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Probability Matching and the Law: A New Behavioral Challenge to Law and Economics

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Abstract

Economic analysis of law assumes that individuals with fixed preferences who face a choice repeatedly will behave consistently. Reality, however, is different. A driver sometimes drives legally and at other times speeds; a businesswoman sometimes defrauds the tax authorities and at other times pays her due. This paper uses the phenomenon of "probability matching," well-documented in psychological literature, to provide a comprehensive theory of behavioral changes. By using experimental literature and by conducting a new experiment, this paper demonstrates that behavioral changes can be predicted, theorized, and can provide a basis for policy making.

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Introduction

Both criminals and tortfeasors incur costs of a probabilistic nature. In the case of criminal behavior, the criminal incurs a cost only if caught and prosecuted. In cases of negligence, a tortfeasor incurs a cost only if the damage materializes. Therefore, to determine whether a rational, utility-maximizing individual is likely to perform a crime or a tort requires knowledge of four variables: the probability that the cost will materialize, the size of the cost, the benefit the perpetrator gains from her behavior, and her attitude towards risk. Given these four factors, traditional law and economics suggests that individuals will act—consistently—in a way that maximizes their utility. If an individual repeatedly faces a choice between paying a parking fee or parking illegally, and her relevant beliefs and preferences remain constant, she will always make the same choice. If, on the other hand, she alters her behavior, this change must be attributed to changes in her beliefs or preferences.

Using psychological tools, this article challenges this assumption and demonstrates that behavioral changes can be predicted. Most importantly, this article demonstrates that, contrary to the predictions of law and economics, an individual facing identical choices – even if her relevant beliefs, preferences, and attitudes to risk remain fixed – is unlikely to act consistently. A driver will sometimes drive legally and, at other times (and under identical circumstances) will speed. A businesswoman faced with repeated opportunities to defraud the tax authorities will sometimes cheat and at other times pay her due. Yet, although individuals do not act in a consistent manner, their behavior is not erratic. It is sufficiently rule-governed to facilitate the rational design of enforcement mechanisms.

This article has both descriptive as well as normative ambitions. Descriptively, it challenges a dominant tradition in law and economics – the tradition that holds that individuals are expected to act consistently when they face identical choices, and that inconsistencies are to be explained by changes in preferences or beliefs. Normatively, the article challenges some of the most established recommendations of law and economics in the areas of law enforcement, sentencing policy, and tort law.

This article is divided into four sections. Section I provides the psychological background. It presents the robust findings of the psychological literature concerning "probability matching." Probability matching is the term used by psychologists to describe the behavior of individuals who repeatedly face choices involving probabilistic costs and benefits. Probability matching suggests that, when repeatedly faced with such choices, individuals do not act consistently in a way that maximizes their utility. Rather, they choose to adopt a "mixed strategy" in which they make choices dictated by the probability of the costs or benefits. Section II explains the relevance of probability matching to the legal context and also describes an experiment designed to illustrate this relevance. This experiment—the "traffic warden experiment"—demonstrates that individuals facing a choice between either conforming to the law or violating it and facing the risk of a fine do not act in a way that maximizes their payoffs. Instead, they manifest behavior patterns that fit the predictions of probability matching. Section III explores the normative implications of this approach. In particular, it demonstrates that an optimal enforcement system ought to take into account the inconsistencies predicted by probability matching. A policy-maker or legislator ought to base their policies, not on the assumption that individuals always maximize their payoffs, but rather on the understanding that people sometimes behave as "probability-matchers." Probability matching provides an intelligible framework to articulate the common accusation that human beings are inconsistent and, at the same time, to account for this inconsistency in a way that is conducive to the legal regulation of behavior.

I. Probability Matching: Psychological Background

Assume that you are given a die with 4 red faces and 2 white faces. You are told that the die will be rolled 100 times. You are also told that if you predict correctly the color of each roll, you will receive a reward—$10 for a correct "red" guess and $10 for a correct "white" guess. What would one do under these circumstances? What ought one to do under these circumstances?

The "maximization rule"—the rule that maximizes the expected value of the awards—would require participants to choose the red color in all 100 rolls. Yet, subjects participating in such game who were asked to evaluate alternative strategies often preferred a mixed approach.[1] According to this strategy, bets would be divided so that red is chosen in 2/3 of the rolls and white in 1/3 of the rolls.[2] Psychologists have labeled this phenomenon as "probability matching." Probability matching can be defined as the disposition to adopt a mixed strategy dictated by the relative frequency, even when the utility-maximizing strategy would be to always behave in a way that presupposes that the most probable event would occur.

"Probability matching" implies that there is a difference between the behavior of participants in a single-shot game with binary results and cases involving repeated games. In a single roll of a die with 4 red faces and 2 white faces, individuals consistently pick the red color. In contrast, when presented with a repeated game involving many rolls of the die, subjects do not simply decide as if each game is independent. Instead, their guesses are guided by the ratio of relevant probabilities and consequently they adopt a mixed strategy. Put differently, while in a one-shot game with binary options individuals are expected to maximize their prospects of success, in repeated choice scenarios they will behave in a sub-optimal manner.[3]

Probability matching has been extensively documented in the psychological literature.[4] Several tens of experiments have showed that participants consistently deviate

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[1] For studies reporting such results, see, for example, Ido Gal & Jonathan Baron, *Understanding Repeated Simple Choices*, 2 THINKING AND REASONING 81 (1996) (reporting that a majority of college students participating in a die-rolling experiment did not opt for the maximization rule); Richard F. West & Keith E. Stanovich, *Is Probability Matching Smart? Associations between Probabilistic Choices and Cognitive Ability,* 31(2) MEMORY & COGNITION 243 (2003) (finding that most students rejected the maximization rule and instead applied the strategy of "probability matching".).

[2] Choosing the red color for all 100 rolls produces, on average, 66.6 correct red guesses. The "probability matching" strategy provides 44.4 correct red guesses (2/3 × 2/3) and 11.1 (1/3 × 1/3) correct white guesses, thus a total of roughly 55.5 correct guesses.

[3] The fact that participants fail to maximize their payoffs in the repeated choice scenarios has attracted the attention of many theorists. Kenneth Arrow, for example, noted that "We have here an experimental situation which is essentially of an economic nature in the sense of seeking to achieve a maximum of expected reward, and yet the individual does not in fact, at any point, even in a limit, reach the optimal behavior." Kenneth J. Arrow, *Utilities, Attitudes, Choices: A Review Note*. 26 ECONOMETRICA 1 (1958)

[4] See, for example, Edmund Fantino & Ali Esfandiari, *Probability Matching: Encouraging Optimal Responding in Humans*, 56 CANADIAN JOURNAL OF EXPERIMENTAL PSYCHOLOGY 58 (2002), stating that "Probability matching is an extremely robust phenomenon".

from the maximization rule.[5] In one of the classical experiments, duplicated many times, participants observed a long series of flashing lights, some of them green and others red. The flashing lights appeared on the screen randomly, but such that 70% of the flashing lights were green and 30% red. At the end of an initial session in which the lights were shown, participants were asked to guess the color of the next 100 flashing lights. Consistent with the probability matching phenomenon, 70% of the time participants predicted that the next flashing light would be green, and 30% of the time that it would be red. Participants were capable of observing the probability of the lights, but failed to pursue the optimal strategy—the strategy most likely to maximize their pay-offs. Instead of always choosing green and thus guessing correctly in 70% of cases, they adjusted their answers to the relative frequency of the events.

