pi}_{2h}^{LP} = \frac{1}{9} - c & \text{if he develops independently.} \end{array}$$

The rival will misappropriate only if $c > \overline{c}^{LP} = \frac{1}{9}$.[23] The probability of misappropriation is $\theta^{LP} = 1 - G\left(\frac{1}{9}\right)$. The duplication expenditure is $C^{LP} = \int_0^{\overline{c}^{LP}} c \, dG'(c)$.

Under UE, the ex-ante payoff of the rival is

$$\begin{array}{ll} \widehat{\Pi}_{2d}^{UE} = 0 & \text{if he misappropriates,} \\ \widehat{\Pi}_{2h}^{UE} = \frac{1}{(3-\theta)^2} - c & \text{if he develops independently.} \end{array}$$

If a larger fraction of rivals misappropriate, Π_{2h}^{UE} increases and the incentive to misappropriate decreases. The cost threshold $\overline{c}^{UE}$ should meet:

$$\frac{1}{\left[3 - \left(1 - G\left(\overline{c}^{UE}\right)\right)\right]^2} - \overline{c}^{UE} = 0,$$

with $\overline{c}^{UE} > \frac{1}{9}$. The probability of misappropriation is: $\theta^{UE} = 1 - G\left(\overline{c}^{UE}\right) < \theta^{LP}$, and duplication expenditure is $C^{UE} = \int_0^{\overline{c}^{UE}} c \, dG'(c) > C^{LP}$.

In sharp contrast to the non-strategic setting, UE exerts more deterrence than LP. In a strategic setting, the payoff of the dishonest rival cannot go below 0 - otherwise the rival would just quit the market. So, the incentives to misappropriate are driven uniquely by the profits that the rival can make by developing the technology by legal

[23] The fact that the α is close, but not equal, to 1 guarantees that misappropriators do not leave the market. In a similar vein, Choi (2009) uses $\alpha \to 1$ to select among multiple equilibria in the patent infringement game.

means. These profits are higher under UE, where the incumbent takes a non-aggressive stance.

Let us consider the incumbent's market profits under the two regimes. We have:

$$\pi_1^{LP} = \frac{1}{3}\left(1 - \frac{1}{3} - \theta^{LP}\frac{1}{6} - \left(1 - \theta^{LP}\right)\frac{1}{3}\right) = \frac{1 + \frac{\theta^{LP}}{2}}{9} > \frac{1}{9},$$
$$\pi_1^{UE} = \frac{1-\theta}{3-\theta}\left(1 - \frac{1-\theta^{UE}}{3-\theta^{UE}} - \frac{1}{3-\theta^{UE}}\right) = \frac{1-\theta^{UE}}{(3-\theta^{UE})^2} < \frac{1}{9}.$$

Thus,

$$\pi_1^{LP} > \pi_1^{UE}.$$

The incumbent earns greater profits in the LP regime. In the UE regime, the incumbent sacrifices her own profits to increase the damages award.

By comparing (6) and (11), we can easily see that:

$$D^{UE} > D^{LP}.$$

Under UE, the incumbent gives room to the rival, so as to increase damages. Under LP, the dishonest rival reduces his own production to reduce damages.

Taking profits and damages into account, we get:

$$\Pi_1^{LP}\left(\theta^{LP}\right) = \frac{1}{9} + \frac{5}{36}\theta^{LP},$$
$$\Pi_1^{UE}\left(\theta^{UE}\right) = \frac{1}{(3-\theta^{UE})^2},$$

with

$$\Pi_1^{LP}\left(\theta^{LP}\right) > \Pi_1^{LP}\left(\theta^{UE}\right) > \Pi_1^{UE}\left(\theta^{UE}\right),$$

since $\theta^{LP} > \theta^{UE}$.

The net payoff of the incumbent is larger under LP. The higher damages that the

incumbent receives under UE are not sufficient to compensate for the lower market profits.

