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Public Security vs. Private Self-Protection: Optimal Taxation and the Social Dynamics of Fear

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Summary

In this paper, we develop a simple model of social dynamics governing the evolution of strategic self-protection choices of boundedly rational potential victims facing the threat of prospective offenders in a large population with random matching. We prove that individual (and socially transmitted) fear of exposure to criminal threats may actually condition choices even in the face of objective evidence of declining crime rates, and thereby cause the eventual selection of Pareto inefficient equilibria with self-protection. We also show that a suitable strategy of provision of public security financed through discriminatory taxation of self-protective expenses may actually overcome this problem, and drive the social dynamics toward the efficient no protection equilibrium. In our model, we do not obtain, as in Cressman et al. (1998), a crowding-out result such that the net impact of public spending on the actual social dynamics is neutral and the economy keeps on cycling between phases of high and low criminal activity with varying levels of self-protection; quite to the contrary, it can be extremely effective in implementing the social optimum, in that it acts primarily on the intangible dimension, that is, on the social dynamics of fear. We claim that this kind of result calls for more interdisciplinary research on the socio-psycho-economic determinants of fear of crime, and for consequent advances in modelling approaches and techniques.

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Public Security vs. Private Self-Protection:

Welfare-Improving Taxation and the Social Dynamics of Fear

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Summary

In this paper, we develop a simple model of a social dynamics governing the evolution of strategic self-protection choices of boundedly rational potential victims facing the threat of prospective offenders in a large population with random matching. We prove that individual (and socially transmitted) fear of exposure to criminal threats may actually condition choices even in the face of objective evidence of declining crime rates, and thereby cause the eventual selection of Pareto inefficient equilibria with self-protection. We also show that a suitable strategy of provision of public security financed through discriminatory taxation of self-protective expenses may actually overcome this problem, and drive the social dynamics toward the efficient no protection equilibrium. In our model, we do not obtain, as in Cressman et al. (1998), a crowding-out result such that the net impact of public spending on the actual social dynamics is neutral and the economy keeps on cycling between phases of high and low criminal activity with varying levels of self-protection; quite to the contrary, it can be extremely effective in implementing the social optimum, in that it acts primarily on the intangible dimension, that is, on the social dynamics of fear. We claim that this kind of result calls for more interdisciplinary research on the socio-psycho-economic determinants of fear of crime, and for consequent advances in modelling approaches and techniques.

Public Security vs. Private Self-Protection:
Welfare-Improving Taxation and the Social Dynamics of Fear

"Managing fear is as important as managing the crime itself"

Sheldon F. Greenberg, former police officer;

cited in Hermann (2009)

1 Introduction

Protection against criminal threats is a classical issue that is likely to be conducive to severe market failure, in that it provides a very clear example of interdependent risk (Heal and Kunreuther, 2007). For given levels and characteristics of criminal threats, the very fact that I increase my own level of self-protection by buying suitable goods or services (a burglar alarm, a watchdog, defensive arms, armoured doors and windows, or private security services, to make a few examples) causes a negative externality on those who do not act accordingly (for instance, my neighbours who do not have a burglar alarm or a watchdog, keep arms at home, mount ordinary doors and windows, and are not covered by private surveillance). As a consequence, everybody will be eventually induced to buy goods and services to match the others' levels of self-protection, and criminals will increase their offensive potential accordingly; such negative externalities may even become a relatively powerful engine of growth of the level of economic activity (Antoci and Bartolini, 1999, 2004). Eventually, in spite of the money being spent, potential victims will not manage to enhance their (relative) level of self-protection, and due to the escalation in offensive and defensive means, the probability of being involved in a risky and potentially fatal assault will be increased. Here, interestingly, the welfare loss it is not only a problem of (costly, risk-generating) escalation in physical means of offence and defence. It is also a problem of escalation in the psychological climate of fear, that can substantially modify

people's attitudes toward personal habits and attitudes toward others (Amendola, 1997, 2003). For instance, in a neighbourhood where an escalation of self-defensive means has occurred with the consequential changes in terms of the inhabitants' perceptions of fear and hostility toward potential offenders, it is more likely that someone could be mistakenly identified and attacked as a potential offender as a consequence of particular, unfortunate circumstances, even with fatal outcomes. Moreover, people will tend to assume a more defensive and fearful attitude toward strangers, being exposed more often and more intensively to psychologically stressing and depressing moods, and therefore substantially worsening the possibility and quality of psychological flow processes (Csikszentmihalyi, 1990). In particular, this could likely lead people to reshape their leisure time habits by substituting relational goods with market goods, in order to cope with the need to increase their level of security and control over social relationships, thereby easily leading to the onset of social poverty traps (Antoci et al., 2007). Also the contradictions and ambiguities in penal policies and practice, and thus, among other things, in the provision of public protection against crime and in law enforcement, could cast a negative influence in terms of sociability attitudes (O' Malley, 1999).