Studies indicate that subjects apply "probability matching" for gains as well as for losses. For example, in one version of the flashing lights experiment, participants were given monetary rewards for every correct guess. In another form of the experiment, subjects were granted a certain amount of money as an endowment, and a fine was imposed for every incorrect answer. The results showed that in both instances individuals correctly observed the probability of each color, but failed to adopt the rule that maximizes their prospects of successful guess.[6] Instead, subjects consistently followed

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[5] For an overview of the literature see, for example, Nir Vulkan, *An Economist's Perspective On Probability Matching*, 14 JOURNAL OF ECONOMIC SURVEYS 1 (2003). While probability matching has been extensively documented, several experiments have shown that it may decrease (although not be eliminated) under some circumstances. Some studies, for example, have shown that after a very large number of trials, some individuals' asymptotic performance exceeds that predicted by probability matching. High monetary reward/fines for correct/incorrect guesses were also shown to occasionally induce individuals to improve their choices and apply strategies that produced better results than the ones generated by probability matching. Nevertheless, even under such circumstances, individuals often continued to "match probabilities" rather than apply the maximization rule. For experiments in which participants used the strategy of probability matching despite substantial monetary payoff and the repetition of the experiment see, for example, Sigel Sideny & D.A. Goldstein, *Decision Making Behavior in a Two Choice Uncertain Outcome Situation*, 57 JOURNAL OF EXPERIMENTAL PSYCHOLOGY 37 (1959); Alice F. Healy & Michael Kubovy, *Probability Matching and the Formation of Conservative Decision Rules in a Numerical Analog of Signal Detection*, 7 JOURNAL OF EXPERIMENTAL PSYCHOLOGY: HUMAN LEARNING AND MEMORY 344 (1981); Hal. R. Arkes & Robyn M. Dawes, *Factors Influencing the Use of a Decision Rule in a Probabilistic Task,* 37 ORGANIZATIONAL BEHAVIOR AND HUMAN DECISION PROCESSES 93 (1986); Daniel Friedman & Dominic W. Massaro, *Understanding Variability in Binary and Continuous Choice*, 5(3) PSYCHONOMIC BULLETIN & REVIEW 370 (1998).

[6] See, for example, P. SUPPES & R. C. ATKISON, MARKOV LEARNING MODELS FOR MULTI PERSON INTERACTIONS (1960) conducting three similar experiments differing only in the payoff and penalty given for correct and incorrect guess. In the first experiment, 1 cent was given for a correct guess and 0 for an incorrect guess. In the second experiment, 5 cents were given for a correct guess and a penalty of 5 cents

the "probability matching" strategy. Experiments also showed that probability matching is insensitive to the distribution of the probabilities. Whether the proportion between green and red lights was 90% to 10% or 60% to 40% proved to be insignificant. In all cases subjects predict the subsequent flashings in accordance with the observed probability of each color.[7]

Additional experiments indicate individuals react in a similar manner when confronted with asymmetrical payoffs. In such cases, the rates at which subjects choose each option are equal to the corresponding expected gain. Rather than simply following the probability of each event, participants also adjust for the different payoffs.[8] For example, if in the red/white die experiment, the reward for a correct "red" guess is $6, and $15 for a correct "white" guess, subjects will continue to apply a mixed strategy but increase the rate in which they choose "white." As the expected payoff for a "red" guess is $4 (2/3 × 6), and $5 (1/3 × 15) for a white guess, bets will be divided in a 4 to 5 ratio.

Signal detection and prediction of die rolling are rather artificial environments. Yet probability matching has also occurred in more natural settings, representing more realistic everyday dilemmas.[9] For example, in a series of studies, participants were asked

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for incorrect guess. Finally, in the experiment third format, a correct guess was worth 10 cents and an incorrect guess triggered a penalty of 10 cents. In all three variations subjects generally applied the strategy of probability matching rather than the maximization rule. Other experiments in which penalty for incorrect guess was the only payoff (that is, correct guess triggered no reward and no penalty) similarly demonstrated subjects' use of the "matching" strategy. See Vulkan, *supra* note 5 at 9.

[7] See, for example, W. K. Estes & J. H. Strughan, *Analysis of A Verbal Conditioning Situation in Terms of Statistical Learning Theory*, 47 JOURNAL OF EXPERIMENTAL PSYCHOLOGY 225 (1954) (reporting the use of the probability matching strategy in experiments in which probability distribution was rather extreme, that is, low probability for a green light (15%) and high probability (85%) for a red light); Myers et al. *Differential Memory Gains and Losses and Event Probability in a Two-Choice Situation*, 66 JOURNAL OF EXPERIMENTAL PSYCHOLOGY 521 (1963) (similarly observing the application of probability matching when the distribution of the probabilities is almost balanced (60%--40%)).

[8] This is known as the "matching law", expressed by the following equation:

$$\frac{R1}{R1+R2}=\frac{r1(A)}{r1(A)+r2}$$

Where $R\mathbf{1}$ represents the rate of responding on one response alternative and $R\mathbf{2}$ represents the rate of responding on a second alternative; $r\mathbf{1}$ and $r\mathbf{2}$ represent the respective rates of payoff for those alternative; and A represents the amount by which the payoff for one alternative differs from the amount of the payoff for the other alternative. *See generally* MICHAEL DAVISON & DIANE MCCARTHY, THE MATCHING LAW: A RESEARCH REVIEW (1988).

[9] For a general overview, see Wayne W. Fisher & James E. Mazur, *Basic and Applied Research on Choice Responding*, 30 JOURNAL OF APPLIED BEHAVIOR ANALYSIS 387 (1997)

to assume the role of medical practitioners making diagnoses about a series of patients.[10] Subjects had initially learned the correlation between the existence of certain symptoms and the likelihood for the disease. Subsequently, participants were presented with the description of the symptoms of several patients. To maximize the probability of correct diagnoses, participants should have consistently chosen the outcome (disease/not disease) that had been more frequently associated with that particular symptom pattern. Participants, however, appear to make judgments which are guided by the ratio of probabilities. In one study, for example, one particular symptom pattern predicted a disease with 78% probability. To maximize the probability of correct diagnoses, participants should diagnose any person with the relevant symptoms as having this particular disease. Yet participants in this experiment attributed the disease only to 75% of the cases involving these symptoms.[11]

A recent study strengthens the conjecture that individuals use probability matching in real life situations. Researchers investigate basketball players' allocation of 2 and 3 point shots.[12] Basketball players typically face two options: shooting a long-range 3 point shot, or a short-range 2 point shot. Accumulated data from NCAA and NBA games showed that probability matching successfully predicts the ratio in which players choose between these options. Assume, for example, that a certain player scores, in average, every other 2 point shot, but only one sixth of his 3 point shots. The expected utility of the former is thus 1 point, while only 0.5 point for the latter. If the player followed the

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[10] For description of these studies and their results, see David R. Shanks et al. *A Re-examination of Probability Matching and Rational Choice*, 51 J. BEHAV. DEC. MAKING. 233, 235 (2002). For another recent study using real life setting see Michael H. Brinbaum & Sandra V. Wakcher, *Web-based Experiments Controlled by JavaScript: An Example from Probability Learning*, 34(2) BEHAVIOR RESEARCH METHODS, INSTRUMENTS, & COMPUTERS 189 (2002) (demonstrating participants applied probability-matching strategy in a horse race scenario in which participants had to predict the winner in each of a series of races).

