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Who is afraid of pirates? An experiment on the deterrence of innovation by imitation

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**Who is Afraid of Pirates?
An Experiment on the
Deterrence of Innovation
by Imitation**

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May 2013

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Abstract

In the policy debate, intellectual property is often justified by what seems to be a straightforward argument: if innovators are not protected against others appropriating their ideas, incentives for innovation are suboptimally low. Now in most industries for most potential users, appropriating a foreign innovation is itself an investment decision fraught with cost and risk. Nonetheless standard theory predicts too little innovation. Arguably the problem is exacerbated by innovators' risk aversion as well as their aversion against others benefitting from their efforts without contributing to the cost, and without bearing innovation risk. We model the situation as a game and test it in the lab. We find even more appropriation than predicted by standard theory. But the risk and the experience of appropriation does not deter innovation. We find even more innovation than predicted by theory, and actually more than would be efficient. In the lab, the prospect of giving imitators a free lunch does not have a chilling effect on innovation.

JEL: C91, D22, D62, D63, H23, H41, K11, L17, O31

Keywords: innovation, imitation, appropriation, patent, fairness of desert

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I. Introduction

A standard argument in favor of patent protection relies on the fact that knowledge tends to be non-excludable. Unless the law steps in and the patent creates a temporal monopoly, other users could just copy the invention. Anticipating this, nobody is willing to engage in costly innovation (for a typical voice see Menell and Scotchmer 2005: sec. IA). In its weaker and more realistic form, the argument expects investment into innovation to be suboptimally low if innovators are not protected against others tapping into their efforts. This line of argument has long been criticized on empirical grounds. In many markets, the cost of imitation is pronounced. While the idea could also be used by others, competitors or not, if they want to appropriate it they would first have to engage in reverse engineering, they would have to change their production process or product, or they would have to invest into marketing the new product. Realistically, appropriating a foreign innovation is an investment decision itself, with its associated degree of uncertainty. Figure 1 illustrates this claim with survey data.¹ It also shows that there is pronounced heterogeneity, both within and between industries.

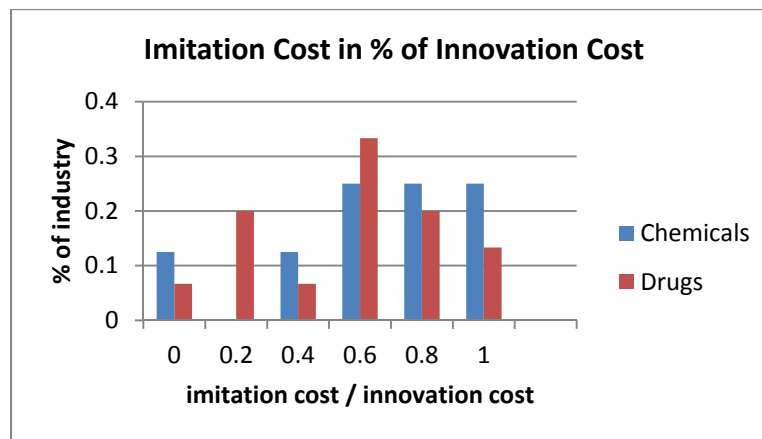


Figure 1

Imitation Cost

data from (Mansfield et al. 1981)

x-axis: 0.8 means that the cost of imitation is 80% of the cost of innovation

y-axis: fraction of an industry that states imitation cost to be that high, relative to innovation cost

In the policy debate, it sometimes sounds as if the mere possibility of appropriation by others were to deter any innovation.² At the opposite end of the spectrum, idealists equate appropriation of “intellectual property” with theft,³ and should consequently expect those tempted to be held back by moral compunctions. For either extreme position, the cost and the risk of appropriation are immaterial.

1 For further sources see below 0.

2 Take what (Menell and Scotchmer 2005: sec. IA) define as “the economic problem”: “Most firms would not invest in developing new technologies, and potential creators might not spend their time on creative works, if rivals could enter the market and dissipate the profit.”

3 See, e.g. <http://www.ideaights.com/ideatheft.htm>.

If all actors are fully rational money maximizers, and if all of them anticipate all others to hold the same preferences, none of these extreme positions is supported. The theoretical prediction hinges on the expected individual profitability of innovation on the one hand, and of appropriation on the other hand. In equilibrium, actors split their resources between innovation and imitation. Standard theory therefore predicts the policy problem to be much more contained. Yet if all actors hold standard preferences, there is too little investment into innovation, compared with the social optimum.

From a behavioral perspective, the policy problem might loom even larger. Investors are simultaneously exposed to two sources of risk: stochastic and strategic. The risk of the innovation to fail is stochastic. The risk that another player uses one's innovation without having contributed to its cost is strategic. The more would-be innovators are risk averse, and the more they expect appropriation to be common, the more they might be deterred by this combined risk. If a player holds social preferences, she might lose utility if her innovation is appropriated. The player might in particular consider appropriation to violate the fairness norm of desert. Arguably appropriation is most unfair if the appropriator had the same opportunity, and the same resources, to invest into innovation, but chose to keep her money for a fishing expedition.

In this paper, we investigate these hypotheses experimentally. We introduce a two-person game of two stages – in the first stage a player may invest into her own innovation project and in the second stage into the appropriation of the co-player's innovation of the first stage. We make innovation risky, and manipulate the conditions for appropriation. In the *Low Risk* treatment, appropriation is risky (and costly), but the risk of not succeeding to appropriate a foreign innovation is small. In the *High Risk* treatment, this risk is pronounced. To disentangle motives, we further elicit beliefs, each participant's risk preference, and her attitude towards the fairness norm of desert. That way, we are able to test alternative explanations.

In the field appropriating another firm's innovation often simultaneously has two effects: the appropriator saves money for her own innovative efforts; she gets a free lunch. And the innovator loses her competitive advantage. It would not have been difficult to implement both effects in the lab. Had we done so, in a way we would have increased external validity. Yet experiments are not meant to map reality. They are tools for identifying causal effects. If appropriation had reduced the innovator's profit, and if we had found less innovation the easier appropriation, we would not have known why. We could not have said whether innovation is deterred by a reduction in expected profit, or by the fairness problem resulting from the public good character of innovation. In our experiment, we isolate the latter effect (and show that it is not present). While the situation we have tested is not regular in the field, it is not uncommon either. Our experiment is analogue to the spillover of innovation from one industry to another.

In first approximation, experimental results support the predictions from standard theory. Participants split their endowments between innovation and appropriation, and keep the remain-

der. As predicted by the equilibrium, they spend more money on appropriation when the risk of losing the appropriation investment is high, and less if this risk is low (and thus a small investment into appropriation suffices to have high chances for successful appropriation). Again as predicted by standard theory, there is no significant difference in innovation investment between both treatments.

While the ordinal predictions of standard theory are supported, point predictions are clearly refuted. In both treatments, there is more appropriation *and* more innovation than predicted. Participants lose money because they do not save enough of their income. With repetition, in both treatments investment into innovation decays over time (but remains above the theoretical expectation throughout the game). If the risk of appropriation to fail is high, participants invest less into appropriation in the beginning and more in the end. None of this is predicted by standard theory.

Most patent applications are filed for inventions made by the employees of a firm. Different legal orders use different techniques to make sure that the employer may dispose of the invention. We test student subjects who decide on their own. We do not mean to claim that firms behave the same way as individuals. Firms are highly aggregate, institutionally embedded, historically entrenched corporate actors (Engel 2010). Yet ultimately, it is not possible to implement firms in the lab. One may have groups decide instead of individuals, or agents on behalf of principals. But it is still a long way from here to a true corporate actor. In principle, field experiments with firms are a possibility. But even if firms were to agree, it would be next to impossible to fix the probability of success or appropriation. While information about patent applications and patents granted is publicly available, innovative activity that does not lead to patent filing is much harder to observe in the field. We thus trade some aspects of external validity for experimental control. We deem the price acceptable for two reasons: while risk and fairness preferences, as well as perceived social norms, are not likely to be in firms exactly as in individuals, ultimately individuals have to decide on behalf of firms, and will be influenced by these behavioral traits. Moreover, in the legal discourse justifying intellectual property, the individual innovator is the regulative model. Even if, in economic terms, the ultimate owner of the intellectual property right is the firm, this requires an explicit transfer of a right that, legally, originates in the individual. And in the field, individuals marketing their own innovation are not uncommon. To them, our results directly apply.

Our experiment makes a contribution to the policy discourse about intellectual property in that it isolates one key argument: to which degree is a property right in innovation necessary or at least desirable if [1] innovation is costly and risky and [2] imitation is possible but itself also costly and risky? If the legislator cares about incentives for innovation, standard theory overestimates the size of the problem. In the lab, there is considerably more innovation investment than predicted. Intervention is easier to justify if the legislator wants to give innovators the protection it believes they deserve. We find even more appropriation than standard theory predicts. Yet note that innovators are not deterred, although they experience even more appropriation than theory predicts. Intervention could thus not be justified on the utilitarian

ground that otherwise innovation is deterred. The legislator would intervene because it deems an excessive windfall profit on appropriators unfair.

The remainder of the paper is organized as follows: section II relates our experiment to the literature on intellectual property policy, and to the existing empirical and experimental literature. Section III presents the design of our experiment. Section IV spells out hypotheses. Section V reports results. Section VI concludes with discussion.