The issue has so far received substantial attention in different disciplinary fields, such as the economics, the sociology and the social psychology of crime and prevention, but the various threads of investigation have remained somewhat separated, so that there is a substantial lack of a unified analytical approach allowing to address it from several, complementary viewpoints. In particular, what has been especially lacking is a unified framework allowing to deal at the same time with both the physical and psychological aspects of the self-protection escalation dynamics (and consequently with their joint welfare implications). This lack of a common framework, in particular, has prevented to point out and analyse in a proper way the positive feedback (i.e. self-reinforcing) interaction between the two dimensions, and thus has lead to under-estimate the actual social and economic costs of such phenomena. In this paper, we propose a simple analytical model that attempts to fix this lacuna by rephrasing it within a game-theoretic, evolutionary framework that has already been used in the past to tackle similar issues related to the socio-economic dynamics of corruption (Antoci and Sacco, 1995, 2002).

In particular, taking as a reference previous work by Cressman et al. (1998), we study a situation of randomly matched interaction between criminals and potential victims in a strategically interdependent context with random matching, where individual levels of vulnerability to criminal offences depends on their own defensive choices, as well as on someone else's (for instance, on their own spatial or social 'neighbours' in a given circumstance), and also, of course, on the potential offender's. Protection

can be self-provided by individuals, or may be offered as a public, publicly financed service. The perception of vulnerability depends on the actual available information on the prevailing social level of self-defensive protection (and thus on the actual likelihood of being matched to someone else that has a level of protection that is comparable, superior, or inferior to one's own), but also on psychological factors that determine one's perceived level of insecurity. In particular, it depends on the actual private level of self-defence: The more people actually buy defensive goods or services, the more they face evidence that there is a safety problem, and the more they reinforce their safety-related fear and distress, thereby becoming relatively more inclined to anti-flow psychological states such as worry or anxiety. People's self-defensive propensities depend on the perceived relative convenience of privately buying protection or not, depending on the observed relative return of the two options, which has both a material and a psychological component. What we need to understand is which of the two regimes fares better, and under what conditions.

We find that, for parameter values such that both regimes (privately vs. publicly provided protection) can be dynamically stable under certain conditions, the public provision equilibrium always strictly dominates the private provision one. Moreover, this dominance result can occur even when the private provision equilibrium is the only dynamically stable one. The Public Administration's optimal strategy is, therefore, trying to reduce self-protective expenses by taxing them, thereby curbing the negative psychological escalation. If, however, taxation is uniform independently of the individual level of self-defence expenses, there is no effect on the social selection of behaviours and there is no incentive for self-defendants to switch to the other option. What is needed to change the social dynamics is that taxation depends on the actual self-defence expenditure level, thereby discriminating between the two classes of individuals. In this case, for suitable taxation schemes, the Public Administration may implement the Pareto optimal equilibrium. This result represents a substantial improvement upon the original Cressman et al. (1998) model, where public intervention crowded out private self-protection expenses and could not bring about efficient outcomes, and where the only possible outcome of the social dynamics was a robust oscillating dynamics (i.e., convergence to a hypercycle). The reason why we obtain this result whereas Cressman and co-workers didn't is the presence of the psychological escalation factor, which causes the breakdown of the crowding out result. We see this fact as a clear illustration of the point that a true understanding of the socio-economic impact of alternative crime protection strategies requires a truly interdisciplinary, namely, socio-psycho-economic, approach (see e.g. Braithwaite, 2000). We mean this contribution as a preliminary exploration of the issue, which we hope will lead to further investigation and more articulated welfare analysis for more complex

analytical settings.

The plan of the rest of the paper is the following. Section 2 contains a relatively concise interdisciplinary review of some of the relevant literature. Section 3 presents the model. Section 4 presents the basic mathematical results. Section 5 contains the welfare and policy analysis. Section 6 concludes.