[11] David R. Shanks, A *connectionism account of base-rate biases in categorization* 3 CONNECTION SCIENCE 143 (1991)

[12] Timothy R. Vollmer & Jason Bourret, *An Application of the Matching Law to Evaluating the Allocation of Two-and-Three-Point Shots by College Basketball Players*, 33 JOURNAL OF APPLIED BEHAVIOR ANALYSIS 137 (2000) (finding that for players with substantial playing time, results showed that the overall distribution of two-and-three point shots was predicted by the "probability matching" strategy and not the maximization rule). Vollmer and Bourret's original research used data regarding NCAA players. Subsequent research, using data regarding NBA games, has also shown the applicability of the "matching law" for the allocation of shots. *See* Jason Bourret & Timothy R. Vollmer, *Basketball and the Matching Law*, 3 BEHAVIORAL TECHNOLOGY TODAY 2, 4 (2003)

strategy that maximizes his prospects of winning, he would shoot only short-range shots. The data, however, indicate otherwise. Basketball players generally apply the strategy of "probability matching." The allocation of shots follows the relative payoff each shot produces, considering the probability of scoring and the point to be awarded if successful (2 or 3 points). Hence, since the expected payoff for a 2 point shot is twice the expected payoff for a 3 point shot, the player shoots one long-range shot for every two short-range shots.[13]

The robustness of the probability matching phenomenon is further indicated by its occurrence even when the subject is cued about the correct strategy to pursue. For example, in the flashing lights experiments, instructing subjects that winning the game requires guessing correctly only 75% of the time - when green lights were to be flashed 75% of the time – did not induce subjects to apply the maximization rule.[14] For every several greens, subjects continued to occasionally guess red. Similarly, even explicitly informing the subjects in the lights experiment of the exact probabilities increased the number of correct guesses but did not lead participants to adopt the maximization rule.[15]

Why do people prefer to adopt the probability matching strategy to the maximization rule? One can only speculate, but it seems that the explanation is partly grounded in the instinctive wishes of participants to prefer a strategy that can guarantee full success (with very little probability) over a strategy that would yield a relatively large

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[13] Under some circumstances, it is rational for players to choose the type of shot that is less likely to maximize their payoff. With only moments to the end of the game, for example, a rational player should immediately shoot the ball regardless of the expected payoff. Considering, however, that such shots are not frequent, Vollmer and Bourret's use of only players with substantial playing time and number of shots ensures that such rare shots will not affect the final results. Sub-optimal allocation of shots, to some degree, can be a rational strategy. By diversifying the types of shots, a player makes it more difficult for his opponent to anticipate his next shot. Yet, this cannot explain the consistent results in Vollmer and Bourret's study. Diversification would justify only a certain percentage of sub-optimal shots. As Vollmer and Bourret indicate, however, the ratio of shots is different from player to player. Probability matching thus appears to be the only account for the data.

[14] *See* Fantino & Esfandiari, *supra* note 4 at 62. See also Arkes & Dawes, *supra* note 5 at

[15] *Id.* See also Michael H. Birinbaum & Sandra W. Wakcher, *supra* note 10 at 197 (concluding from their results that that despite "explicit instructions concerning the optimal strategy, accompanied by information about the probability of events … [participants'] performance still falls well short of optimal behavior"). For another familiar experiment see Richard C. Nies, *Effects of Probable Outcome Information on Two-Choice Learning*, 64 Journal of Experimental Psychology 430-433 (1962) (reporting that providing participants the exact probability for each possible outcome made only 4 of the 192 participants to attain the optimal strategy of always predicting the more likely event).

number of correct guesses, but would inevitably lead to some errors. [16] Choosing "red" in all 100 rolls guarantees a large number of correct guesses, but inevitably produces wrong guesses about 1/3 of the time; after all red is expected to appear in only 2/3 of the rolls. Using instead probability matching (that is, guessing red in 2/3 of the rolls and white in 1/3) can yield, even if with little chance, 100 correct guesses.

Some scholars have argued that probability matching might actually be a rational strategy.[17] Using insights from game theory, it has been shown that opting for the less frequent event can be efficient in competitive environments with multiple agents. Assuming payoff is constant, because it is expected that most subjects will choose the more frequent event, this payoff will be distributed among many. In contrast, choosing the less frequent event promises the decision maker the whole payoff, undivided, when it materializes.[18] Consider, for example, the die-rolling experiment. If the game is conducted with multiple players, it can be rational to occasionally select "white" rather than "red." Although "white" is the less frequent event, since most players choose "red," each will receive only a small part of the prize. A decision maker choosing "white," however, will receive the prize alone, which may more than compensate for the reduced chances of winning. As such, the wide application of the probability matching strategy can be viewed as a rule of thumb, appropriate to many of the environments in which individuals interact. Some environments, however, are not competitive. In such environments application of the maximization rule would have produced better results.

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[16] *See* Arkes & Dawes, *supra* note 5 at 94 (explaining that individuals avoid adopting strategies that are "blatantly imperfect", securing for example a hit rate of 70%, even if any other strategy is statistically inferior). Several studies have suggested that subjects, even if told and demonstrated that the sequence is random, tend to believe there is nevertheless a pattern. Probability matching occurs because "[a]ny reasonable pattern hypothesized by the subjects would have to match frequency if it were to be a correct hypothesis." George Wolford, Michael B. Miller, and Michael Gazzaniga, *The Left Hemisphere's Role in Hypothesis Formation*, 20. RC64 THE JOURNAL OF NEUROSCIENCE 1 (2000). *See also* Fantino & Esfandiari, *supra* note 4 at 59 (suggesting probability matching occurs because "subjects in probability-matching task are attempting to devise a strategy in which they are correct on close to 100% of trials.").

[17] *See e.g.*, GERD GIGERENZER, ADAPTIVE THINKING: RATIONALITY IN THE REAL WORLD 204-06 (2000) (arguing that while the maximization rule is efficient in social isolation, probability matching can be the optimal strategy in many contexts involving social interaction).

[18] *See, e.g.*, CHARLES. R. GALLISTEL, THE ORGANIZATION OF LEARNING, Ch. 11 (1990) (explaining that probability matching can be the most efficient strategy in competitive environments.)

II. Probability Matching and Criminal/Negligent Behavior

A. Introduction

This section is divided into two sub-sections. In sub-section B we demonstrate the relevance of probability matching to law-related behavior. More specifically, we argue that traditional economic analysis of law cannot provide a useful theory concerning behavioral changes. While it concedes that the same individual facing identical choices behaves inconsistently, these differences are not properly theorized. In contrast, probability matching can provide useful predictions concerning preference changes. In sub-section C we present the results of a simple experiment designed to investigate the relevance of probability matching to legal contexts. Most significantly, both sections demonstrate that behavioral changes can be explained and theorized in a way that so far has not been exploited by legal theorists.

B. Probability Matching as Predictive of Criminal/Negligent Behavior

Different individuals who face identical options often make different choices. Economic analysis of law has traditionally explained this phenomenon by pointing to the different beliefs and preferences that people possess. Some individuals find it particularly difficult to take certain precautions while others are disposed to take such precautions. Some individuals are willing to take greater risks than others. But what can explain the fact that the very same person can behave differently under identical circumstances? What can explain the fact that sometimes people speed on their way to work and park illegally while – at other times – the very same person will strictly adhere to traffic laws?

In addressing this question, advocates of law and economics may take one of several tacks. First, behavioral changes can be attributed to changes in one's preferences. A person, for example, can care either less or more about arriving late to work. Second, a person can become more or less risk averse, and changes in one's attitudes towards risk inevitably lead to behavioral changes. Finally, it is possible that the perceived costs and benefits of a course of action may change in accordance with the individual's beliefs. For example, it is possible that the person speeds on days that he believes his manager may notice that he is late to work, or on days that he believes that the police are less likely to catch him. The common denominator of all these approaches is that changes in behavior must be attributed to changes in beliefs or preferences.