II. Related Literature

The standard argument in favor of patent protection is, for instance, made by (United States Government Accountability Office 2010). It has been criticized on theoretical grounds. It has been claimed that innovation is often a process rather than an isolated event. Then an imitator does not just copy, but uses the earlier innovation to make the next innovative step, which is made difficult by patent protection (Heller and Eisenberg 1998; Aghion et al. 2001; Mukoyama 2003; Bessen and Maskin 2009). If a firm's success depends on its R&D intensity, the subsidy inherent in patent protection reduces overall innovative activity and hence growth (Segerstrom 1991; Grossman and Helpman 1992; Davidson and Segerstrom 1998). Depending on payoffs from innovation and imitation, the resulting static game may not be a prisoner's dilemma (Engel 2012), and the deadweight loss resulting from the monopoly over knowledge may outweigh the social benefit from the stronger innovation incentive (Kaplow 1984). Empirically, protection is never perfect, which is why patent might be better modeled as a probabilistic right (Lemley and Shapiro 2005).

One major counterargument stresses that, in the field, new technological knowledge is often not a pure public good. Not only for creating, but also for using it, tacit knowledge is necessary that is, at least initially, only possessed by the innovator. Even if that is not the case, imitators often face a positive cost of appropriation, and innovators have some lead time (Cimoli et al. 2011). Empirical studies have found imitation cost to be pronounced in many industries. It not so rarely even exceeds innovation cost, but industry characteristics are critical (Mansfield, Schwartz et al. 1981). In the well-known Yale Survey, 650 respondents from various industries rated patent protection to be the least important measure for securing a competitive advantage, while they on average put most stress on lead time, followed by going down the learning curve quickly, being good at sales and service, and secrecy. Again there were pronounced differences between industries, though, with producers of drugs and chemicals seeing patents as most important (Levin et al. 1987). In the subsequent Carnegie Mellon Survey, the estimated disadvantage of patent was less pronounced. But patent was still outperformed by secrecy and lead time (Cohen et al. 2000). Similar findings have been made for Germany, Portugal (Faria and Sofka 2010), Switzerland (Harabi 1994) and the US, but not for Japan (Cohen et al. 2002). On average, patent protection only prolongs the imitation lag by a few months (Cohen, Goto et al. 2002). Note that the evidence on the comparative importance of protection technologies asks how "important" patent is. This evidence thus not only

measures the ex post cost of imitation. It also speaks to the chilling effect resulting from imperfect or entirely missing patent protection. Apparently, industry representatives also do not deem patent particularly important from the ex ante perspective of engaging in innovation. Whole industries like fashion, food, stand-up comedy or sports are not protected by property rights for creativity, and still all of them are rife with innovation (Raustiala and Sprigman 2012).

Lab experiments on innovation and intellectual property rights have focused on different issues. The closest analogue is (Suetens 2005). She had participants in a duopoly repeatedly decide how much to invest into risky innovation. New knowledge was either completely protected, or could be used at zero cost by the other player. Absent institutional intervention, results were close to the Nash predictions. If knowledge was protected, only binding (collusive) contracts helped participants reduce overinvestment. If knowledge was not protected, cheap talk was even more effective than a contract in mitigating underinvestment. The main difference to our approach stems from the fact that, in line with field evidence, we also make imitation costly and risky, and thereby have participants choose between innovation and imitation. We also test different degrees of success probability for appropriation, and we generate explanatory variables through post-experimental tests. (Diduch 2010) uses a setting similar to (Suetens 2005) for a classroom experiment. (Darai et al. 2009) offer members of an experimental triopoly either no additional incentive for engaging in risky and costly process innovation, a subsidy or a property right. They find overinvestment in all treatments, higher investment with either intervention, and no significant difference between both interventions. (Isaac and Reynolds 1992) show that there is more R&D with competition than with a monopoly. (Suetens 2008) finds that cooperative investment facilitates tacit price collusion. (Deck and Erkal 2012) find that research cooperation falters the closer firms move to success. (Cantner et al. 2009) use a naturalistic setting to have members of a random duopoly engage in a patent race. They find interaction driven by the fact that either competitor uses a bold or a cautious strategy. (Sbriglia and Hey 1994; Zizzo 2002; Silipo 2005) also study patent races in the lab. (Bäker et al. 2011) investigate the impact of creativity, analytic skills and personality traits on innovation behavior. (Ullberg 2010b) experimentally investigates trade in licences. (Ullberg 2010a) explores whether patenting serves as a signal for the productivity of inventive efforts in a technology.

III. Design

To test the competing expectations, we run a lab experiment. Participants are randomly assigned to groups of two. Every player has an endowment $e = 20$ tokens, which she can keep or invest into one of two purposes: innovation or appropriation. Investment is sequential, with the innovation stage preceding the appropriation stage.

Specifically in the first stage each player i decides how much of her endowment e to invest into an (innovation) project. Innovation is costly and risky. The probability of success of a

project increases with contribution c_i , the tokens invested into the project, according to the following logistic probability function:

$$prob = \frac{c_i}{1 + c_i}$$

This creates a function as in Figure 2. The first token invested sets the probability of success to 50%. With all 20 tokens invested, this probability is at 95.24%. We thus implement an innovation function with decreasing returns to investment.

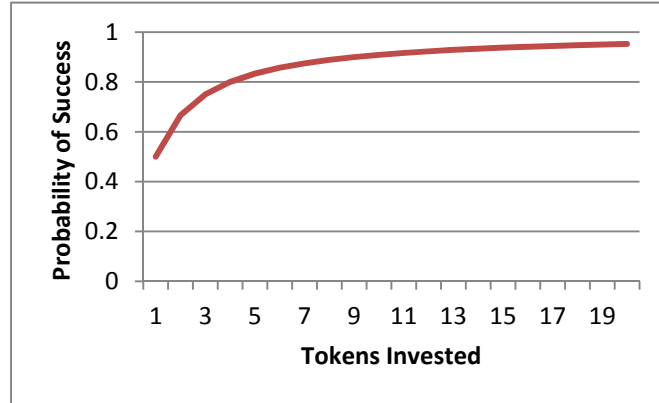


Figure 2
Probability Function at Innovation Stage

If the project is successful, the player reaps gain $g_i = 40$ tokens. At the beginning of the second stage each player is informed about her own investment and the success of her own project, as well as her counterpart's investment and the success of the foreign project. Out of the remaining endowment (i.e. endowment minus tokens invested at stage 1) players may at this stage invest into appropriation of the project of their counterparts. For appropriation, we implement two levels of uncertainty of success: a low risk of failure (*Low Risk* treatment), or a high risk of failure (*High Risk* treatment). Probability functions are logistic and given by

$$prob = \frac{\frac{a_i}{y_i}}{1 + \frac{a_i}{y_i}}$$

with a_i being the tokens invested into appropriating the counterpart's innovation. Parameter y_i is equal to 1 in the *Low Risk* treatment. In this condition, the probability functions for innovation in stage 1 and appropriation in stage 2 are hence the same. Parameter y_i is equal to 10 in the *High Risk* treatment. With *High Risk*, one token invested leads to 9.1% probability of successful appropriation, while 20 tokens invested push this probability up to 66.66%. Expected returns from appropriation thus also decrease in investment. In the *Low Risk* environment, appropriation is easy and cheap, in the *High Risk* environment, appropriation is difficult and costly. Figure 3 summarizes the treatment manipulation.

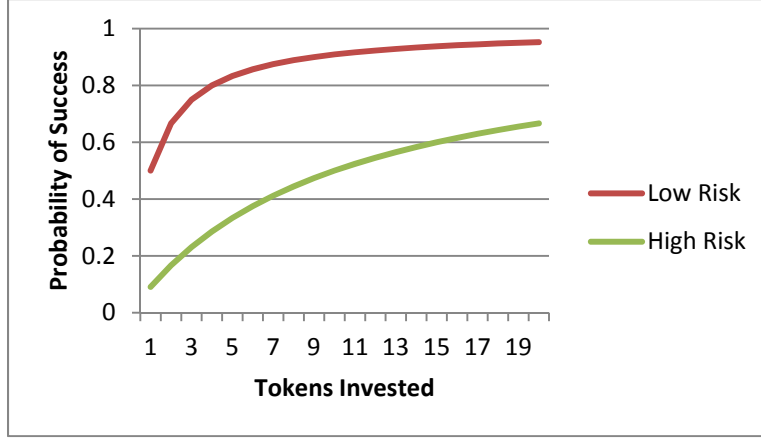


Figure 3
Treatments: Probability of Appropriation Success

The player whose appropriation is successful reaps gains of βg_j . In our experiment the degree of appropriability β equals 0.9, which means that successful appropriation accounts for gains $\beta g_j = 36$ tokens. Note that gains from appropriation are conditional on the success of the counterpart's project.

Expected profit is hence given by

$\pi_i = e - c_i - a_i + \frac{c_i}{1+c_i} g_i + \beta \frac{\frac{a_i}{y}}{1+\frac{a_i}{y}} \frac{c_j}{1+c_j} g_j$	(1)
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This constitutes a linear public good, with four features meant to capture the essence of the patent problem: [1] returns from investment are not deterministic, but probabilistic; [2] the second agent does not automatically benefit from contributions by the first agent, but has to invest into appropriation; [3] appropriation is not deterministic, but probabilistic; [4] appropriation is never complete. To make sure participants have understood the game, we both provide them with a table translating investment into a probability of success, and we give them a graphical representation. For detail, readers are referred to the translated instructions in the appendix.