2   The socio-psycho-economics of defensive behaviour: A few insights from the literature

The issue of the choice between public and private policing has a long history, and is subject to complex long-term trends (Jones and Newburn, 2002; Zedner, 2006). In the wake of the foundational paper of Becker (1968) on the economics of crime, two pioneering contributions to the economic analysis of self-defence are those of Bartel (1975) and Clotfelter (1977). Bartel posits the problem of whether one should consider public vs. private policing as substitutes or complements, with special reference to firms' choices, also investigating the relationships between self-protection and the demand for insurance. She finds that firms tend to substitute between private and public policing and that they reason in terms of a target level of protection that is most likely achieved by a suitable bundle of public and private policing. There was, moreover, no trade-off between private policing and insurance as the insurance rates are clearly affected by the amount of security services bought. Clotfelter directly reasons in terms of substitutability between public vs. private policing, and develops an efficiency analysis in terms of the relative costs of private vs. public police, arguing that the private side tends to become more efficient as unions succeed in decoupling wage increases for public officers from increases in productivity. This may explain the diffusion of private policing in the USA. Likewise, but in a more general framework, Ehrlich and Becker (1972) find that market insurance and self-insurance (reducing the size of a loss) tend to be substitutes, whereas self-protection (reducing the probability of a loss) and market insurance may be complements. See also Ehrlich (1996) for a critical survey. Dionne and Eeckhoudt (1985), Briys and Schlesinger (1990) and Jullien et al. (1999) study the effects of an increase in risk aversion on self-insurance vs. self-protection, and find that risk aversion typically causes an increase of the former but not necessarily of the latter. Lee (1998) considers the case of activities that are targeted at ensuring self-insurance and self-protection at the same time (SICP: Self-

insurance-cum-protection), and provides sufficient conditions (based on the shape of the loss function) for increases in risk aversion causing increases in the demand for SICP. The results of this economically motivated stream of literature are pretty intuitive: When potential victims are rational decision makers, there is typically a potential trade-off between public and private policing; the most likely outcome is a mix between the two, where the actual weights depend on the actual productivity and effectiveness of public policing, and, somewhat more subtly, on the risk aversion of potential victims. It is then quite possible that crowding out effects may arise in certain circumstances.

Another, strictly complementary stream of literature focuses in more detail on the strategic interdependence between the choices of offenders and potential victims. van Dijk (1994) proposes a game-theoretic model where rational offenders and victims strategically interact and set at a Nash equilibrium state at which the level of self-protection and the level of criminal activity are fine tuned against each other. Zhuang and Bier (2007) study an attacker-defender game where both endogenous (e.g. terrorism) and exogenous (e.g. natural disasters) threats may arise, and where the attacker has to optimise over a continuous effort scale. In this context, quite complex dynamic effects may arise, leading, among other possibilities, to escalation or to setback of attack/self-defence intensity. Hausken (2006) focuses on self-protection strategies for firms against cyber attacks, and examines in particular the case of interdependent potential victims where both self-protection investments and attacks impact on both firms, no matter who is the actual investor/target, showing that in this case there may be opportunistic free riding (the more so the higher the level of interdependence) and that offenders will tend to rationally allocate attack initiatives across both targets. In this scenario, the attacker will typically manage to appropriate a larger share of the firms' profits with respect to less interdependent contexts. Self-protection will typically increase in the value of the firm asset under attack and in the efficiency of the security investment, whereas the propensity of attack is positively influenced by the value of the asset and negatively by the efficiency of the investment. Once again, very complex dynamic patterns may arise. Bier et al. (2007) study an inverse problem where a defender has to protect multiple locations, where the attacker has to pick one. The defender's actual allocation is observable, whereas the attacker's preferences are not. There is, therefore, a classical problem of negative externalities typical of interdependent self-defence problems: Putting more resources on a given location makes the others more exposed to attack. The rather sophisticated rational behaviour of the defender is therefore taking advantage of such interdependence by strategically exposing some (less valuable) locations to attack and thereby protecting (more valuable) others; this may even entail giving up zero-cost opportunities to enhance protection for some locations. The centralized allocation