This view has at least two ramifications. First, in the absence of special circumstances, there is no fundamental difference between the behavior of individuals facing the same choice repeatedly or facing that choice only once. A repeated choice is analyzed simply as a series of single choices. Mere repetition should not change the way in which a behavior ought to be analyzed by the social scientist.

Second, and most importantly, this analysis implies that changes in the behavior of a person facing a recurring choice are erratic. Changes in one's beliefs or preferences are mental events in one's subjective world that economic theory cannot predict, control, or exploit for the sake of designing legal rules. As such, ironically, a theory that aims to provide a rational way of predicting and regulating human behavior leaves a central aspect of behavioral reality unaccounted for.

Probability matching is a tool that can be used by the legal theorist to fill this gap in economic theory. Using probability matching to account for behavioral changes addresses each one of these concerns. First, probability matching predicts that a person who confronts a choice repeatedly will make different decisions than when she confronts that choice only once. Second, probability matching provides a tool to predict behavioral changes in a way that is intelligible and rule-governed. Consequently, it can serve to harmonize what otherwise may seem as erratic behavior.

To illustrate, consider the following example. Assume that a driver stops at red lights. Traditional law and economics would suggest that one can conclude that the sanction for running red lights is sufficient to deter this person. In the future, this person is not expected to disobey a red light. It is possible that the person may change her beliefs concerning the size of the sanction or the probability of detection, or that she may become less risk averse. But, in the absence of such changes, one could predict that the sanction is sufficient to deter the person from running a red light.

Probability matching suggests that this prediction is wrong. Rather, it is likely that the person will sometimes run a red light and at other times will not. The person may have adopted a mixed strategy, and his behavior may depend on both the probability of detection as well as on the sanction. Probability matching is a tool which enables us to concede the existence and importance of behavioral inconsistencies without abandoning the hope of accounting for these inconsistencies in a way that is conducive to the legal regulation of behavior. The next section illustrates through an experiment concerning compliance with parking regulation, the relevance of probability matching to the legal context.

C. The Traffic-Warden Experiment

Studies demonstrating the impact of probability matching on individuals' choices were typically conducted in contexts that did not have legal significance.[19] The "Traffic-Warden Experiment," presenting participants with a choice whether to pay a parking fee, demonstrates the phenomenon of probability in a legal context.

Participants. A hundred and two undergraduate students from the Hebrew University of Jerusalem participated in the experiment. The participants were recruited through a campus advertisement promising a monetary reward for participating in a decision making task.

Procedure. Upon arrival, each participant was given instructions concerning the task by an experimenter. All questions concerning the experiment were answered and instructions were repeated until the participants indicated that they fully understood the instructions. During the instructions, the participants learned that the task would be repeated for twenty-four experimental rounds, and that they would be paid on the basis of their decisions in each round. Participants were encouraged to think carefully about each of the decisions.

Participants were initially endowed with 10 New Israeli Shekels ("NIS") to decrease the likelihood that the more unruly participants end up having to pay the

[19] See the studies described in Part I.

experimenter.[20] Then participants were told that they drive a van and have to drop off a package. For every delivery of a package the participant is paid *NIS* 2. Yet, prior to delivery, the participant has to park the van and decide whether to pay or not to pay the parking fee of *NIS* 1. Thus, a participant deciding to pay the parking fee earns *NIS* 1 for each round. A participant who does not pay the parking fee and is not caught by a traffic warden earns *NIS* 2 for each round. Participants who decide not to pay, however, face a risk of being "caught" by a traffic warden and having to pay the fine. In order to determine whether a warden has detected the violation, participants were asked to roll a die. One face of the die was labeled "warden has come." Every time the participant is asked to "deliver a package," she must first decide whether to pay the parking fee. The die is then tossed. If it lands on the side labeled "warden has come," and the participant decided not to pay the parking fee, the participant is fined for "illegal parking." The probability of being "fined" is therefore 1/6 for each round.

The same process is repeated twenty-four times. Twenty-four was chosen because it is not too large a number such that the participants would get bored and fail to take the task seriously and it is sufficiently large such that patterns of probability matching can be detected.[21]

Design. Participants were divided into three sub-groups of thirty-four, differing in the fine imposed for illegal parking. The fine for group A was *NIS* 3, for group B *NIS* 6, and for group C *NIS* 12.

Let us compare the results as predicted by traditional law and economics and by psychological theory. Under traditional law and economics participants behavior depends upon their attitude to risk. We shall assume that participants are risk neutral.

For group A (with a fine of 3 *NIS*) the expected cost of illegal parking is *NIS* 0.5 (3 × 1/6), half the cost of the parking fee (*NIS* 1). A risk-neutral individual, attempting to maximize payoffs, would therefore never pay the parking fee. For group B (with a fine of *NIS* 6), the expected cost of illegal parking is *NIS* 1 (6 × 1/6), equal to the cost of the parking fee. A risk-neutral individual would therefore be indifferent between paying and

[20] At the time of the experiment, 4.5 New Israeli Shekel were worth roughly $1.

[21] Twenty four rounds may appear too little to replicate daily experience. Yet, the experiments described in the psychological literature indicate that increasing the number of rounds to several hundreds generally did not change the results. See references in *supra* note 5

not paying. For group C (with a fine of *NIS* 12) the expected cost of illegal parking is *NIS* 2 (12 × 1/6), twice the cost of the parking fee. A risk-neutral individual in this group, attempting to maximize payoffs, would therefore always pay the fee.

Probability matching, however, predicts different behavior. Recall the predictions of probability matching in the case of asymmetric payoffs.[22] According to this model, in group A, where the cost of paying the parking fee (*NIS* 1) is twice as much as the cost of being fined (3 × 1/6 = .5 *NIS*), participants are expected to pay 1/3 of the time; in group B, where the cost of paying the fee is equal to the expected cost of the fine the prediction is that a participant would choose to pay for parking 1/2 of the time. In group C, where the cost of paying the fee is half the expected cost of the fine (12 × 1/6 = 2 *NIS*), participants are expected to pay 2/3 of the time. Table A summarizes these predictions.

Table A

	Parking Fee	Fine for Illegal Parking	Expected Fine for Illegal Parking	No. of Rounds Fee is Paid as Predicted by L&E	No. of Rounds Fee is Paid as Predicted by Probability Matching
Group A	1 NIS	3 NIS	0.5 NIS	0	8
Group B	1 NIS	6 NIS	1 NIS	12	12
Group C	1 NIS	12 NIS	2 NIS	24	16

[22] See *supra* note 8.

Results: Table B summarizes the results. The numbers in table C denote the mean number of times participants chose to pay the fine and the 95% confidence intervals of these means.

Results—Table B

	Pay	Lower Bound	Upper Bound
Group A	3.08	1.186	4.991
Group B	5.53	3.627	7.432
Group C	9.68	7.774	11.579

The first question is whether participants were at all sensitive to the different expected payoffs in the different fine levels.

The results clearly indicate that participants understood the game and acted in a way that is sensitive to its payoffs, namely, to the size of the fine. The participants in group A (low fine) were less willing to pay than the participants in group B (moderate fine), and the participants in group B were less willing to pay than the participants in group C (high fine). The data was submitted to a one-way ANOVA,[23] with Size-of-Fine as factor. The effect of the Size-of-Fine is highly significant ($F(2,99)=12.071$, $p<.001$). Even more importantly, the linear component of the analysis contributed .998 of the variance accounted for, and was even more significant ($F(1,99)=24.09$, $p<.001$).

The second question is which of the two models – that of maximizing or that of the probability matching best predicts the result.