We have chosen parameters such that innovators always have enough money for appropriation, and vice versa. If they stop innovating once the marginal benefit from investing another unit of their endowment into innovation is below 1, they still have enough of their endowment to independently decide how much to invest into appropriation of their counterpart's project, should it have been successful. That way we can be sure that a level of innovation below the theoretical benchmark indeed results from reticence of innovators to give others a free lunch. By the choice of parameters, we also exclude another potential confound. If we were to find

less innovation than predicted by theory, we would know that this is because innovators dread exploitation, not because they want to keep enough resources for being exploiters themselves.

While we implement a sequential game, with an investment stage followed by an appropriation stage, a player holding standard preferences must decide at the first stage how to split her endowment between innovation, (a chance for) appropriation, and money she intends to keep. We do not give a successful innovator the possibility to use the profit for appropriating a foreign innovation. This design choice is motivated by external validity. Typically, marketing an innovation takes time. Before the innovation has translated into higher profit, banks are unlikely to monetarize the value of the innovation, since the value of pure knowledge is hard to quantify.

We also do not give a successful innovator a chance to invest into defending her innovation against appropriation. This design choice is motivated by the desire to induce a clean choice between innovation and imitation. Had we also given the additional option, we could not have said whether reticence to invest into innovation is due to a desire to appropriate, or due to the intention to keep money for defending success.

In our game, payoffs directly follow from investments. There is no demand side, and no market on which innovators compete. This simplification not only makes it easier to implement the game in the lab. It more importantly helps us isolate the effect we are interested in. Had we played out the market stage, when deciding upon investment fully prevoyant participants would have had to anticipate how the odds for collusion in the market are affected by investment, or investment success. If we had found little innovation investment, we would not have known whether this is due to the fact that participants dread appropriation, or whether they are afraid that the resulting asymmetry of earnings (or efficient quantity choices) would make it more difficult to establish collusion. Note that modeling new knowledge as a pure public good implicitly makes the same choice.

In our experiment, there is no room for trade. If I have been successful, while another participant's efforts have been futile, she cannot buy a license to use my innovation. Had we allowed for trade, we would have changed the game into one where two firms may share the risk of invention.

At the beginning of the experiment, the game is played once. Participants only know that the experiment has further parts, but they do not know what later parts are about. This design feature provides us with a clean test for behavior in a one-shot game, and makes it impossible for participants to decide under the shadow of the future. After the end of part 1, and before giving participants feedback about the appropriation stage 2, we elicit beliefs about appropriation. We pledge a bonus if participants correctly estimate the fraction of participants who decide to appropriate foreign investments, and the mean size of the investment. For the sake of keeping observations independent across matching groups, we withhold feedback on this auxiliary task until the end of the experiment.

To investigate whether effects are stable over time, we then repeat the stage game 10 announced times. We implement a stranger protocol. Following the procedure that is standard in the experimental literature (see e.g. Charness 2000; Montero et al. 2008), we assign participants to matching groups of 6, but do only tell them they will be re-matched every period, not that matching groups have limited size. This procedure is meant to guarantee independent observations, without inducing participants to try to second guess group composition.

For each participant, after the end of the main experiment we elicit risk preferences, using the standard procedure by (Holt and Laury 2002). To the best of our knowledge, there is no standard test for fairness of desert. Since participant’s attitude towards this fairness norm may be key for understanding our results, we design the following new test: At the end of the experiment, we inform participants that they will be randomly matched to new pairs of two participants. Ex post, the computer will assign the role of dictator (neutrally framed as “active player”) to one participant, and the passive role of recipient to the other. Using the strategy method (Selten 1967), we ask participants which fraction of their income of 125 tokens from this part of the experiment they want to give to the passive player, should they be the dictator. We have them decide for the four cases summarized in Table 1.

		Recipient	
		no income	earned income
dictator	endowment		
	earned income		

Table 1
Fairness of Desert Test

In the endowment cells, the dictator’s endowment is given and need not be earned in a real effort task. In the no income cells the recipient has no income. In the earned income cells participants have to perform a real effort task. For this test, we use the task developed by (Mazar et al. 2008). For each token participants have to find the one pair of cells that adds up to 10, in matrices as in Table 2.

4.67	4.81	3.05
5.82	5.06	4.28
6.36	5.19	4.57

Table 2
Task in Fairness of Desert Test

There is no time limit. But all earnings from the entire experiment are held back until a participant has correctly solved the required number of problems, to make sure that income is indeed earned.

The experiment was conducted in 2012 in the Cologne Econ Lab. The experiment was implemented in zTree (Fischbacher 2007). Participants were invited with the software ORSEE (Greiner 2004). Participants had to answer control questions to make sure they had under-

stood the instructions. 120 students of various majors participated. In the one-shot game, choices are independent. In the repeated game, we have 20 independent observations. 65 (54.17%) were female. Mean age was 25.99 years. At the end of the experiment earned tokens were converted into €– for the main experiment with the conversion rate of .02 €/token – and paid to the participants in cash. Participants on average earned 16.73 € (20.54 \$ at the days of the experiment), range [8.86 €, 22.35 €]. Sessions lasted about one and a half hours.

IV. Hypotheses

In the policy debate, not so rarely the impression is conveyed that the legal protection of intellectual property is a precondition for any innovation. Specifically, it is claimed that no reasonable person, or firm for that matter, would invest money into the risky creation of new knowledge if potential users were free to pass by and use the innovation for their own benefit, without compensating the former agent for her efforts (see e.g. United States Government Accountability Office 2010). At first glance, this argument seems to be backed up by standard economic theory. If knowledge is a pure public good (Cornes and Sandler 1996), should this not be another instance of the tragedy of the commons (Hardin 1968)? In our experiment, there is no institutional protection of innovation success. Arguably, from a behavioral perspective, the concern could be even more pronounced. If others lay their hand on the success of my efforts, isn't that an obvious violation of the fairness norm of desert? If the concern sometimes voiced in the policy debate gets it right, we should find

H₁: There is no investment into innovation (and therefore nothing to appropriate). There are no treatment differences.

Much of the policy debate has a moral undertone. If intellectual property goes unprotected, this is not only inefficient. It is also unjust. Intellectual property is property. Appropriating property without having contributed to its generation is theft, or so the argument goes (see again United States Government Accountability Office 2010). Such statements are not meant as contributions to an idealistic discourse. Labeling appropriation as theft hopes to trigger moral compunctions most people have against stealing tangible property. While, in the experiment, we of course do not use such value laden words, from the incentive structure it still is clear that appropriation is an act of tapping into foreign efforts. If morally grounded hesitance to do so is indeed as powerful as this policy discourse wants it, we should see

H₂: There is investment into innovation, but no investment into appropriation. There are no treatment differences.

Both claims from the policy debate of course ignore the main point of both the experiment and the situation in most industries: appropriating foreign knowledge is not free of charge, but costly and risky. If participants are risk neutral maximizers of payoff, each of the treatments constitutes a game. Each game has a unique equilibrium in pure strategies. Specifically, a money maximizing player reasons in three steps: [1] what would be the optimal investment

into appropriation, provided the budget constraint does not bind? [2] what would be the optimal investment into innovation, again provided the budget constraint does not bind? [3] does the budget constraint bind? If so, how shall the player optimally trade a chance for innovation success against a chance for appropriation success?

Participants play a game of two stages. At the second stage, they have made an investment c_i into innovation. If they learn that the investment of their counterpart has failed, they keep $e - c_i$. If their counterpart's investment has been successful, they decide how much to invest into appropriation. Any token kept gives them a sure gain of 1. They thus invest into appropriation until the marginal expected gain is at or below 1. They find this threshold by maximizing

$\pi(a_i) = \frac{\frac{a_i}{y}}{1 + \frac{a_i}{y}} \beta g_j - a_i$	(2)
--	-----

with respect to a_i , which yields

$a_i^* = \sqrt{g_j y \beta} - y$	(3)
----------------------------------	-----

At the first stage participants must decide how much to invest into innovation. Provided the budget constraint does not bind, the opportunity cost of any token invested is again 1. Money maximizing participants invest into innovation until the marginal expected gain is at or below 1. They find this threshold by maximizing

$\pi(c_i) = \frac{c_i}{1 + c_i} g_i - c_i$	(4)
--	-----

with respect to c_i , which yields

$c_i^* = \sqrt{g_i} - 1$	(5)
--------------------------	-----

The budget constraint binds provided

$e < a_i^* + c_i^* = \sqrt{g_j y \beta} - y + \sqrt{g_i} - 1$	(6)
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We are not interested in the conflict between innovation and appropriation per se. Rather we want to learn whether the prospect of appropriation deters participants from innovating, even if this would be in their best interest. We are thus interested in the fairness problem resulting from the fact that unprotected innovation gives outsiders a free lunch. In the interest of isolating this effect, we choose parameters such that the budget constraint does not bind. Conse-

quently, both at the appropriation and at the innovation stage, choosing the profit maximizing level of investment is a dominant strategy. A further implication concerns the innovation stage. Our treatments only differ at the appropriation stage. Since the budget constraint does not bind, money maximizing individuals choose the same level of innovation in both treatments.