of defensive resources for the defender is superior at equilibrium to the decentralized one, and it is advantageous to disclose the defensive strategy rather than concealing it. Muermann and Kunreuther (2008) study optimal self-protection strategies of insured players in an interdependent setting with positive externalities, where in the absence of an effective coordination device, a somewhat typical under-investment result emerges. They also study some welfare improving policies such as publicly enforcing a limited insurance coverage to partially internalise the externality (private enforcement would be ineffective as competition would lead insurers to offer full coverage): In this case, risk averse players would be willing to invest more in self-protection, unless the probability of a loss is large enough to discourage self-protection altogether, as originally found out by Ehrlich and Becker (1972). Lakdawalla and Zanjani (2006) analyse the possibility of public intervention in insurance markets for losses from offensive attacks (e.g. terrorism), suggesting that public subsidies can discourage self-protection and therefore the negative externalities that go with them, and that have been repeatedly discussed above. An interesting aspect of the paper is that it tries to analyse some aspects of the psychological feedback effects that self-protective choices may cause (such as losses to national prestige or impairments to the public morale). These socio-psychological factors warrant stronger reactions from the public administration with respect to analogous choices in other (catastrophe) insurance markets. Ben-Shahar and Harel (1995) take a somewhat different perspective and propose an enforcing scheme that may incentivate potential victims to substitute or complement, according to cases, public policing action. Specifically, they make a case for a 'contributory fault' scheme, namely, to oblige potential victims to buy the socially optimal level of private self-protection, making them liable, in the negative case, to losing part of the publicly provided protection; even sanctions to offenders could be linked to the victim's actual self-protection choices and their relationship with the socially prescribed level.

With the partial exception of Lakdawalla and Zanjani (2006), then, economically and game-theoretically motivated studies tend to focus on the design of optimal incentive structures to countervail the social inefficiencies that arise from the natural externalities in self-protection choices, without paying excessive attention to the socio-psychological dimension of such externalities and to the feedback effects that they may generate. It is therefore interesting to see what kind of insights emerge from the socio-psychologically motivated literature on complementary topics, and in particular on the relationship between fear of crime and self-protection choices. Baumer (1979) proposes an early account of the main factors explaining fear of crime, among which gender (women definitely worry more than men), age (the elderly substantially worry more than the young), whereas other variables

such as ethnic groups, income or education are less strongly correlated to fear of crime. There are, however, other spatially-related factors that count, such as size of the city and residential location within the city, and familiarity with the neighbourhood and with local urban life. Also the level of information about criminal activities counts. The three main factors influencing fear of crime seem therefore to be vulnerability, awareness of the incidence of criminal offences, and crime-related environmental cues. Baumer also points out that alternative approaches can be developed, among which rational choice ones based on the probabilistic reasoning about likelihood of occurrence and dangerousness of offences on the basis of environmental factors, personal characteristics and actual previous experience, or emotionally based ones that explain fear in terms of response to the psychological stress deriving by threat assessment and anticipation. Shortland et al. (1979) showed that different types of crimes elicit different emotional responses in a classical target groups such as women; in particular, physical assault generates a stronger response than burglary, recurring crimes prevail upon occasional ones, and crimes occurring in one's residential neighbourhood prevail upon crimes occurring elsewhere. Ziegenhagen and Brosnan (1990) carry out a survey on New York City subway riders in high-crime areas finding a substantial diffusion of private self-protection devices (weapons), and finding that the stronger predictors for the carrying of weapons were previous victimization and fear of victimization. They also argue that the degradation of the physical environment may be a powerful trigger factor for fear of crime. Silverman and Della-Giustina (2001) explain how too aggressive public police protection strategies may actually feed fear, rather than curbing it. Gabriel and Greve (2003) analyse in detail the psychological aspects of fear of crime, arguing about its multidimensional nature, and consequently explore its affective, cognitive, and motivational dimensions: Proper fear of crime calls for beyond-threshold levels of activation of all three dimensions at the same time. In particular, this implies that actual self-protective choices cannot be meaningfully phrased, understood and explained if all of these components are not taken into account and properly incorporated into the analytical framework, together with their mutual interdependencies. Studying individual and social patterns of self-protection without a clear notion of the complex feedbacks among the affective (being afraid of the possible offence), cognitive (reasoning about the likelihood of the possible offence) and motivational (conditioning one's own behaviour on the possibility of the offence) aspects, is likely to produce a serious misrepresentation of the actual choice and behavioural scenario, and thus to bias the design of policy strategies. Box et al. (1988) provide another multidimensional approach to fear of crime, based on a wide plurality of factors. Jackson (2008) examines fear of crime as a marker of perceived vulnerability, and finds a complex