Recall that, according to the maximizing model—the model that predicts individuals would look to maximize their payoff—participants of group A should never pay the fee and participants of group C should always do so. The 95% confidence

[23] ANOVA (analysis of variance) is a statistical technique designed to test whether differences in means between experimental conditions are significant (i.e. whether it is reasonable to assume that there are real differences in the population) or whether one is able to reject with confidence the hypothesis that the means are equal (i.e. that the differences we see are just "noise" in the sample).

intervals appearing in Table B clearly show that neither of these predictions is met. Still, one may ask how close the actual means are to the predictions of each model. To do that, let us first look at group B.

For group B, the parking fee is equal to the expected fine for illegal parking. According to both models, risk-neutral individuals would therefore be indifferent between paying and not paying the fee. The results indicate that individuals of group B are not indifferent; instead they are more often disposed to take the risk and not pay the fee. On average, a participant in Group B paid only in 5.53 of the 24 rounds. Group B manifested, therefore, a significant propensity not to pay. The propensity not to pay may have different explanations: It may be the byproduct of playfulness on the part of participants, or a disposition for risk-seeking behavior. Irrespective, however, of what the explanations of this propensity are, it ought to be taken into account in analyzing the results in groups A and C. Consequently, if we assume the same propensity not to pay in all groups, the predictions of both models can be modified taking this propensity into account. To do that, the difference between the expected 12 rounds of pay and the actual mean of 5.53 rounds (6.47) should be subtracted from all predictions.

Table C summarizes our results and compares them with the results predicted by the two models with and without the correction for the propensity not to pay. *Column 1* presents the average number of rounds the participants chose to pay. *Column 2* presents the mean number of rounds a participant would choose to pay as predicted by the maximizing model for a risk neutral individual. *Column 3* presents the means of the same model, adjusted. One peculiar result of this procedure is that the number of rounds in which people would be expected to pay according to these predictions is negative in the case of group A. Since this is impossible, one would at least expect a mean of zero. Given the natural propensity of participants not to pay, it is particularly difficult for conventional law and economics based on the maximizing model to explain the fact that individuals in group A – the group with the lowest fine – decided to pay, on average, a little over 3 times.

Column 4 describes the results as predicted by probability matching. *Column 5* describes the projected outcome as dictated by probability matching, adjusted for the observed propensity not to pay.

Table C

	1	*2*	*3*	*4*	*5*
	Pay Actual	Pay Predicted by L&E	Pay Predicted by L&E and Adjusted	Pay Predicted by Probability Matching	Pay Predicted by Probability Matching and Adjusted
Group A *NIS* 3 Fine	3.08	0	-6.47	8	1.53
Group B *NIS* 6 Fine	5.53	12	5.53	12	5.53
Group C *NIS* 12 Fine	9.68	24	17.53	16	9.53

It is clear from the results that the predictions of the adjusted probability-matching model (presented in column 5) are closest to the actual means (presented in column 1). As table B indicates, in all cases the actual numbers do not differ significantly from the predicted value indicated in column 5. As such, probability matching best accounts for participants' behavior in the Traffic-Warden game.

III. Probability Matching and Law Enforcement

The last section has demonstrated that individuals facing probabilistic costs or benefits often behave as "probability matchers" rather than as "maximizers." It also showed that this pattern of behavior is manifested in law-related contexts, e.g., when a person is faced with a repeated choice of whether to pay a parking fee or be exposed to a probabilistic fine. This scenario is quite typical to law enforcement contexts. Because it is impossible to place a police officer next to every stop sign or to audit all tax returns, the imposition of legal sanctions is inevitably probabilistic. As such, probability matching has important implications concerning optimal law enforcement policy. This section is devoted to examining the ways in which probability matching can improve and enrich policy-making.

For illustration, consider this example: assume that the police wish to deter drivers from illegally crossing an intersection. The only sanction for crossing the intersection illegally is $100 and the benefit of crossing it illegally without being caught is also $100. Assume, in addition, that drivers cross the intersection repeatedly. Finally, assume that a police car can be placed such that drivers who cross the intersection cannot see it in advance. Thus, the drivers' behavior is determined solely by the sanction and by the subjective probability they attribute to the placing of the police car in the intersection.

Under the predictions of traditional law and economics, if drivers are risk neutral, it is sufficient to place the police car in 51% of the cases (or at least to make drivers believe that it is there in 51% of the time). This guarantees that it would be irrational to cross the intersection illegally since the expected costs of crossing it illegally are higher than its expected benefits.[24] Placing the car less than 51% of time is wasteful because drivers would never stop; placing the car more than half of time is inefficient since the same deterrence could be achieved with less investment.

Probability matching suggests otherwise. Placing the police car 51% of the time would cause drivers to cross legally the intersection in roughly 51% of the cases. Increasing the presence of the police car to 70% of the time would therefore increase law-abiding behavior. If the differential cost of placing the police car in 70% rather than 51% of the time is sufficiently low, it may be desirable on the part of the police to make this investment.

To illustrate the relevance of probability matching to optimal investment in law enforcement, consider the following case. Assume that every day 500 vehicles cross the intersection. Assume that a car crossing the intersection illegally imposes an expected

[24] The benefit from crossing the intersection illegally, if not caught, is $100. If the police officer is placed 51% of the time, expected benefit is $49 ((100% – 51%) × $100). The sanction for crossing illegally the intersection, if caught, is $100. If the police officer is placed 51% of the time, expected cost is $51 (51% × $100). Placing the police officer 51% of the time therefore makes it unprofitable for the drivers to cross illegally the intersection.

social cost of $1. Finally, assume that the marginal costs of placing a police officer in the intersection increase in the following way:

Days on Which a Police officer is placed	Marginal Enforcement Cost	Total Enforcement Costs
First day	$100	$100
Second day	$400	$500
Third day	$1500	$2000
Fourth day	$3000	$5000

Traditional law and economic analysis would suggest, under these circumstances, that it is irrational (assuming that the drivers are risk-neutral) to place a police officer in the intersection. As drivers' costs from crossing the intersection illegally are equal to their benefit, they will cross the intersection illegally unless it is more likely than not that they would be caught. Therefore, deterrence will be achieved only if a police officer is placed at least 4 days a week (more than 50% of the time). In weekly terms, this would indeed save $3500 in social costs (7 × $500), but would require investing $5000 (100 + 400 + 1500 + 3000) in enforcement. Any attempt to place a police officer less than 4 days would be a waste of money, as drivers would not be deterred from crossing the intersection illegally.

In contrast, if people are "probability matchers", placing a police officer for two days would be efficient. Every day that a policeman is placed deters 500 vehicles from crossing the intersection illegally, saving $500 in social costs. Drivers, noting that the police officer is present one-seventh of the time, will obey the light at the same rate – one day a week. Given that the costs of placing a police officer for a first and a second day are lower than $500, a policymaker ought to place a police officer in the intersection for two days.

This example illustrates that a policymaker relying on the predictions of probability matching may invest more in enforcement than a policymaker relying on the conventional economic analysis of law. A small alteration of the assumptions can also illustrate that probability matching can justify a lesser investment in enforcement.[25]

In the last example it was assumed that social costs produced by criminal behavior (crossing the intersection illegally) remains fixed for every car. In some contexts, however, the marginal social cost generated by the illegal behavior is expected to increase for every additional level of activity. Under such conditions, even if one assumes that marginal enforcement costs are fixed, probability matching may again recommend a different policy than that mandated by conventional law and economics.

Consider, for example, the dumping of toxic materials. Assume that the marginal social harm resulting from every additional unit of dumping increases. While one unit of toxic material is harmless, the second unit causes a harm of $100; the third unit causes harm of $200 and so forth. For illustration, assume that there is a factory which produces the same unit of toxic materials each day, seven days a week. Assume also that the only sanction for each instance of illegal dumping is $100 and that the factory gains $100 from each instance of undetected dumping. Finally, assume that the cost of employing a detection team to identify illegal dumping is $550 a day. The following table describes the marginal and total social costs resulting from illegal dumping.