In Table 3 we report equilibrium investments. Since the budget constraint does not bind, the prediction how much of her endowment a money maximizing participant keeps is simply calculated as $k_i^* = e - c_i^* - a_i^*$. Since participants are randomly rematched, assuming that standard preferences are common knowledge, the prediction for the stage game does not change with repetition.

		Innovation investment		Appropriation investment		endowment kept (if foreign project succeeds)	
		Nash	efficient	Nash	efficient	Nash	efficient
Treatment	<i>Low Risk</i>	5.325	7.062	5.000	5.000	9.675	7.938
	<i>High Risk</i>	5.325	5.932	8.974	8.974	5.701	5.094

Table 3
Benchmarks

Welfare is given by

$$\begin{aligned}
 W = & \frac{c_i}{1+c_i}g_i + \frac{c_j}{1+c_j}\left(\frac{\frac{a_i}{y}}{1+\frac{a_i}{y}}\beta g_j - e - c_i - a_i\right) + \left(1 - \frac{c_j}{1+c_j}\right)(e - c_i) \\
 & + \frac{c_j}{1+c_j}g_j + \frac{c_i}{1+c_i}\left(\frac{\frac{a_j}{y}}{1+\frac{a_j}{y}}\beta g_i - e - c_j - a_j\right) + \left(1 - \frac{c_i}{1+c_i}\right)(e - c_j)
 \end{aligned} \tag{7}$$

In (7), the first line is the welfare contribution resulting from choices by the first player, and the second line by the second player. In both lines the first term is gain from investment into innovation. The second term is profit if the foreign project turns out successful. Then this player participates in foreign innovation success if she invests into appropriation and this leads to success, and keeps the remainder of her endowment. The third term is profit if the foreign project fails. Then this player keeps the portion of her endowment she did not invest into innovation. Taking first derivatives with respect to the four decision variables, solving the resulting system of equations, and taking into account all non-negativity constraints, we have the unique solution characterized by (8). With the parameters of the experiment, this yields the values as in Table 3. Comparing (3) with (8), we see that the individually and the socially optimal amount of appropriation are identical. Yet from a welfare perspective, individuals holding standard preferences invest too little into innovation. The difference is pronounced if the risk of appropriation is small, while the gap is small if this risk is high.

$c_i^{**} = \sqrt{g_i(1 + \beta) + y - 2\sqrt{\beta y g_i}} - 1$ $c_j^{**} = \sqrt{g_j(1 + \beta) + y - 2\sqrt{\beta y g_j}} - 1$ $a_i^{**} = \sqrt{\beta y g_j} - y$ $a_j^{**} = \sqrt{\beta y g_i} - y$	(8)
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Given we implement a sequential structure, we expect

- H3:** If participants hold standard preferences and this is common knowledge, we expect
- a) investments as in Table 3 if the counterpart's investment is successful
 - b) investments into innovation as in Table 3, and withholding the remainder of the endowment if the counterpart's investment has not been successful

To get an intuition of the forces driving appropriation choices, consider Figure 4. With a few tokens, the expected benefit from investing another token into appropriation is huge in the *Low Risk* treatment, but it decays rapidly. In the *High Risk* treatment, the expected benefit of investing the first tokens is much smaller.

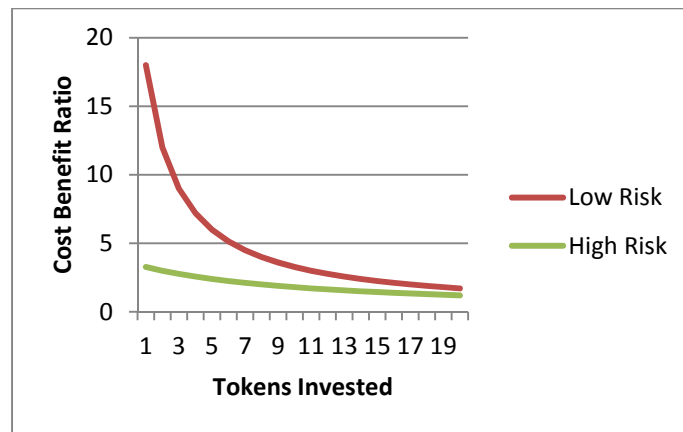


Figure 4
Expected Benefit per Token Invested Into Appropriation

Standard preferences assume risk neutrality. Empirically, most individuals are more or less intensely risk averse. In principle, risk preferences can of course be formalized. We refrain from calculating the equilibria conditional on risk preferences other than risk neutrality, though, since point predictions would require that we fix functional form (absolute or relative risk aversion, constant or not?), and parameters. If appropriation involves a bigger risk than

innovation (treatment *High Risk*), the governance problem should be mitigated; there should be less appropriation. If both investment choices involve the same risk, risk aversion alone should not have an impact on the severity of the governance problem. Using our post-experimental test of risk preferences, we test

- H4:** If participants are risk averse, we expect
- a) less investment into innovation than in equilibrium
 - b) less investment into appropriation than in equilibrium the higher the uncertainty about appropriation
- We expect both effects to be the more pronounced the more the participant is risk averse.

To the extent that actors dislike violations of fairness of desert, we expect the normative problem to exacerbate. While there are competing formal models for distributional fairness (inequity aversion and reciprocity featuring most prominently), the fairness norm of desert has attracted less formal attention. Since it is center stage for our research question, we again abstain from calculating formal behavioral equilibria, and state our expectation qualitatively. Using choices in the modified dictator game for explanation, we expect:

- H5:** The more a participant is sensitive to violations of fairness of desert, the less she invests into innovation.

Finally, even if moral compunctions are not strong enough to completely deter appropriation, participants might still be sensitive to what they see as common in their environment. Using beliefs about the prevalence of appropriation for explanation, we therefore expect:

- H6:** The more a participant thinks it is common to appropriate the success of foreign investment, the more she does so herself.

In the repeated game, we implement a stranger protocol. Participants do therefore not gain knowledge about their individual partner in the current period. Yet they have a chance to learn at the population level. Bad experiences leave a deeper impression than good ones (Engel et al. 2011). We therefore predict

- H7:** If a participant has experienced that her partner has exploited her innovation success, she reduces her innovation activity. To a lesser extent, this also happens if she has successfully appropriated her partner's success.

V. Results

We first present results from the one-shot game, and investigate in the end in which ways results change with experience. Figure 5 first shows that, with both specifications of the appropriation technology, participants on average invest a substantial fraction of their endowment into innovation. Descriptively we clearly find no support for **H1**. Knowing that another anon-

ymous participant will have an opportunity to lay her hand on one's innovation success does not completely deter participants from innovative activity. Actually not a single participant keeps her entire endowment for appropriation. All invest at least a small amount into innovation. One sample sign rank tests refute the hypothesis of no investment into innovation at $p < .0001$, both overall ($N = 120$), and separately for each treatment ($N = 60$).⁴ Actually we even reject the hypothesis in a Popperian sense: we do not observe a single participant who invests nothing into innovation.

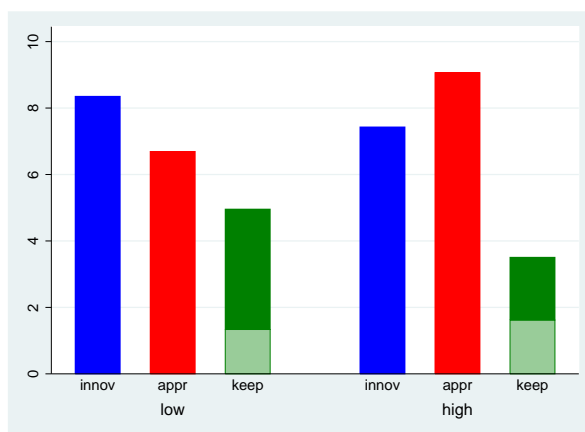


Figure 5

Investment Choices in One-Shot Game

light green: endowment kept if partner's project was not successful

dark green: endowment kept if partner's project was successful

left bars for choices in the Low Risk treatment, right bars for choices in the High Risk treatment

This gives us

Result 1: If innovation and appropriation are costly and risky, the possibility that another participant appropriates one's innovation success does not deter all investment into innovation.

Figure 5 further shows that, in all treatments, investment into appropriation is substantial. Descriptively we thus also clearly refute H_2 . Participants may have moral compunctions against appropriating the success of foreign efforts. But if they exist, these compunctions are not strong enough to completely deter appropriation. Actually, Figure 6 suggests that moral compunctions have at most a very minor effect. Provided the project of their random partner was successful, very few participants do not try at all to increase their income by appropriation. One sample sign rank tests of the hypothesis that participants invest nothing into appropriation reject at $p < .0001$ both overall ($N = 104$) and separately for each treatment ($N = 52$ in both treatments).⁵

4 All statistical tests reported in this paper are two-sided.

5 The sample is confined to cases where the counterpart's project was successful, so that the choice (not) to appropriate is meaningful.