pattern of association between the two dimensions. Women are shown to worry more than men, and this worry can actually be demonstrated in terms of the incidence of comparatively higher vulnerability factors such as less ability for physical defence, and so on. But, at the same time, the young are found to worry more often than the elderly (a result that contradicts previous evidence, such as the one cited in Baumer, 1979), in spite of the fact that this gap cannot be traced back to comparatively higher vulnerability. The key factor seems to be of a cognitive nature, i.e., actual levels of worry seem to be linked to judgements of absolute and relative risk. Farrall et al. (2000) present an explicit socio-psychological model of the fear of crime and show that socio-psychological and socio-demographic variables may account for a relatively large component of the overall variance of the phenomenon. Warr and Ellison (2000) further expand the issue by observing that fear of crime need not be referenced only to fear of personal damage, but also of damage for others (altruistic fear); such fear may even be more intense than personal one and may be deeply structured in family interaction. Several self-protective choices might thus be rephrased in terms of altruistic fear.

Coming to more sociologically-based approaches, Felson and Cohen (1980) argue that the likelihood and incidence of direct offences are largely conditioned by the structural dimensions of the social organization of work, educational or leisure activities, which create conditions for typical target of criminal offences such as women or elderly people to be more exposed to threats, and this can explain, for instance, the increase in crime rather in the United States during the 60a and the 70s, namely, in the period during which most of these social changes took place more intensively; in this view, crime would largely be a by product of socio-economic progress and thus would be largely un-eliminable without substantial changes in the social organization of activities, somewhat downplaying the relative importance of the issue of self-provided vs. publicly provided protection. Reiss (1986) points attention upon the socio-group dynamics of delinquency, and the occurrence of critical social factors that cause, at the same time, less social control and higher social incentives to criminal behaviour. Sampson and Groves (1989) test a community-level approach to crime based on the Shaw and Mc Kay (1969) theory of community disorganization, finding that the major factors causing the latter, such as economic poverty, ethnic heterogeneity, residential mobility and family disruption tend to be strongly associated to both criminal offending and victimization in two large British samples. Pantazis (2000) argues that fear of crime in contexts characterized by economic poverty is strongly associated to other forms of insecurity, and the joint actions of these factor causes a clear perception of a safety gap on their part. Gibson et al. (2002) analyse the impact of social integration upon fear of crime in three US cities, finding that socially integrated individuals have a stronger perception of collective efficacy in crime

prevention and therefore are less prompted to develop self-protection strategies. Moreover, this effects tend to prevail on other factors such as socio-demographic characteristics, perceptions of local social disorder, and even prior victimization. Rosenbaum (1988) provides a review on the existing evidence on community-based forms of crime prevention, finding a substantial lack of carefully designed studies that demonstrate how, and under what conditions, such alternative forms of protection may emerge as a real alternative to classical forms of publicly and privately provided protection. Clearer evidence in this respect is provided by Sampson et al. (1997) and Sampson and Raudenbush (1999)'s 'collective efficacy' approach. Kennedy (1997) argues that structural social factors that make criminal offences recurrent and predictable provide an important opportunity for the design of a systematic strategy of crime prevention. The picture that emerges from this literature is therefore that it is the underlying social structure that explains criminal behaviour and vulnerability as two sides of the same coin, namely, a disrupted - and disruptive - social environment. Consequently, in this perspective self-protection choices cannot be entirely rationalized as independent, purposeful choices but rather prove to be a predictable consequence of the incumbent logic of social relationships.

However cursory and synthetic, an analysis of the sociologically motivated literature thus clearly points toward the structure and characteristics of the social environment as a primary factor for the understanding of fear of crime and self-protective behaviours. Riger and Lavrakas (1981) provide an early account of how community ties may contribute to building an emotionally based feeling of attachment that creates a perception of safety and self-efficacy in residential neighbourhoods. Katzman (1980) provides an equally early account of how perception of criminal activity may be an important factor of urban decline by selectively disincentivating potential movers - in particular, families with children and affluent people, independently of the ethnic group. An economically motivated paper by Rizzo (1979), moreover, underlines how one of the major consequences of the fear of crime, and thus of its consequences for potential victims, is that it causes changes in property values, and thus urban degradation, whose cost is borne mainly by local residents, also in terms of costs of self-protection. Ellin (1997, 2001) provides an articulate critical review of the relationship between fear of crime and city design in modern and contemporary urbanism, explaining how planners and local communities have devised through time alternative, more or less effective strategies of self-protection that have deeply affected urban structure and the social logic of urban space use. Davis (1998) provides an impressive account of how the technological scanning of urban space for protection purposes is changing the very nature of urban life and experience. In emerging countries, protection and safety concerns increasingly often lead to the creation of integrally policed 'gated' communities, sorts of