Let us consider the market profits of the dishonest rival:

$$\pi_{2d}^{LP} = \frac{1}{6}\left(1 - \frac{1}{3} - \frac{1}{6}\right) = \frac{1}{12},$$
$$\pi_{2d}^{UE} = \frac{1}{3-\theta^{UE}}\left(1 - \frac{1-\theta^{UE}}{3-\theta^{UE}} - \frac{1}{3-\theta^{UE}}\right) = \frac{1}{\left(3-\theta^{UE}\right)^2} > \frac{1}{9},$$

thus

$$\pi_{2d}^{UE} > \pi_{2d}^{LP}.$$

Under UE the dishonest rival earns higher market profits and pays higher damages.

Let us consider the honest rival. We have:

$$\pi_{2h}^{LP} = \frac{1}{9},$$
$$\pi_{2h}^{UE} = \frac{1}{\left(3-\theta^{UE}\right)^2} > \frac{1}{9},$$

thus:

$$\pi_{2h}^{UE} > \pi_{2h}^{LP}.$$

Since the payoff of the honest rival is higher under UE, while the payoff of the dishonest rival and the opportunities to duplicate are the same under both regimes, we must have that, in expected terms, the rival's payoff is higher under UE.

Let us now compare market quantities. We have:

$$Q^{LP}\left(\theta^{LP}\right) = \frac{1}{3} + \theta^{LP}\frac{1}{6} + \left(1-\theta^{LP}\right)\frac{1}{3} = \frac{2}{3} - \frac{1}{6}\theta^{LP},$$
$$Q^{UE}\left(\theta^{UE}\right) = \frac{1-\theta^{UE}}{3-\theta^{UE}} + \frac{1}{3-\theta^{UE}} = \frac{2-\theta^{UE}}{3-\theta^{UE}}.$$

Since the quantities decrease with θ, and $\theta^{LP} > \theta^{UE}$, we have

$$Q^{UE}\left(\theta^{UE}\right) > Q^{UE}\left(\theta^{LP}\right) > Q^{LP}\left(\theta^{LP}\right).$$

The latter result is particularly important, since market welfare (consumer surplus + producer surplus) is proportional to Q.

If we denote as Δ the standard market deadweight loss (maximum feasible welfare minus actual welfare), we get:

$$\Delta^{UE} = \frac{1}{2}\left[1 - Q^{UE}\left(\theta^{UE}\right)\right]^2 < \frac{1}{2}\left[1 - Q^{LP}\left(\theta^{LP}\right)\right]^2 = \Delta^{LP}.$$

Under UE, damages have a less distortionary impact on competition.

The following result is based on the assumption of (nearly) perfect adjudication ($\alpha \to 1$).

Proposition 1 *The Lost Profits and Unjust Enrichment doctrines affect competition and misappropriation decisions in different ways. The outcomes of the game are summarized by the following Table.*

Incumbent's market profits:	$\pi_1^{LP} > \pi_1^{UE}$
Damages awards:	$D^{LP} < D^{UE}$
Incumbent's payoff:	$\Pi_1^{LP} > \Pi_1^{UE}$
Dishonest rival's market profits:	$\pi_{2d}^{LP} < \pi_{2d}^{UE}$
Dishonest rival's payoff:	$\widehat{\Pi}_{2d}^{LP} = \widehat{\Pi}_{2d}^{UE} = 0$
Honest rival's market profits:	$\pi_{2h}^{LP} < \pi_{2h}^{UE}$
Probability of misappropriation:	$\theta^{LP} > \theta^{UE}$
Market deadweight loss:	$\Delta^{LP} > \Delta^{UE}$
Duplication expenditure:	$C^{LP} < C^{UE}$

Proposition 1 shows that the two damages regimes provide sharply different strategic

incentives. In the LP regime, in which damages depend on the incumbent's actual loss, the dishonest rival gives up some of his profits to increase the incumbent's market share and thus reduce his prospective liability. The incumbent earns a larger payoff (profits + damages), even if damages are lower. When the honest rival comes up against the incumbent, competition is relatively intense and the rival's profits are low.