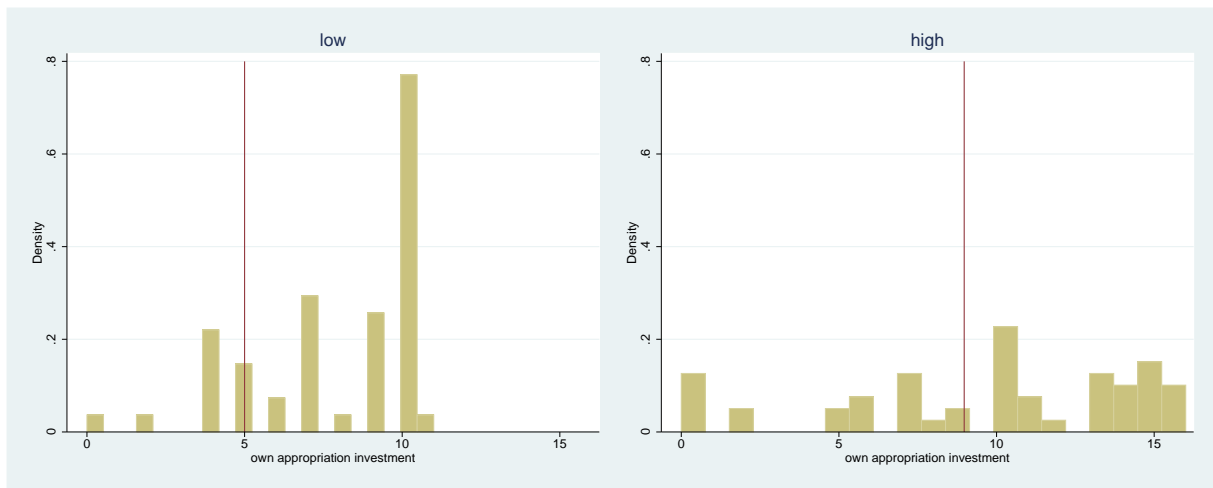


Figure 6
Individual Appropriation Investments in One-Shot Game if Other Project Was Successful
 red line: prediction from standard theory

This leads to

Result 2: Participants have no reticence to appropriate foreign innovation success.

As Figure 5 shows, descriptively appropriation investment is more pronounced in the *High Risk* treatment. Descriptively, there is slightly less investment into innovation in the *High Risk* treatment than in the *Low Risk* treatment, but investment levels are very close. In the *Low Risk* treatment, there is less appropriation than innovation. In the *High Risk* treatment, the opposite holds true. All of this is in line with H_3 derived from standard economic theory.

Mann-Whitney tests show that the treatment effect on appropriation investment is significant, whether we use all data ($N = 120$, $p = .0137$) or confine the sample to cases where the foreign investment was successful ($N = 104$, $p = .0040$). By contrast, the treatment effect on innovation investment is not significant ($p = .112$). Yet, as Figure 7 shows, distributions of innovation investments look very different across treatments. In the *Low Risk* treatment, almost 50% of participants invest exactly half of their endowment into innovation. This peak at 50% of the endowment is absent in the *High Risk* treatment. A Kolmogorov-Smirnov test shows a weakly significant ($p = .052$)⁶ difference in distributions.

6 The Epps Singleton test, which also takes higher moments of the distribution into account and has more statistical power, yields $p = .00204$ on this comparison.

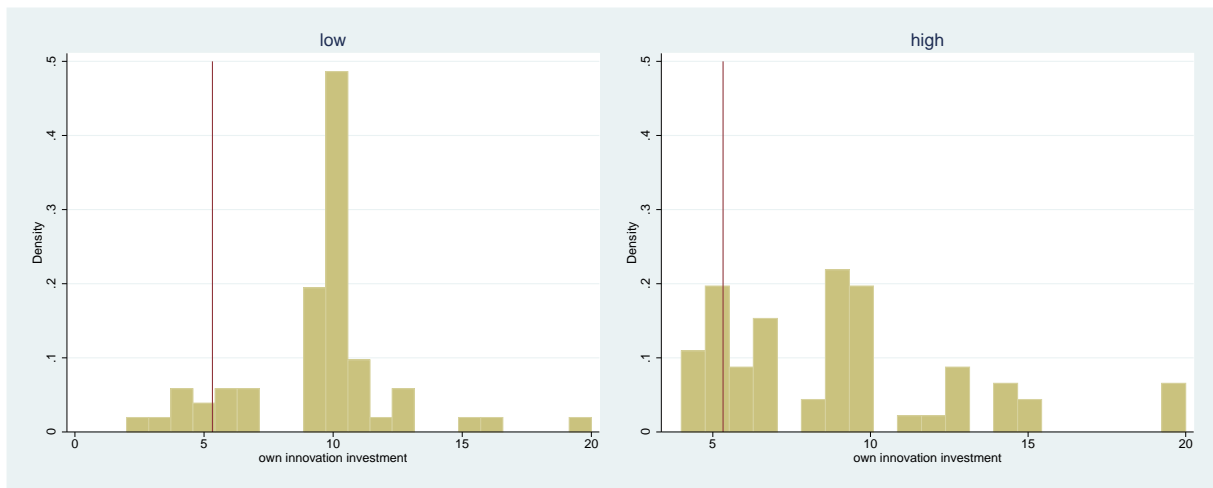


Figure 7
Individual Innovation Investments in One-Shot Game
 red line: prediction from standard theory

We thus support H_3 :

Result 3: If innovation and appropriation are costly and risky, participants split their budgets between innovation and appropriation and react to the cost and the risk of appropriation in the qualitative way suggested by standard economic theory.

Yet standard theory is only qualitatively supported. As Figure 6 shows, in the *Low Risk* treatment, there is more appropriation than predicted by standard theory. This impression is supported by a one sample sign rank test of the point prediction from standard theory ($N = 52$, $p < .001$).⁷ By contrast, the level of appropriation does not significantly differ from the theoretical prediction in the *High Risk* treatment. As suggested by Figure 7, investment into innovation is above the theoretical prediction in both treatments (signrank tests against the point prediction from Table 3, $N = 60$, $p < .001$).

Figure 5 suggests a further deviation from standard theory: it seems that participants spend too much on innovation and appropriation, and save too little of their endowments, compared with the theoretical prediction. In case the foreign project failed, this impression is difficult to verify statistically since we do not know which fraction of the endowment participants would have wanted to use for appropriation. We do, however, have a clean test of the theoretical prediction if the foreign project was successful. In both treatments, the endowment kept is significantly below the prediction from Table 3 (one-sample sign rank test, both $N = 52$, $p < .001$). Participants overinvest.

⁷ The test is again confined to those cases where the foreign project was successful.

Interestingly, in both treatments, innovation investment is closer to the efficient solution than to the Nash prediction. Yet in both treatments, innovation investment is even significantly above the efficient benchmark from Table 3 (one sample signrank tests, $N = 60$, $p < .001$).⁸

To explain the deviations from standard theory, and to cast light on the underlying mental processes, we turn to our post-experimental tests. We start with the decision to invest into appropriation. We estimate Tobit models since our data are slightly left censored. Since appropriation choices are only meaningful if the foreign project was successful, we confine the sample to these cases. Fairness of desert, as measured by the variants of the dictator game, does not explain these choices. By contrast both the belief about the appropriation decisions of others and risk preferences have explanatory power throughout.

As Figure 8 demonstrates, beliefs considerably differ between treatments. The difference is statistically significant (Mann Whitney, $N = 120$, $p = .0008$). Note that, on average, beliefs are fairly accurate. Interestingly, in the *Low Risk* treatment, beliefs are much closer to the empirical distribution than to the theoretical prediction. In the *High Risk* treatment, beliefs are much more spread out, which suggests that participants are considerably less certain what other participants will do.

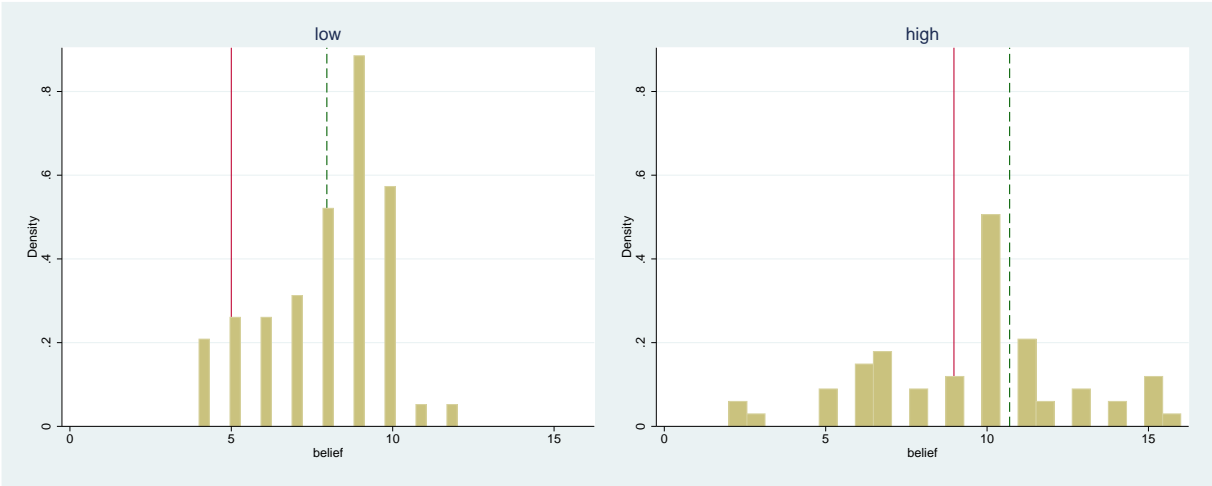


Figure 8
Belief About Amount Others Invest in Appropriation
 red solid line: prediction from standard theory
 green dashed line: actual mean investment