'civil fortresses' shielding affluent residents from the threats of often close-by, high crime quarters (see e.g. Caldeira, 2001; Rotker, 2002; Landman and Schönteich, 2002). But also highly developed countries like the US seem to follow the same trend: Blakely and Snyder (1997) find that, in the mid nineties, some 9 millions of US residents lived in gated communities. Since then, figures are more likely to have gone up rather than down: For the case of the Phoenix Metro area, Frantz (2001) reports that gated dwellings hosted about the 12% of the whole population of residents; for a general discussion, see also Webster et al. (2002). Loader (2001) and Newburn (2001) argue that the recent increase in demand for private policing may be the result of a specific trajectory of socio-cultural evolution, namely, the advent of a post-modern consumer culture leading to the commodification of security. Bowles and Jayadev (2006) have estimated that 'guard labour', namely, un-productive workers taking part to the surveillance-punishment game on both sides (supervisors, guards, military personnel, prisoners, unemployed people), has risen from 6% of the US labour force in 1890 to 26,1% in 2002; moreover, there are significant country differences in these figures, and the main driving factor behind such disparities seems to be the level of income inequality.

Although a really systematic interdisciplinary review of all of the above issues would rather be fitting a (voluminous) book, even from this concise review it is clear that, considering from a methodologically pluralistic perspective the issue of public vs. private protection, and all of its implications in terms of fear of crime and related topics, provides an impressive amount of insight and countless suggestions for possible formal models exploring a few of the cited factors and mechanisms at a time. It is also evident that the gaps between disciplinary approaches are large, and deep: For instance, the sociological literature tends to underplay the role of rational choice in the shaping of self-protection decisions, whereas the economic literature, on the contrary, pays little attention to the incumbent structural social conditions. Both appear as serious limitations, in view of the above discussion of some of the available evidence. The socio-psychological literature is probably the field where one finds more room for the development of an abridged viewpoint that keeps together, at least to some extent, the possibility of individual optimising behaviour and the environmental relevance of social constructs. Fear of crime seems to be the key factor in this respect, in its inescapably multi-dimensional nature that combines psychological, social and economic elements, while at the same evolving in complex, challenging ways: For instance, it may be rising even in the face of data that prove that criminality rates are going down (this is what has recently happened, for instance, in a high-crime urban setting such as Baltimore; see Hermann, 2009). It seems to be warranted, then, that excessively one-dimensional approaches are giving away some fundamental aspects of the issue,

thereby failing to capture and explain an excessive amount of observed evidence. For this reason, in the present paper we try and construct an interdisciplinary motivated model that contemplates the possibility that individuals are at least boundedly rational decision makers, while at the same time being sensible to the psychological dimension of fear of crime and to imitation-based forms of social dynamics driving the cultural selection of behaviours. We will intentionally keep the model as simple as possible, interpreting it as a sort of basic theoretical platform to be further developed and articulated in future research, as more subtle, multi-dimensional aspects are taken into account and explicitly modelled. The contention is that, if the model in its actual stripped-down form is able to deliver a realistic enough array of dynamic scenarios and to provide a sound basis for simple policy analysis, then it can be seen as a reasonable compromise that may hopefully spark more interdisciplinary research upon, and modelling of, self-protective behaviours.

3 The model

Our model is based upon Cressman et al. (1998), who study a two-population evolutionary game: One of potential offenders, and the other of potential victims. As already remarked, in this context they obtain a crowding out result: Publicly provided protection entirely crowds out private self-protection, so that the net effect of public spending on the overall level of protection is null.