In the UE regime, in which damages disgorge the dishonest rival's profits, the incumbent plays soft against the rival. Damages are high, but the incumbent's total payoff is low. The honest rival, facing a relatively soft incumbent, makes high profits.

While the dishonest rival obtains the same zero payoff under both regimes, the honest rival earns a higher profit under UE, in which he faces a soft incumbent. So, the UE regime provides the rival with greater incentives to develop independently and avoid liability.

3.4 Policy considerations

The previous observations leave us with the hard task of comparing the two damages regimes from a policy perspective. Here, a variety of factors come into play.

■ *Incentives to innovate.* If we think that the main purpose of trade secrets law is to promote the creation of innovative knowledge, then we should focus on the reward for the innovator. Here, LP performs better, as it provides a greater payoff to the incumbent: $\Pi_1^{LP} > \Pi_1^{UE}$. Note that, in contrast to the non-strategic case, now the reward to the innovator does not derive from higher damages awards, but from higher market profits. LP softens the competition from dishonest rivals concerned about the loss they cause to the plaintiffs.

■ *Deterrence.* Trade secrets law offers a very special type of protection to innovators. It does not provide them with an exclusive right to the use of an invention (as a patent would do). It only protects them from the competition of rivals that have obtained

the technology by improper means. In fact, trade secrets law provides ample leeway to competition by proper means, e.g., by allowing reverse engineering. If we think that the goal of trade secrets law is to channel competition into the proper means, then UE is the preferred regime. It provides the rival with the strongest incentives not to engage in misappropriation.

■ *Market deadweight loss.* In deciding the scope of the protection that the law grants to holders of secret knowledge, the lawmaker cannot ignore the costs that such protection is likely to inflict to the consumers. As we have seen, the different damages regimes tend to distort the firms' market behavior, effectively curbing competition. The regime that provides the greatest benefits to the consumers is UE. Under this regime, the incumbent reduces to some extent her production, while both the honest and dishonest rival produce larger quantities. Competition remains healthy, although not as healthy as under Cournot.

■ *Deadweight to profit ratio.* Trade secrets law is not the only tool available to firms to protect their innovative knowledge. If the innovation meets the requirements of novelty and nonobviousness, it can be protected by a patent. In the comparison of different protection tools, as well as of conducts that impinge on both competition and innovation, a rough index of the overall desirability of a tool is the *deadweight loss to profit ratio*: it measures the social cost associated with each unit of profit netted by the innovator. Given that a reward has to be provided to the innovator for the innovation to come by, the ideal IPR should entail the least cost for each dollar of reward.[24]

In our case, we have

$$\frac{\Delta^{LP}}{\Pi_1^{LP}} = \frac{\frac{1}{2}\left[1-\left(\frac{2}{3}-\frac{1}{6}\theta^{LP}\right)\right]^2}{\frac{1}{9}+\frac{5}{36}\theta^{LP}} < \frac{\frac{1}{2}\left[1-\frac{2-\theta^{UE}}{3-\theta^{UE}}\right]^2}{\frac{1}{(3-\theta^{UE})^2}} = \frac{\Delta^{UE}}{\Pi_1^{UE}} = \frac{1}{2}. \tag{12}$$

[24] This methodology, first developed by Kaplow (1984), has been successfully applied to IPRs by several authors. See Scotchmer (2004), Denicolò and Franzoni (2010), Denicolò and Franzoni (2012), Friedman and Wickelgren (2019), and references therein.

Note that the deadweight to profit ratio under UE is equal to the deadweight loss to profit under standard Cournot.[25]

Inequality (12) is strengthened by the fact that, under LP, the expected duplication costs (which add to the deadweight loss) are smaller. This confirms that the social cost of each dollar of profit earned by the innovator/incumbent is smaller under LP.

Finally, it is worth noting that the market deadweight loss would be even smaller if the prospect of damages awards did not interfere with the firms' strategic choices.