As models 1 and 2 of Table 4 show, beliefs about the appropriation choices of others indeed explain whether a participant invests into appropriation herself.⁹

8 Since the Nash prediction coincides with the efficient investment in appropriation, a separate test of this dependent variable against the efficient benchmark is pointless.
 9 The fact that models 1 and 2 have $N = 104$ results from the fact that, in 16 cases, the innovation was not successful. The fact that models 3 – 6 have $N = 95$ results from the fact that 9 participants were inconsistent on the risk aversion test, so that we do not have a reliable measure of their risk preference.

	model 1	model 2	model 3	model 4	model 5
belief	.815*** (.157)	.777*** (.168)			
<i>High Risk</i>		.875 (.769)		1.593 ⁺ (.889)	3.476*** (.945)
risk aversion			-1.039 (.881)	-.919 (.854)	1.668 ⁺ (.866)
risk aversion* <i>High Risk</i>					-5.059** (1.484)
cons	1.679** (1.411)	1.574 (1.353)	8.938*** (.590)	8.112*** (.617)	7.059*** (.580)
N	104	104	95	95	95
p model	<.0001	<.001	.2412	.0464	.0010
pseudo R ²	.0551	.0578	.0027	.0092	.0272

Table 4
Explaining Appropriation Investment in One-Shot Game

Tobit, lower limit 0

appropriation choices if foreign project was successful

standard errors in parenthesis

*** p < .001, ** p < .01, * p < .05, ⁺ p < .1

In line with **H₆**, we find:

Result 4: Participants invest more into appropriation if they believe that others do so as well.

With our data, we cannot tell whether this is a normative or a descriptive belief. Participants may expect others to appropriate since this expresses their normative conviction about socially acceptable behavior. Or they may expect others to appropriate since they set aside normative compunctions and maximize profit. Yet we know for sure that all participants expect a certain degree of appropriation, and that this expectation is sensitive to our treatment. If there is a norm against appropriation, participants expect it at best to be very imperfectly obeyed.

As usual, few participants are risk seeking (have a negative risk aversion score), while the majority are mildly risk averse.¹⁰ 9 of our 120 participants were inconsistent on this test, meaning that they switched more than once from the risky to the safe option. Since such data is hard to interpret, and in line with the prevalent practice in the literature, we drop these data points from those specifications that use risk aversion as an explanatory variable.

In models 3 and 4 of Table 4 it seems as if risk aversion had no effect on appropriation choices. Yet the pronounced effect of risk preferences becomes visible in model 5, i.e. if we inter-

¹⁰ Risk aversion does not significantly differ between treatments.

act risk aversion with treatment. The effect differs by treatment. In the *Low Risk* treatment, the more participants are risk averse, the more they invest into appropriation ($p = .054$). By contrast in the *High Risk* treatments, risk averse participants invest much less into appropriation (net effect -3.392 , $p = .0060$). This is intuitive. In the *Low Risk* treatment, a small investment already makes appropriation success quite likely. By contrast, in the *High Risk* treatment, appropriation success remains unlikely even if the investment is high. Risk averse participants are deterred from investing into appropriation by the low probability of success. We thus support **H₄** about the effect of risk preferences on investment in appropriation and have

Result 5: Risk averse participants invest more into appropriation if appropriation is as risky as innovation. If appropriation is riskier than innovation, they invest less into appropriation.

Table 5 collects explanations for the amount invested into innovation. Risk aversion does not play a role (we do not support the first statement of **H₄**), but the expectation about the appropriation behavior of others matters, in the expected direction. The more a participant expects her anonymous partner to appropriate her innovation, should it be successful, the less she invests into her own project (model 1). Model 2 shows that there are no treatment differences in this respect. This seems to suggest that innovation investment is deterred by the prospect that others will get a free lunch. Yet model 3 shows that this interpretation is not correct. Once we control for this player's own appropriation investment, the belief becomes insignificant. Despite the fact that in equilibrium the budget constraint does not bind, participants see the use of their endowment as an investment problem. If they believe investment into appropriation is common, they too invest more into that activity, and less into innovation.

	model 1	model 2	model 3	model 4	model 5	model 6
belief	-.254* (.119)	-.255* (.126)	-.110 (.140)			-.257* (.121)
appropriation investment			-.312** (.087)			
<i>High Risk</i>		.012 (.665)	.327 (.620)		-.332 (.629)	.049 (.648)
dictator game giving				.059* (.027)	.059* (.027)	.060* (.027)
cons	11.420*** (1.117)	11.419*** (1.118)	12.403*** (1.155)	8.823*** (.337)	8.990*** (.371)	11.040*** (1.108)
N	120	120	120	120	120	120
p model	.0351	.0390	.0001	.0281	.0821	.0104
R ²	.0390	.0390	.1928	.0554	.0577	.0944

Table 5
Explaining Innovation Investment in One-Shot Game
OLS¹¹

*** $p < .001$, ** $p < .01$, * $p < .05$, + $p < .1$

11 Innovation investment choices are not censored, which is why there is no need to estimate Tobit models.

Three of the four decisions in the dictator game do not have explanatory power. Yet the one dictator game situation that is most congenial also significantly explains choices, model 4-6 of Table 5. In this game, the dictator receives money from the experimenter, while the potential recipient only has an opportunity to earn the same amount in a real effort task. This thus is a situation with an asymmetry not in income, but in the disutility of labor. In such a game, most dictators give nothing. Yet some do.¹²

Models 4-6 of Table 5 provide a further explanation for innovation investment. The more a participant would be willing to donate money to another participant although that participant could earn money herself, the more she is also willing to invest into innovation even if she knows that this may give her anonymous partner a free lunch. This is intuitive. Both situations capture a similar fairness concern. The other player is not deserving. At least at the outset, she has the same opportunity to gain an income. Arguably the more participants set this concern aside in the dictator game, the less they are sensitive to violations of fairness of desert. With this interpretation of the choices in the dictator game we thus support **H₅**.

This gives us

Result 6: The more participants are willing to donate to another participant who could earn money by laborious effort, the more they are also willing to invest into innovation if success can be appropriated by others.

Individual innovators need not be repeat players. They once have a brilliant, marketable idea, and then go back to day-to-day business. For firms in innovation rich industries, this may be different. But repeated innovation need not mean the repeated experience of appropriation. The data from the one-shot game is therefore informative for the policy discourse. But it of course is also interesting to learn whether the effects from the one-shot game are stable over time. Data from the repeated game also helps us see whether learning changes outcomes.

Figure 9 suggests that both innovation and appropriation behavior is sensitive to experiences, yet in different ways. In both treatments, innovation investments decay over time. In the *High Risk* treatment, appropriation investment increases over time. By contrast, appropriation investment decreases in the *Low Risk* treatment. In both treatments, even in the long run there is more appropriation than standard theory predicts. In the *High Risk* treatment, over time appropriation even further deviates from the theoretical prediction.

12 Giving patterns do not significantly differ across treatments.

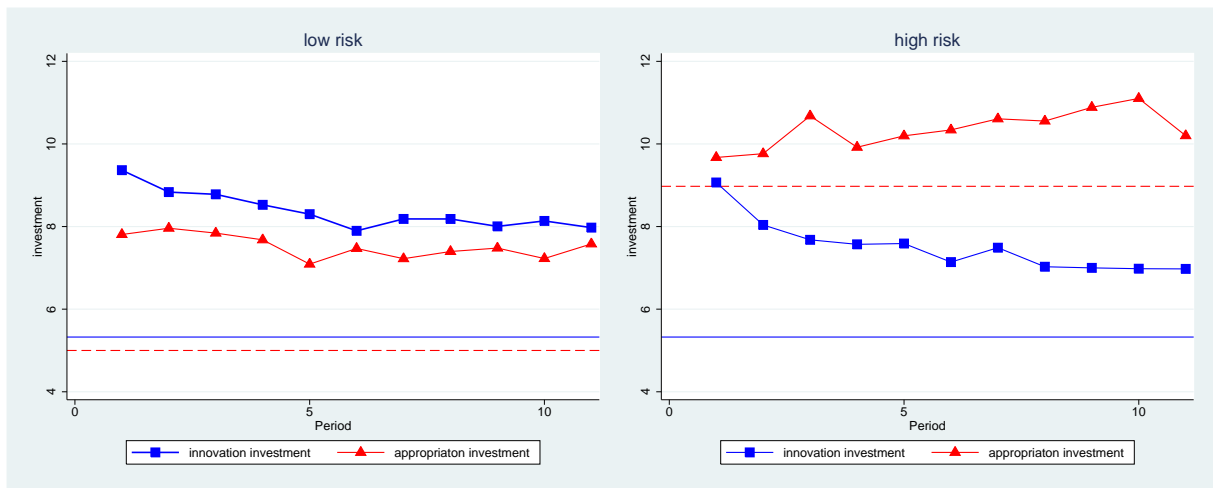


Figure 9

Investment Choices in Repeated Game

appropriation investment: data confined to cases where counterpart's project was successful

This impression is fully supported by statistical analysis, Table 6.¹³ In the repeated game, we replicate the treatment effect on the level of appropriation behavior. If the risk of appropriation investment to fail is high, participants invest significantly more into appropriation. They are thus sensitive to the marginal profitability of appropriation investment, as suggested by standard theory, see Figure 4. The main effect of period is significantly negative, showing that, in the *Low Risk* treatment, appropriation decreases over time. In the *High Risk* treatment, through the interaction effect the overall time trend is pronouncedly positive.¹⁴

As in the one-shot game, in the repeated game, we do not find a treatment effect on innovation investment. The time trend is negative, and even more negative if the risk of appropriation is high.