Our model departs from that of Cressman et al. in that, here, interaction takes place through random matching among three players: Two potential victims ('neighbours'), a and b, and a prospective offender, c. Self-protective expenses by a potential victim generate negative externalities on the neighbour (as well as on prospetive offenders, of course), in that they cause greater relative exposure to offences. This negative effect has a tangible correlative – if a potential victim protects herself by buying an armored door, an alarm system, a watchdog etcetera, the offender will attack the neighbour provided that he is lacking such protection resources – but *also* an intangible, psychological one, in particular, feelings of fear and insecurity, which may be connected to one's greater relative exposure, but that may also be entirely independent of objective conditions of peril.

Time is continuous, draws are from continuous populations defined upon the unit interval, and each player chooses her strategy without knowing ex ante the choices of other players. In this way, we are

able to study the interdependencies that arise within the population of potential victims as a consequence of the players' self-protective choices.

At each instant t, one draw is made, a triple $(a, b \mid c)$ is randomly matched, and a one-shot stage game is played. Potential victims have to choose between two strategies: P (purchasing a self-protection device, e.g. an armoured door), and NP (not purchasing any self-protection device). Prospective offenders have to choose between R (assaulting a victim) and NR (not assaulting anyone).

Let us assume that the payoff matrix for the potential victim a (and likewise for b) has the form

$$
\begin{array}{ccccc}
& R, P_b & R, NP_b & NR, P_b & NR, NP_b \\
P_a & -\alpha - \dfrac{1}{2}\beta_1 - \gamma_1 & -\alpha & -\alpha - \gamma_1 & -\alpha \\
NP_a & -\beta_2 - \gamma_2 & -\dfrac{1}{2}\beta_2 & -\gamma_2 & 0
\end{array}
\tag{1}
$$

where the parameter $\alpha > 0$ denotes the cost of the self-protective strategy. The parameters β_1 and β_2 denote the damage incurred in case of assault for victims adopting, respectively, the P vs. NP strategy; we assume $0 \leq \beta_1 < \beta_2$, namely, those who adopt P incur a smaller damage in case of assault. We notice that if $\beta_1 > 0$, then strategy P does not warrant a full protection (whereas this is the case if $\beta_1 = 0$). The parameters γ_1 and γ_2 measure the damage incurred by the potential victim a because of the psychological externality generated by the choice of P_b on the part of the potential victim b in case a adopts, respectively, strategy P vs. NP. We assume $0 < \gamma_1 < \gamma_2$, namely, psychological damage is bigger if player a chooses NP.

In the payoff matrix (1), we have assumed that when both potential victims adopt the same strategy (P or NP) the attack may hit any of them with the same (0.5) probability. If instead the two potential victims adopt different strategies, then the one that chose not to self-protect is attacked with certainty.

As to the payoff matrix of prospective offenders, we assume:

$$
\begin{array}{ccccc}
& P_a, P_b & P_a, NP_b & NP_a, P_b & NP_a, NP_b \\
R & a & b & b & c \\
NR & d & d & d & d
\end{array}
\tag{2}
$$

and postulate that: $c > b > a$. The meaning of this condition is pretty obvious; notice, however, that we

do not make any assumption on *d*. The best possible situation for the prospective offender is that none of the two potential victims self-protects, whereas the worst possible one is when both potential victims self-protect.

Denoting by *x(t)* the share of potential victims who self-protect, and by *y(t)* the share of prospective offenders who choose to attack, the expected payoffs from playing *P* vs. *NP* are given, respectively, by

$$\Pi^P = -\left(\alpha + \frac{1}{2}\beta_1 + \gamma_1\right)xy - \alpha(1-x)y - (\alpha + \gamma_1)x(1-y) - \alpha(1-x)(1-y) \qquad (3)$$

$$\Pi^{NP} = -(\beta_2 + \gamma_2)xy - \frac{1}{2}\beta_2(1-x)y - \gamma_2 x(1-y) \qquad (4)$$

so that one has:

$$\Pi^P - \Pi^{NP} = \frac{\beta_2 - \beta_1}{2}xy + (\gamma_2 - \gamma_1)x + \frac{\beta_2}{2}y - \alpha$$