If damages were independent of the profits that firms make in market competition, firms would compete à la Cournot. Market profits would be equal to $\frac{1}{9}$ for all firms.

For $D \leq \frac{1}{9}$, the payoff of the rival would be

$$\begin{array}{ll} \widehat{\Pi}_{2d}^{LP} = \frac{1}{9} - D & \text{if he misappropriates,} \\ \widehat{\Pi}_{2h}^{LP} = \frac{1}{9} - c & \text{if he develops independently.} \end{array}$$

The rival misappropriates if $D \geq c$, and the share of misappropriators is: $\theta^C = 1 - G(D)$. For $D > \frac{1}{9}$, the rival either develops independently (for costs $c \in \left[0, \frac{1}{9}\right]$) or leaves the market.

The payoff of the incumbent is (for $D \leq \frac{1}{9}$) :

$$\Pi_1^C = \frac{1}{9} + \theta^C D.$$

Market quantities are: $q_1^C = q_{2d}^C = q_{2h}^C = \frac{1}{3}$, and the deadweight loss is

$$\Delta^C = \frac{1}{2}\left(\frac{1}{3}\right)^2 < \Delta^{UE} < \Delta^{LP}.$$

A suitable choice of D can provide the incumbent with the same payoff that she would get under either LP or UE, but with a lower market deadweight loss.

[25] We have: $q_1^{UE} = (1-\theta)\, q_{2d}^{UE}$. Thus, $\Pi_1^{UE} = q_1^{UE} p^{UE} + \theta q_{2d}^{UE} p^{UE} = q_2^{UE} p^{UE} = \pi_{2d}^{UE}$. Since the dishonest firm plays a Cournot best reply, he acts like a monopolist on the residual demand curve. The ratio between the deadweight loss and π_{2d}^{UE} is thus the same as under monopoly (and under Cournot).

The difficulty with such a damages regime lies with the fact that it offers little guidance to the courts. For instance, if they intended to set damages at the level that completely discourages misappropriation, $D = \frac{1}{9}$, they would need to speculate about the level of profits that firms would make if they did not act strategically (in general, this depends on the shape of the demand curve and the level of the production costs).

Still, there are damages calculation methods that do not depend on market outcomes. Damages calculated on the basis of the technology development costs, for instance, share this feature (see the Introduction).

4 Extensions

■ *Imperfect enforcement.* Our analysis considers the ideal case in which a dishonest rival is always liable for misappropriation. Here, the strategic incentives apply with full vengeance. Do our results still hold when misappropriation does not carry liability? Simulations performed on the general formulas of our model show that the analysis carries through if α is not "too small" (with a uniform distribution of the costs, this means $\alpha \geq .18$).[26] When α is very small the prospect of liability appears very remote: the dishonest firm behaves very much like the honest one, the incumbent is not concerned about the type she is facing. All firms produce quantities close to the Cournot quantities ($\frac{1}{3}$ each). Damages, when they happen to be awarded, are higher under LP (they are close to $\frac{1}{4} - \frac{1}{9}$) than under UE (they are close to $\frac{1}{9}$). If solvency is not an issue, the incentive not to misappropriate is larger under LP. The deadweight loss is the same under both damages regimes. Essentially, the non-strategic analysis applies.

■ *More efficient rivals.* Let us consider the case in which the rival's manufacturing and retailing facilities are better than the incumbent's.[27] As a result, the rival faces

[26] For some values of α, $\widehat{\Pi}_{2h}^{LP} - \widehat{\Pi}_{2d}^{LP}$ is non-monotonic in θ, and multiple Nash equilibria arise. From the set of the equilibria, we have focussed on the stable one.