13 Conditional on the counterpart's project being successful, appropriation investment data is not censored (we only have 45 of 1677 cases where the partner does not invest at all into appropriation). No participant ever invests all 20 tokens into appropriation. Innovation investment data is not censored either. No participants ever invests nothing into innovation. Only in 15 of 1800 cases, a participant invests her entire endowment of 20 tokens into innovation. Since we have data from choices nested in individuals nested in matching groups, we estimate mixed effects models. Hausman tests are insignificant, so that we are justified in using this more efficient estimator.

14 Wald test of period + period*treatment, $p < .0001$.

	appropriation investment	innovation investment
period	-.071** (.025)	-.116*** (.020)
<i>High Risk</i>	1.643** (.631)	-.559 (.648)
period* <i>High Risk</i>	.184*** (.036)	-.061* (.029)
cons	7.955*** (.446)	9.049*** (.458)
N	1143	1320
p model	<.001	<.001

Table 6

Investment Choices in Repeated Game

mixed effects models, choices nested in individuals, nested in matching groups

model 1: sample confined to cases where counterpart's project was successful

Hausman tests insignificant

*** p < .001, ** p < .01, * p < .05, + p < .1

This leads to

Result 7: Experienced players invest less into innovation. If the marginal profitability of additional investment into appropriation is high, experienced players also invest more into appropriation.

In the repeated game in both treatments and for all periods there is significantly more appropriation than predicted by standard theory (Wald tests on constant + period in the *Low Risk* treatment, and on constant + period + treatment dummy + interaction term in the *High Risk* treatment, for all periods, against the predictions from Table 3, data from cases only where counterpart project was successful); in the *High Risk* treatment, in the one-shot game this was not the case. As in the one-shot game, for both treatments and all periods, there is significantly more innovation investment than predicted (same tests, but all data).

From a policy perspective, it is even more interesting to compare results with the efficient outcome (for benchmarks see Table 3). Since the Nash solution is efficient for appropriation, we already know that appropriation is inefficient in both treatments and all periods. Yet innovation investment is also significantly above the efficient level in both treatments for all but the final period (same tests on model 2 of Table 6); the difference is only weakly significant in period 10 (p = .0663 in the *Low Risk* treatment, and p = .0788 in the *High Risk* treatment).

The regressions in Table 7 show that two forces influence the evolution of innovation behavior over time. The more participants experience that others get a free lunch, the more they reduce their innovation activity in the next period (model 1). The reduction is even more pronounced if the partner's innovation was successful (model 2). We thus support our process hypothesis

H7. By contrast, if they have been successful themselves in appropriating foreign innovation success, they increase their own investment in the next round. Participants dislike the experience of others tapping into the results of their effort. But they appreciate the additional earning possibilities for everybody inherent in the public good nature of unprotected innovation if they benefit from others' success.

	model 1	model 2	model 3
lagged appropriation choice of partner	-.057*** (.012)	-.059*** (.012)	-.058*** (.012)
lagged innovation success of partner		-.300* (.151)	-.573** (.173)
lagged own appropriation success			.405** (.126)
<i>High Risk</i>	.058 (.105)	.057 (.105)	.181 ⁺ (.112)
cons	.242* (.106)	.523** (.177)	.445* (.178)
N	1200	1200	1200
p model	<.001	<.001	<.001

Table 7

Explaining Dynamics of Innovation Investment

dv: first differences of innovation investment

linear mixed effects, choices nested in individuals nested in matching groups

Hausman tests insignificant

*** $p < .001$, ** $p < .01$, * $p < .05$, ⁺ $p < .1$

We summarize

Result 8: Players reduce innovation investment if their innovation has been appropriated, and if their counterpart's innovation has been successful. They increase innovation investment if they have made additional profit from appropriation.

VI. Conclusion

In the policy debate, often the impression is conveyed that tight legal protection is a precondition for the willingness of individuals or firms to take the risk of innovation. Arguably, from a behavioral perspective, the problem should be even more pronounced. If someone else exploits the success of my efforts, this violates the fairness norm of desert. I am the sucker, which violates distributional fairness. If innovation is risky, risk aversion should further deter investment into innovation.

To test these conjectures, we ran a lab experiment. Overall, we do not find support for the concern. Qualitatively, participants behave as predicted by standard economic theory. They understand that the setting calls for splitting their budget between innovation and appropriation, reacting to the comparative profitability of both investments.

We do find more appropriation than predicted by standard theory, though. This is unwanted from a welfare perspective. But the deadweight loss exclusively results from the fact that participants save too little. Innovation is not deterred. To the contrary, we not only find more innovation than standard theory predicts, but even more innovation than would be welfare maximizing. Participants overinvest into both activities.

Appropriation choices are explained by the expected behavior of one's peers. Risk averse individuals invest less into appropriation if the risk is high that this investment fails.

Innovation choices are sensitive to fairness concerns. The more participants expect innovation success to be exploited by others, the less they invest. If their random counterpart has tapped into their efforts in the previous period, they reduce innovation in the subsequent period. They also do so if their anonymous partner had been successful in her innovation investment in the previous period. Yet the more participants are willing to give as dictators to a recipient who might earn an income herself, the more they also invest into innovation. If they have received additional income from appropriating foreign investment in the previous period, in the subsequent period they increase their own investment into innovation. And, despite their sensitivity to fairness concerns, participants still invest even more than the efficient amount.

Experiments are not meant to map reality. They are tools for identifying causal effects. Consequently, one should be cautious when drawing policy conclusions. Policymakers might nonetheless find it important to learn that the cost and the risk of appropriation matter. If appropriation is not free of charge, and if its success is uncertain, innovation is not deterred, even if it is not protected by intellectual property rights. If the law nonetheless grants a monopoly, this may lead to a welfare loss, provided the additional benefit from giving the innovator even stronger incentives is smaller than the resulting deadweight loss. Policymakers might still want to do something about excessive appropriation, both on efficiency grounds and since innovators dislike it. Yet if one may extrapolate from the lab to the field, the main concern in the policy debate is not valid. If innovation is not legally protected, this does not stifle innovation, as long as appropriation is also costly and risky.

We have, of course, only tested two situations in which the risk is pronounced that investment into appropriation fails. In future work, one might want to make appropriation even less costly, or less risky, than innovation. It is not unlikely that innovative activity would cease if the comparative profitability of appropriation is too high. But such a setting would not only change the fairness assessment, it would also affect predictions from standard theory. Moreover we would no longer be able to isolate the disincentive resulting from the fact that another agent may tap into one's success. Rather we would only have seen the well-documented disincentive from (expected) payoff falling behind the payoff of a peer. Besides it would also be an interesting next step to have imitation reduce innovators' profit. All we wanted to test in this paper is the chilling effect on innovation resulting from the prospect that another agent gets a free lunch. We have not found any such chilling effect.

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Appendix: Instructions

[The following are the instructions for the *High Risk* treatment. For the *Low Risk* treatment, replace the second table and the second graph as in Figure 3]

Welcome to our experiment!

If you read the following instructions carefully, you can earn a substantial amount of money, depending on your decisions. It is therefore very important that you read these instructions carefully.

During the experiment, any communication with the other participants is strictly forbidden. Disobeying this rule will lead to exclusion from the experiment and from all payments. If you have any questions, please raise your hand. We will come to you.

In most parts of the experiment, we shall speak not of Euro, but instead of Taler. In these parts of the experiment, your income is hence initially calculated in Taler. The total Taler amount you earn during the experiment is converted into Euro at the end, at the following rate, unless stated otherwise:

1 Taler = 2 Eurocent

At the end, you will be paid your total earnings from the experiment **in cash** and in Euro. Your earnings will not be less than 4 Euro.

The experiment consists of six parts. We will begin by explaining the first part. You will receive the instructions for the other parts afterwards. **Payments from all later parts do not depend on your decisions or income from earlier parts of the experiment.**

First Part of the Experiment

In this part of the experiment, you are randomly matched with a second participant. You are not told which participant this is.