Number of Instances of Illegal Dumping a Week	Marginal Social Costs	Total social Costs
1	$0	$0
2	$100	$100
3	$200	$300
4	$300	$600
5	$400	$1000
6	$500	$1500
7	$600	$2100

[25] Assume that expected social cost due to a car crossing the intersection illegally is $2 rather than only $1. Traditional law and economics, under this condition, supports the placement of the police officer. Placing the police officer for 4 days would deter drivers from crossing the intersection illegally. As such, $7000 (500 × 2 × 7) in social costs would be saved, outweighing enforcement costs ($5000). Probability matching, however, indicates that the police officer should be placed for only 2 days. Because enforcement costs of the third and fourth days are $1500 and $3000 respectively, such enforcement is inefficient considering the fact that social cost saved for each day are only $1000 (2 × 500).

Under these circumstances, traditional law and economic analysis would recommend no enforcement. Because the benefit of the factory from illegal dumping is equal to its cost, the factory would dump only if it is more likely than not that it would not be caught. Deterrence, therefore, would be achieved only if a detection team is employed at least 4 days a week. In weekly terms, operating the detection unit saves $2,100 in social costs, but would require investing $2200 ($550 × 4) in enforcement. Any attempt to employ the detection unit less than 4 days would be a waste of money, as the factory would not be deterred from illegally dumping its toxic materials.

Probability matching, in contrast, mandates operating the detection unit once a week. Such level of enforcement is expected to induce the factory to refrain from dumping once out of seven times; the factory would dump only six times rather than seven. Consequently, $600 would be saved, which outweighs the enforcement costs ($550). A small change in the assumptions can illustrate that probability matching may also justify a smaller investment in enforcement than that demanded by conventional economic analysis.[26]

[26] Assume that the marginal social costs of illegal dumping increase more rapidly, so that the first unit of dumping is harmless, the second unit causes harm of $150 (rather than $100), the third unit causes a harm of $300 (rather than $200) and so forth. The following table summarizes the social costs resulting from illegal dumping under this modified assumption.

Number of Instances of Illegal Dumping a Week	Marginal Social Costs	Total Social Costs
1	$0	$0
2	$150	$150
3	$300	$450
4	$450	$900
5	$600	$1500
6	$750	$2250
7	$900	$3150

Traditional law and economics, under this condition, supports the employment of the detection unit. Operating the detection unit for 4 days would deter the factory from illegal dumping. As such, $3150 in social costs would be saved, which outweighs enforcement costs ($550 × 4). Probability matching, however, indicates that the detection unit should be employed only for 3 days. Employing the detection unit for an additional day costs $550, but would save only $450 in social costs.

In sum, the preceding analysis demonstrated that if either the social cost of illegal activity or the costs of enforcement (or both) are not constant, probability matching and traditional economic analysis may support different enforcement policies. Differences may cut both ways: probability matching may justify both higher as well as lower enforcement levels than suggested by conventional law and economics.

Legal scholarship has overlooked the possible effects of probability matching on the optimal investment in law enforcement. It has also failed to grasp the usefulness of probability matching in explaining legal doctrines. The next Part is devoted to this task.

IV Probability Matching and Legal Doctrine

A. Introduction

This Part examines legal doctrines that can be explained by the tendency of individuals to "match probabilities." Section B explains the prevalence of "escalating penalties" in criminal law for repeat offenders, as well as its functional analogue in tort law—the imposition of punitive damages on "recidivist" tortfeasors. Section C rationalizes the practice of allocating subsidies only for those involved in repeat (rather than one-time) beneficial activities.

B. Escalating Sanctions

Escalating penalties are widespread in criminal law.[27] Repeat offenders are often punished more severely than one time offenders. Under the U.S. Sentencing Commission's guidelines for punishment of federal crimes, both imprisonment terms and criminal fines are increased if a defendant has a prior record.[28] Likewise, specific statues often set higher penalties for repeat offenders. For example, hiring, recruiting, and

[27] *See, e.g.*, C.Y. Cyrus Chu et al., *Punishing Repeat Offenders More Severely*, 20 INT'L REV. L. ECON. 127, 127 (2000) (observing that punishing repeat offenders more harshly "is a generally accepted practice of almost all penal codes or sentencing guidelines".).

[28] *See* UNITED STATES SENTENCING COMMISSION (1995, § 4A1.1, Ch. 5 Pt. A, and § 5E1.2).

referral violations under the Immigration Reform and Control Act impose a minimum fine of $250 for a first offense, $2,000 for a second offense, and $3,000 for subsequent offenses; in addition, "due consideration shall be given to …. the history of previous violations" in setting penalties for paperwork violations.[29] Similar schemes of escalating penalties characterize the treatment of violations of environmental, health, safety, and labor regulations.[30] The legal system seems to differentiate sharply between repeat offenders and individuals who commit a crime for the first time.

Law and economics has struggled to provide a rationale for the practice of escalating penalties for repeat criminal offenders.[31] In fact, some recent theorists provided compelling arguments against the practice of imposing escalating penalties.[32] Probability matching provides a novel rationale for this practice. Individuals who face a one-time choice to commit an illegal activity tend, as the experiment demonstrate, to behave as maximizers.[33] Consequently, it is sufficient to deter them by imposing a sanction whose expected value is larger than their benefit. In contrast, individuals facing repeated opportunities to perform an illegal activity may act as "probability matchers." They may thus occasionally choose to perform the activity even if its expected cost is higher than its expected benefit. To provide an incentive for "probability matchers" to

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[29] *See* U.S.C. § 1324a(e)(4)-(5) (1997).

[30] For a detailed overview of laws applying escalating penalties, both federal and state, see David Dana, *Rethinking the Puzzle of Escalating Penalties for Repeat Offenders*, 110 YALE L. J. 733 (2001)

[31] *Id.,* at 737 ("For economists and law-and-economics scholars, however, the principle of escalating penalties based on offense history is puzzling"); Winand Emons, *A note on the Optimal Punishment for repeat offenders*, 23 INT'L REV. L. & ECON. 253, 253 (2003) ("For the rather developed law and economics literature on optimal law enforcement escalating sanction schemes are still a puzzle."). For some attempts to rationale the application of escalating penalties from economic perspective, see, Moshe Burnovski & Zvi Safra, *Deterrence Effects of Sequential Punishment Policies: Should Repeat Offenders Be More Severely Punished?*, 14 INT'L REV. L. & ECON. 341 (1994); A. Mitchell Polinsky & Daniel L. Rubinfeld, *A Model of Optimal Fines for Repeat Offenders*, 46 J. PUB. ECON. 291, 303 (1991); A. Mitchell Polinsky & Steven Shavell, *On Offense History and the Theory of Deterrence*, 18 INT'L REV. L. & ECON. 305, 305 (1998); C.Y. Cyrus Chu et al., *supra* note 27. Neither of these attempts, however, provides a sufficient explanation. *See* Emons, at 254 (describing previous research and concluding that "[a]t the very best the literature … has shown that under special circumstances escalating penalty schemes may be optimal.").

[32] Dana, *supra* note 30 at 737 (arguing that "the economic model of optimal deterrence actually supports declining penalties based on offense history for some categories of offenses, rather than nonescalating or escalating penalties," since convicted offenders are more likely to be detected if they commit additional crimes.); Emons, *supra* note 31 at 254 (concluding that "optimal sanction scheme is decreasing rather than increasing").