[27] The case in which the rival is less efficient of the incumbent cannot be analyzed under the hypothesis

a marginal cost that is lower than that of the incumbent (see the Annex for a formal analysis). Under LP, the dishonest rival nets now a positive payoff. Under EU, all profits of the dishonest rival are extracted. The incumbent plays a very soft market strategy to enhance the profits of the dishonest rival. If the rival is dishonest with a sufficiently large probability, the incumbent in fact produces nothing. Under UE, damages are higher and so is the difference in payoff between honesty and dishonesty. While the strategic analysis retains the same features as before (the inequalities of Proposition 1 apply), a further effect should be noted. Recall that under LP, the dishonest rival plays a non-aggressive strategy. Under UE, the incumbent plays a non-aggressive strategy. For this reason, under UE the rivals take a larger share of the market: this reduces the production inefficiency (i.e., the additional production costs due to the fact that the inefficient plant is used).

If rivals are more efficient:	*Production inefficiency LP > Production inefficiency UE.*

This effect should be accounted for in the calculation of the deadweight loss associated with the two damages rules.

Finally, let us consider the case in which the efficiency advantage of the rival is so large that licensing becomes profitable ($\pi_d^1 + \pi_d^2 > \pi_m$, where π_d^1 and π_d^2 are the profits under licensing). We know from the non-strategic analysis that here misappropriation and duplication are used as bargaining threats: they define the payoff levels that parties would obtain if the negotiation broke down. In this counter-factual situation, firms would still act strategically, and the results of the previous paragraph would apply. What matters now are the payoffs to the parties.

We have: $\Pi_1^{LP} > \Pi_1^{UE}$, $\widehat{\Pi}_{2d}^{LP} > \widehat{\Pi}_{2d}^{UE} = 0$, $\widehat{\Pi}_{2h}^{UE} > \widehat{\Pi}_{2h}^{LP}$. The incumbent nets a higher payoff under LP. Under UE, the incumbent plays a soft market strategy and obtains

that α is close to one. The rival is not able to pay LP damages to the incumbent without incurring in a loss. The payoff from dishonesty is thus negative and this implies that competition can only occur upon honest duplication.

very small market profits. The fact that damages are higher does not make up for the missing market profits. The payoff of the dishonest rival is higher under LP, while the payoff of the honest rival is higher under UE (thanks to the soft stance of the incumbent).

The preferences of the rival with respect to the damages regime depend on the her development cost: if the development cost is high, so that she is bound to be dishonest, then she prefers LP. If the development cost is low, so that she can afford to be honest, then she prefers UE. For intermediate values, the rival is honest under UE and dishonest under LP. The comparison of the two regimes is ambiguous because the payoff under UE depends on the probability of dishonesty (and this, in turn, depends on the distribution of the duplication costs).

These hypothetical (and rather speculative) payoffs define the outside options in the licensing negotiation. The outside options only affect the allocation of the negotiation surplus: they have no impact on market quantities, deadweight losses, probability of misappropriation, etc. because, in equilibrium, the technology will in fact be licensed. Here, damages serve a distributive purpose, as they affect the rewards for incumbent and rival. A policy choice based on efficiency considerations should then look at additional factors, like whether the reward for the incumbent is large enough to incentivize the development of the superior technology and the reward for the rival is large enough to incentivize the investment in (superior) manufacturing and retailing facilities.

5 Final remarks

Trade secrets litigation has recently attracted sustained attention. The establishment of a federal cause of action for misappropriation under the DTSA and the remarkable magnitude of recent damages awards invite a scholarly reflection on the implications of liability for misappropriation on the firms' strategic incentives.

Our model offers insights that should allow courts and policymaker to better under-

stand the subtle market effects of the different damages doctrines. We have considered LP and UE in isolation. They offer diverging incentives to develop original knowledge, to carry out unlawful practices, and to compete on the market. Either doctrine could be preferred, depending on the desiderata of the policymaker. If the focus is on rewarding the production of innovative knowledge, then LP is likely to perform better, as it provides the greatest payoff to the original trade secret's owner. Perhaps surprisingly, if the focus is on deterring unlawful practices, then UE seems to perform better, as it provides a greater reward to honest competitors. Finally, if the goal is to contain the deadweight loss associated with the incentive to innovate, then LP seems to perform better, because it yields a lower deadweight loss to profit ratio.