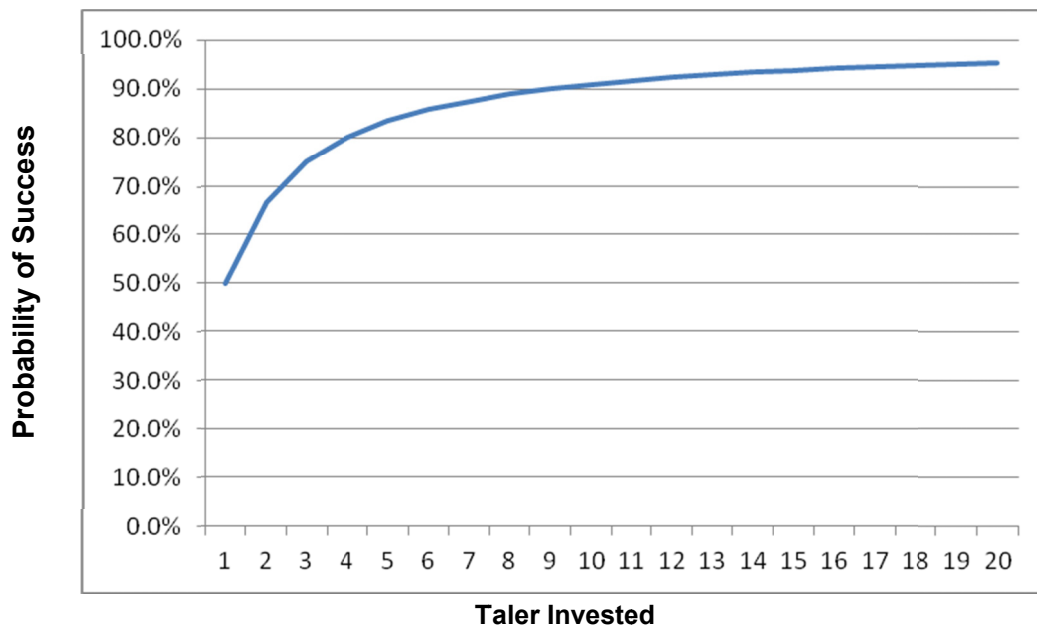
The first part of the experiment consists of two steps.

You will receive an endowment of 20 Taler. You may keep this endowment in its entirety or in part. Alternatively, you may also use all or part of your endowment in the first or the second step. In the second step, however, you can only use the Taler that you have retained in the first step.

Step One

In the first step, you can invest Taler in a project. If the project is **successful**, you will receive **40 Taler**. The more Taler you invest, the more likely it is for the project to be successful. The following table shows you with which probability the project will be successful if you invest a certain number of Taler in the project. The figure is a graphic depiction of the same context.

Taler Invested	Probability of Success, in %
1	50.0
2	66.7
3	75.0
4	80.0
5	83.3
6	85.7
7	87.5
8	88.9
9	90.0
10	90.9
11	91.7
12	92.3
13	92.9
14	93.3
15	93.8
16	94.1
17	94.4
18	94.7
19	95.0
20	95.2



The participant assigned to you has exactly the same task as you do. This participant also decides, in the first step, how many Taler to invest in his or her project.

Step Two

In the second step, you are told whether your project from step one has been successful. At the same time, you are told how many Taler the participant with whom you have been randomly matched invested in the project in step one, and whether this participant's project (referred to henceforth as the "foreign project") has been successful. Similarly, this participant is told how many Taler you invested in your project, and whether your project has been successful.

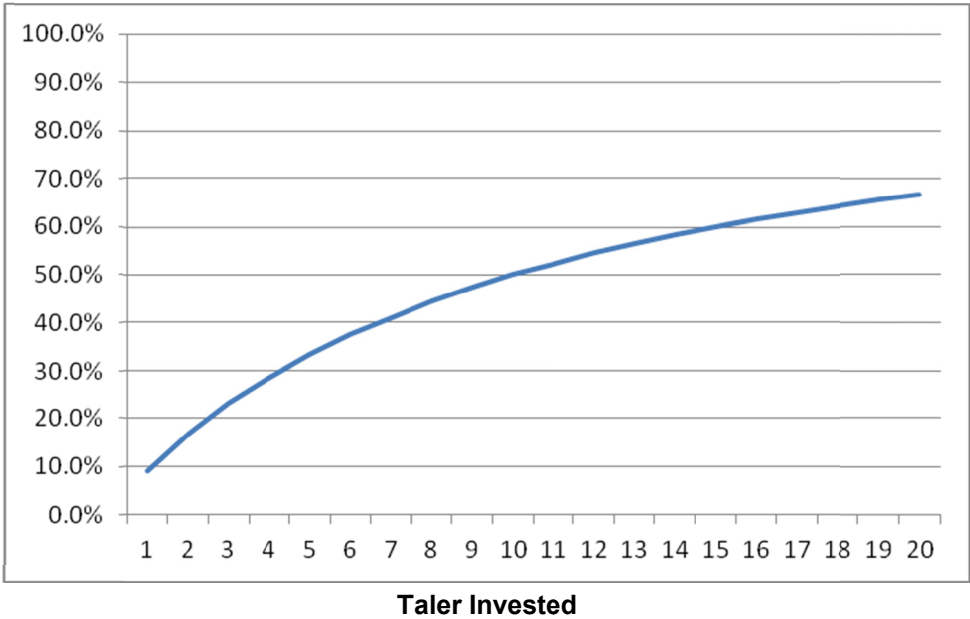
In this second step, you have the opportunity to use the success of the project of the participant assigned to you for your own means. In order to do this, you may invest a maximum of all Taler remaining at your disposal from your endowment. You will receive a maximum of 90% of the winnings the other participant has made from his or her project in step one. In turn, the participant assigned to you has the opportunity to use the success of your project from step one for his or her purposes. **Neither the success of your own project from step one nor the success of the foreign project from step one is affected by these decisions. Participants hence keep their respective winnings from step one in their entirety.**

The more Taler you invest, the more likely it is that you will gain from using the foreign project (assuming the foreign project was successful). Every Taler invested thus increases the likelihood that you will receive winnings from using the foreign project, and that will be **90%** of the winnings of the foreign project. The following table shows you with which possibility you will receive winnings from using the foreign project, if

you invest a certain amount of Taler. The figure is a graphic depiction of the same context.

Taler Invested	Probability, in %, of successfully gaining from using the foreign project
1	9.1
2	16.7
3	23.1
4	28.6
5	33.3
6	37.5
7	41.2
8	44.4
9	47.4
10	50.0
11	52.4
12	54.5
13	56.5
14	58.3
15	60.0
16	61.5
17	63.0
18	64.3
19	65.5
20	66.7

Probability, in %, of successfully gaining from using the foreign project



Total Earnings

Your total earnings from this part of the experiment add up as follows:

$$\begin{aligned} \text{Your total earnings} &= \text{Your endowment} \\ &\quad - \text{Investment in your project} \\ &\quad + \text{Winnings from your project (first step)} \\ &\quad - \text{Investment in using foreign project} \\ &\quad + \text{Winnings from using foreign project (second step)} \end{aligned}$$

Second Part of the Experiment

This part of the experiment follows from the first part. We would like to hear your opinion. What do you think about the following?

1. In your opinion, what percentage of participants invested, in step two, in using the success of the project of the participant assigned to them for themselves, assuming that this project was successful in step one?
2. In your opinion, how many Taler have these participants invested on average in step two? I.e., how many Taler have the participants who decided to use the success of the project of the participant assigned to them invested on average, assuming that the project of the participant assigned to them was successful in step one?

You will receive 50 Taler if your estimate in question 1 is no further away than 5 % from the actual percentage. You will receive an additional 50 Taler if your estimate in question 2 is no further away than 1 Taler from the actual average amount invested.

We will inform you about the results from this part of the experiment at the end of the experiment.

Third Part of the Experiment

The third part of the experiment is exactly the same as the first part of the experiment. Only now, a new participant is randomly assigned to you ten times. Both participants make the decisions we have described in the first part of the instructions. **Participants are randomly matched anew for each of the ten rounds.**

[Fourth Part of the Experiment: Holt and Laury 2002 with standard instructions at the computer screen]

Fifth Part of the Experiment

In this part of the experiment, you will be randomly matched once again with another participant. At the end of this part of the experiment, the computer will be used for a second draw to determine whether you will have the active or the passive role in this part of the experiment. We ask all participants to decide how they intend to behave in case they are given the active role. Participants with the active role have the opportunity to send any part of their income from this part of the experiment to the passive participant. If you choose 0%, you retain your entire income for yourself. If you choose 100%, you send your entire income to the passive participant. You may choose any percentage between 0 and 100%.

We will ask you to make a binding decision for the four different situations that are described in the following table:

		Passive role	
		No income	Income earned
Active role	Income given		
	Income earned		

Which of the four situations actually occurs is also determined by a random draw (all situations are equally probable). If you have the active role, and once the income is "given", you will receive an advance income of 125 Taler. If you have one of the two roles and the income has to be "earned", you will be shown 5 tables like the following one:

4.67	4.81	3.05
5.82	5.06	4.28
6.36	5.19	4.57

Your task is to find the two cells that add up to 10. In each table, there are only two cells that add up to 10. You have as much time for this task as you require. For every task that you have solved correctly, you will receive an income of 25 Taler (hence a possible total of 125 Taler). If you have the passive role and are in one of the "no-income" situations, you will not receive any income of your own.

However, you will only receive a payoff from this part and all other parts of the experiment once you have correctly solved all 5 tasks.

The earnings for participants with active and passive roles are hence as follows in the four situations:

		Passive role	
		No income	Income earned
Active role	Income given	Active role: 125 Taler income – Taler sent Passive role: 0 Taler income + Taler received	Active role: 125 Taler income – Taler sent Passive role: 125 Taler income + Taler received
	Income earned	Active role: 125 Taler Einkommen – Taler sent Passive role: 0 Taler income + Taler received	Active role: 125 Taler income – Taler sent Passive role: 125 Taler income + Taler received

This part of the experiment once again operates with the exchange rate of 1 Taler = 2 Eurocent.