[33] *See supra* Part I.

completely refrain from violating the law requires a higher penalty. In the absence of a scheme of escalating penalties, individuals with repeated opportunities to violate the law would choose to commit the illegal behavior in accordance with the prediction of probability matching. [34]

Arguably, the legal system could achieve the same purpose by imposing a harsh sanction for every violation, irrespective of the criminal history of the offender. Yet harsh sanctions are not costless and ought to be avoided if unnecessary.[35] First, high sanctions may overdeter. If there is a risk of accidental violation, or of an erroneous conviction, harsh sanctions deter legal behavior. Second, severe penalties eliminate marginal deterrence—the incentive to substitute less for more serious crimes. Since the solvency of the criminals is limited, there is a limit to the size of fines that can be imposed. Finally, severe sanctions increase enforcement costs, such as the costs resulting from long incarceration periods, or the costs associated with collecting large fines. Severe sanctions, therefore, must be avoided if more moderate penalties can achieve a similar level of deterrence.[36]

Escalating penalties serve, therefore, the purpose of deterring both one-time offenders and "probability matchers" at the lowest possible cost. The legal system applies

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[34] Consider the following example. Assume that law mandates that the minimum daily wage for a construction-worker must be $200. Assume also that there are employers who consider violating the law and hire workers for only $100. Finally, assume that probability of detection is 50%, and that employers consist of two groups: construction companies (potential repeat offenders) and private individuals (potentially one-time offenders).Setting the penalty, for example, at $300 is sufficient to deter risk-neutral private employers. The expected penalty of $150 ($300 × 50%) is higher than their expected benefit of $100. It is not sufficient, however, to fully deter the construction companies who repeatedly need the services of construction workers. According to the prediction of probability matching, construction companies will adopt a mixed strategy. If the company hires, for example, 200 workers, it is likely the company would underpay some of its workers. More specifically, out of its 200 workers, probability matching predicts it would underpay 50. The company faces a 50% chance to gain $100 and a 50% chance of being subjected to a fine of $300. This ratio of $50 to $150 (that is, 1:3) determines, according to the prediction of probability matching, that the company would underpay every fourth opportunity it faces. To induce the company to fully comply with the minimum wage regulations, a higher penalty must be imposed for any repeat offence. If, for example, the penalty for every additional offence is $30,000, the company is likely to pay all workers the proper amount. By imposing such a penalty, the company would face a 50% chance to gain $100 and a 50% chance of being subjected to a fine of $30,000. This ratio of $50 to $15,000 (that is, 1:300) means the company, even if behaves as "probability matcher", is not likely to underpay any of its 200 workers.

[35] *See* RICHARD A. POSNER, ECONOMIC ANALYSIS OF LAW 221-223 (6th ed., 2003)

[36] As said by Bentham, "[p]unishment, it is still to be remembered, is in itself an expense: it is in itself an evil ... [one ought] not to produce more of it than what is demanded …", Jeremy Bentham, PRINCIPLES OF MORALS AND LEGISLATION, Ch. XV, § XI.

a price discriminating mechanism under which severe (and expensive) sanctions are reserved only for individuals that cannot be deterred by moderate penalties. Setting a low initial penalty serves to deter individuals facing the choice occasionally; higher sanctions are imposed only to deter subjects who face the choice repeatedly and are likely to apply a strategy of probability matching.

The growing literature on escalating penalties focuses its attention on criminal law. It is, however, worthwhile highlighting the fact that a similar phenomenon can be found in tort law. Instead of using "escalating penalties," tort law employs punitive damages to deter "recidivist tortfeasors."

One of the considerations courts investigate in deciding to award punitive damages is whether the defendant is a repeat tortfeasor.[37] As the Supreme Court recently acknowledged, the question whether the harmful conduct "involved repeat action or was an isolated incident,"[38] would be one major factor in imposing punitive damages. This principle has also been recognized by state legislation. State laws often explicitly condition the imposition of punitive damages on the defendant's recurring behavior.[39]

Probability matching can again explain this doctrine. Consider, for example, an activity that causes harm only 50% of the time. When harm does not occur, the benefit from the activity is $100. When the harm materializes, however, the damage from the activity is $300. Setting damages to the actual harm ($300) is enough to deter risk neutral individuals who face a one-time choice to perform the activity. However, if individuals face the choice repeatedly, such a level of compensation is insufficient. Their tendency to "match the probabilities" means that every fourth time they face the choice, individuals would perform the activity. Imposing punitive damages on repeat tortfeasors may serve to counterbalance the effect caused by the probability matching phenomenon.

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[37] *See generally* DOBBS, *Id*., at § 3.11(2) (noting that "[r]epeated misconduct or a policy of misconduct … is often an element in punitive damages cases.).

[38] *State Farm Mut. Auto. Ins. v. Campbell*, 123 S.Ct. 1513, 1521 (2003)

[39] See, for example, D.C. CODE ANN. § 28-3813 (1981) (providing that punitive damages may be awarded for "repeat violations" of consumer protection laws); IDAHO CODE § 48-608 (holding that imposition of punitive damages for unlawful trade practices is conditioned on "repeated" violations); IOWA CODE § 91E.4 (holding that "an employer who, through repeated violation … demonstrates a pattern of abusive recruitment practices may be ordered to pay punitive damages"); ME. REV. STAT. ANN. tit. 22 § 2697 (providing that punitive damages can be imposed only for "repeat" violations of the law concerning profiteering in prescription drugs).

To sum up the discussion, let us coin a new term: "escalating sanctions." Escalating sanctions consist of the practice of escalating penalties in criminal law and the practice of imposing punitive damages on repeat tortfeasors penalties. Probability matching provides a rationale for the use of such sanctions.

C. Allocating Subsidies

The above discussion regarding escalating sanction finds a mirror image in another argument concerning socially desirable behavior. Probability matching indicates that individuals who face repeat choices for socially desirable activities may take risks that are too small. Consider, for example, an entrepreneur who can invest $100 in a project that is expected to yield, with equal probability, either $0 or $300. Although the expected benefit from the project is higher than its costs, a risk neutral entrepreneur who faces the choice repeatedly is expected to invest only occasionally in such projects. While most of the time the entrepreneur would invest, she occasionally would forgo the opportunity, due to her inclination to "match" the probabilities. In such cases, it may be desirable to increase the expected payoff of the project to induce the entrepreneur to invest consistently in all the projects.

[To be added]

D. Risk-Based Liability versus Damage-Based Liability

This section investigates the debate concerning liability for the harmless imposition of risk – an imposition of risk that does not generate harm - in both criminal and tort law. In tort law, the question is whether liability should be imposed for negligence which does not result in harm. In criminal law, the question is whether criminal sanctions should be imposed for unsuccessful attempts. We shall argue that while numerous considerations (either justice-based or efficiency-based) should be taken into account in deciding when liability should be imposed, probability matching is an important consideration that justifies liability simply for the imposition of risk.

Legal systems may adopt different mechanisms for providing incentives to prevent probabilistic harm.[40] On the one hand, a legal system could impose a *risk-based liability system*, namely a system that imposes sanctions on anybody who imposes probabilistic harm regardless of whether the imposition of risk resulted in actual harm. In order to provide efficient incentives, the legal system ought to impose a sanction which would equal the expected damage of the activity.

On the other hand, a legal system could adopt a *harm-based liability system*, namely a system under which only those who inflict a risk which results in actual harm are subjected to sanctions. In this case, the legal system could deter wrongful behavior if it imposes sanctions that are equal to the harm resulting from the behavior of the particular wrongdoer.

Last, a legal system could adopt a *mixed (risk-harm) liability* system under which it imposes different sanctions on those who imposed risk which resulted in harm and on those who imposed risk that did not result in harm. Under such a system, those who imposed risk which resulted in harm would be subject to different sanctions than those who imposed risk which did not result in harm. Let us examine how these three schemes could operate in different fields of the law.