Our analysis assumes some important factors away. In particular, we have not considered the possibility that the rival develops a product to which consumers attach a greater value, and we have not accounted for litigation costs. Furthermore, we have posited errorless adjudication. With all these caveats in mind, we are confident that our contribution provides a good starting point to understand the complex strategic implications of misappropriation remedies.

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Annex

Let us consider the case in which the rival is more efficient than the incumbent. Specifically, the marginal production cost of the rival is nil, while the marginal production cost of the incumbent is $c \leq \frac{1}{2}$.

Monopoly profits are now: $\pi_m = \left(\frac{1-c}{2}\right)^2$.

Going through the same steps as in the Section 3, we get what follows.

Under LP, the market quantities are:

$$q_1^{LP} = \frac{1-2c}{3},\ q_{2d}^{LP} = \frac{1+4c}{6},\ \ q_{2h}^{LP} = \frac{1+c}{3}.$$

With probability θ, the market price is $p = \frac{1}{2}$, damages are $D^{LP} = \frac{1+2c-5c^2}{12}$, the payoff of the incumbent is $\Pi_1 = \pi_m = \left(\frac{1-c}{2}\right)^2$, while the payoff of the dishonest rival is $\Pi_{2d}^{LP} = \pi_{2d}^{LP} - D^{LP} = \frac{c(2+5c)}{12}$.

With probability $1-\theta$, the market price is $p = \frac{1+c}{3}$, the payoff of the incumbent is $\Pi_1 = \left(\frac{1-2c}{3}\right)^2$, while the payoff of the honest rival is $\Pi_{2h}^{LP} = \left(\frac{1+c}{3}\right)^2$.

The production inefficiency is: $q_1^{LP} \times c = \frac{(1-2c)c}{3}$.

Under UE, we get:

$$q_1^{UE} = \frac{1-\theta-2c}{3-\theta},\ q_{2d}^{UE} = q_{2h}^{UE} = \frac{1+c}{3-\theta},\ \text{for } \theta < 1-2c.$$

For $\theta \geq 1-2c$, the incumbent produces $q_1^{UE} = 0$ and only hopes to recover damages from the dishonest rival. The rivals, in turn, behave like monopolists and set $q_{2d}^{UE} = q_{2h}^{UE} = \frac{1}{2}$.

For $\theta < 1-2c$, the market price is $p^{UE} = \frac{1+c}{3-\theta}$. The market profits of the incumbent are $\pi_1^{UE} = \frac{\left[1-c^2(2-\theta)\right][1-\theta-2c]}{(3-\theta)^2}$. Damages are equal to the market profits of the dishonest rival: $D^{UE} = \pi_{2d}^{UE} = \left(\frac{1+c}{3-\theta}\right)^2$. The total payoff of the incumbent is $\Pi_1^{UE} = \frac{1+(4-\theta)c^2-c\left(4-5\theta+\theta^2\right)}{(3-\theta)^2}$. Given θ, the payoff of the incumbent is non-monotonic in c (first it is decreasing and then increasing).

The production inefficiency amounts to: $q_1^{UE} \times c = \frac{(1-\theta-2c)c}{3-\theta}$.

For $\theta \geq 1-2c$, the rival takes the whole market. There is no production inefficiency.

Even if damages are higher under UE, the payoff of the incumbent is higher under LP (thanks to the higher market profits). The incentives to be honest are higher under UE. The payoff of the honest rival is higher under UE, thanks to the non-aggressive stance of the incumbent. The payoff of the dishonest rival is higher under LP, since in this regime she retains part of her profits.

From an ex-ante perspective, a rival with low duplication cost, and hence honest, is better off under UE. A rival will high duplication cost, and hence dishonest, is better off under LP. A rival with intermediate duplication cost will be honest under UE and dishonest under LP. The two payoffs cannot unambiguously compared because the payoff under UE depends on the share of dishonest rivals in equilibrium. This, in turn, depends on the distribution of the duplication costs.