Under a risk-based scheme, as applied to tort law, liability would be imposed for any imposition of risk. The amount of compensation under a risk-based tort system would equal the *expected damage* causally related to the wrongful conduct.[41] If, for example, this conduct were to involve a 50% probability of inflicting damage equal to $1000, then the defendant would have to pay $500 in liability damages. Similarly, a speeding driver would pay in accordance with the expected damages resulting from her behavior irrespective of whether the harm actually materialized.[42] The traditionally prevalent legal

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[40] For a comprehensive discussion, see ARIEL PORAT & ALEX STEIN, TORT LIABILITY UNDER UNCERTAINTY, Chap. IV (2001).

[41] *See* PORAT & STEIN, *Id.*, at 103.

[42] Such a scheme is not merely theoretical. It was proposed by some legal scholars primarily on the grounds that such a scheme is more just. *See, e.g.*, C.H. Schroeder, *Corrective Justice and Liability for Increasing Risks*, 37 UCLA L. REV. 439 (1990); C.H. Schroeder, *Corrective Justice, Liability for Risks, and Tort Law*, 38 UCLA L. REV. 143 (1990). For a critical response, see K.W. Simmons, *Corrective Justice and Liability for Risk-Creation: A Comment*, 38 UCLA L. REV. 113 (1990). For further corrective justice arguments see, E. Weinrib, *Understanding Tort Law*, 23 VALPARAISO L. REV. 485 (1989). One of the advantages of such a system is that it mitigates (although it does not altogether avoid) the problem of "moral luck," namely

position in tort law is that liability in torts can only be imposed when the plaintiff has sustained damage that was wrongfully inflicted by the defendant. Nevertheless, recent developments clearly indicate greater willingness on the part of judges to attribute liability on the basis of the imposition of risk. Doctrines such as "market share liability," "loss of chance," and "evidentiary damage" allow courts to impose liability on the defendants, even if plaintiffs fail to show causal relation between the harm suffered by plaintiffs and defendants' behavior. When applying such doctrines, courts often refer to the *risk of injury* to which the defendant wrongfully exposed the claimant as the criterion for determining defendant's liability. As such, tort law is traditionally a harm-based system that increasingly recognizes risk-based claims.[43] [

The question of whether to employ harm-based or risk-based liability can also arise in the context of criminal law. The legal system could impose (a relatively small) penalty on every person who attempts to commit a crime regardless of whether she succeeds or not, or it can impose (a relatively harsh) sanction only on those criminals who successfully complete the crime. Finally, it could adopt a mixed system and impose different sanctions on successful and unsuccessful perpetrators of crime.

As a matter of practice, modern criminal law adopts either the mixed system or the risk-based system.[44] A greater emphasis on subjectivity as the cardinal parameter in determining criminal responsibility has resulted in the imposition of sanctions for attempts. In some systems the sanctions imposed for attempts are more lenient than the

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arbitrarily different treatment of individuals with identical culpability. For the problem of moral luck, see the recent discussion by David Enoch & Andrei Marmor, *The Case against Moral Luck* (http://papers.ssrn.com/sol3/papers.cfm?abstract_id=475161). For a useful collection of essays, *see* MORAL LUCK (Daniel Statman ed., 1993).

[43] Consider, for example, a typical "loss of chance" malpractice claim. A doctor negligently examines a patient. Consequently, the plaintiff loses 30% of his chances of recovery and dies. Under the traditional harm-based approach, plaintiff's claim is ought to be rejected. As it is more probable than not (70%) that the plaintiff would have died even if the doctor had not been negligent, the plaintiff cannot establish causation. Under the doctrine of "loss of chance", however, the doctor is liable for the risk she exposed the plaintiff to. More specifically, she is liable for 30% of the damage. For a review of American and British torts cases in which courts imposed liability based on risk rather than actual harm, see Ariel Porat & Alex Stein, *Indeterminate Causation and Apportionment of Damages: An Essay on Holtby, Allen and Fairchild*, 23 OXFORD J. LEGAL. STUD. 667 (2003).

[44] Some commentators have noticed a transition towards a reducing the gap in the sanctions imposed for attempts and completed crimes. See Yoram Schachar, *The Fortuitous Gap in Law and Morality*, 6 CRIM. JUST. ETHICS 12, 13 (1987).

ones imposed for the completed offence, while in other systems the sanctions imposed for attempts are identical to the ones imposed for the completed offence.[45]

There are many considerations that dictate whether to adopt a risk-based, harm-based, or a mixed system. A risk-based system has advantages in that it seems less arbitrary and it mitigates the moral luck" concern. Corrective justice arguments may also support a risk-based system. Nevertheless, pragmatic, efficiency-based considerations often preclude the possibility of using a risk-based (and perhaps even a mixed) system in tort law.[46]

The purpose of this section, however, is not to evaluate all the pros and cons of risk-based or harm-based systems. Instead, it aims at investigating the relevance of probability matching to resolving this debate.

Assume an activity which imposes a risk that may or may not materialize. As such, this activity (which could be either a crime or a tort) generates a probabilistic cost. Under a risk-based system, the person who imposes a risk is always required to pay a fee that is equal to the activity's social costs. Under such a system, the agent would engage in the activity if and only if her benefit exceeds the expected cost. In contrast, under a harm-based system the person who imposes a risk is liable only if the risk materialized and generated actual harm. From the perspective of the agent, the fee is a probabilistic cost which will be imposed only if his activity resulted in actual harm. The agent in this case would behave as a "probability matcher." Probability matching suggests that a harm-based system would lead an agent to adopt a mixed strategy in which she sometimes engages in the activity and sometimes does not, even if the expected cost of the activity is higher than its expected benefit. The deterrence resulting from a harm-based system is therefore inefficient. Optimal deterrence requires either preferring a risk-based system or

[45] For a discussion of the treatment of attempts in criminal law, see Omri Ben Shahar & Alon Harel, *The Economics of the Law of Criminal Attempts: A Victim-Centered Perspective*, 145 U. PA. L. REV. 299 (1996). It is worth noting that historically this was not the case and that ancient legal systems, as well as the common law itself, used to endorse a harm-based scheme – a scheme which was gradually transformed into a mixed system and sometimes even into a risk-based system.

[46] *See* PORAT & STEIN, *supra* note 40 at 109-10. Porat and Stein argue that, in order to achieve optimal deterrence and ensure that victims of tort are properly compensated under a risk-based system, it is essential that at least most if not all risk-creators are actually found liable for the expected damage that originates from their wrongful conduct. However, unlike actual damage, imposition of bare risk is largely non-observable by potential plaintiffs. Moreover, even when risk-imposition is observable by plaintiffs, it often remains unverifiable at trial. Hence, it is simply unrealistic to use effectively a risk-based system.

imposing harsher sanctions than those that are expected on the basis of traditional analysis.

Given the plurality of factors which bear on this question, it is difficult to establish that the choice of criminal law to adopt a risk-based (or a mixed system) and the recent transition in tort law towards such a system is in fact grounded in probability matching. Yet the discussion demonstrates that, in choosing among a risk-based, a harm-based or a mixed system, probability matching ought to be a central consideration.

V. Conclusion

Conventional economic analysis of law relies on the assumption that subjects with fixed preferences are expected to behave consistently. Without this assumption, law and economics fails to provide guidelines for policymakers. Reality, however, demonstrates otherwise; individuals often behave inconsistently. Probability matching enables legal theory to account for behavioral inconsistencies, to provide guidelines for policymaking, and to explain existing legal doctrine.