For the prospective offenders, expected payoffs under *R* vs. *NR* are given, respectively, by

$$\Pi^R = ax^2 + bx(1-x) + b(1-x)x + c(1-x)^2 \qquad (5)$$
$$\Pi^{NR} = d \qquad (6)$$

so that one has

$$\Pi^R - \Pi^{NR} = (a + c - 2b)x^2 - 2(c - b)x + c - d$$

Since we are working on a (two population) two strategy case, all payoff monotonic dynamics yield the same results (Weibull, 1995). For simplicity, and following Cressman et al. (1998), we assume that the evolution of *x* and *y* is described by the replicator dynamics

$$\begin{cases} \dot{x} = x(1-x)[\Pi^P - \Pi^{NP}] \\ \dot{y} = y(1-y)[\Pi_c^R - \Pi_c^{NR}] \end{cases} \qquad (7)$$

The replicator dynamics can be seen as a relatively simple model of cultural evolution driven by simple mechanisms of learning by imitation (see Björnerstedt and Weibull, 1995; Weibull, 1995; Sacco, 1995; Schlag, 1998). In particular, it amounts to postulating that players are boundedly rational and update their choices through a simple rule of thumb that leads them to adopt the behavior that seems relatively more rewarding on the basis of the available observations of others' behaviors. In the general case, the

replicator dynamics causes strategies to grow (decline) the more, the higher (lower) their payoff differential with respect to the population average. With only two strategies, of course, the shares dynamics are regulated by their payoff differential; this is also why, in this simple case, the replicator dynamics yields the same results as any other payoff monotonic dynamics. The replicator dynamics has been widely studied and has nice properties in terms of equilibrium selection (Hofbauer and Sigmund, 1988), and for these reasons has been widely adopted in the applied evolutionary game theoretic literature. Our model, therefore, puts together various elements: The interplay between material and psychological consequences of criminal and self-protective behaviour; bounded rationality and cultural selection mechanisms; and strategic interaction between potential victims as well as between victims and prospective offenders. On this basis, we will be able to provide a full characterization of the social dynamics of the model, and to carry out some simple but somewhat insughtful welfare and policy analysis.

4 Basic mathematical results

In this section, we present a complete classification of the social dynamics (7). As we shall see, the most interesting case is the one where the equilibrium at which all potential victims self-protect is Pareto dominated by a no-protection equilibrium.

4.1 Fixed points

The dynamical system (7) is defined on the square Q:

$$Q = \{(x,z) : 0 \leq x \leq 1, 0 \leq z \leq 1\}$$

In what follows, we will denote by $Q_{x=0}$ the side of Q where $x = 0$, and by $Q_{x=1}$ the side where $x = 1$. Similar interpretations apply to $Q_{y=0}$ and $Q_{y=1}$. All sides of this square are invariant; namely, if the pair (x,y) initially lies on one of the sides, then the whole correspondent trajectory also lies on that side. Notice that the states $\{(x,z) = (0,0),(0,1),(1,0),(1,1)\}$ (the edges of the square) are always fixed points of the dynamic system (7). In such states, only one strategy is played in each population. Furthermore, it is easy to check that the other fixed points are: The points F_1 and F_2 at the intersection (when existing) between the interior of the sides $Q_{y=0}$, $Q_{y=1}$ (at which $\dot{y} = 0$), and the curve defined by

$\Pi^P - \Pi^{NP} = 0$ (at which $\dot{x} = 0$); and the point F in the interior of Q where the curves $\Pi^P - \Pi^{NP} = 0$

and $\Pi^R - \Pi^{NR} = 0$ (at which $\dot{y} = 0$) meet, when existing. No fixed point (generically[1]) exists along the

sides $Q_{x=0}$, $Q_{x=1}$. Thus, the highest number of fixed points that can be generically observed is seven.

4.2 Stability of fixed points

The Jacobian matrix of the dynamical system (7) is:

$$
J = \begin{bmatrix} (1-2x)\left(\Pi^P - \Pi^{NP}\right) + \left(\gamma_2 - \gamma_1 + \dfrac{\beta_2 - \beta_1}{2}y\right)x(1-x) & \left(\dfrac{\beta_2}{2} + \dfrac{\beta_2 - \beta_1}{2}x\right)x(1-x) \\ 2\left[(a+c-2b)x + b - c\right]y(1-y) & (1-2y)\left(\Pi^R - \Pi^{NR}\right) \end{bmatrix}
$$

Thus, the following proposition can be easily checked.

Proposition 1 : *The fixed points F_1, F_2 and F, when existing, are saddle points or sources.*
The eigenvalue of $(0,0)$ in direction of $Q_{y=0}$ is $-\alpha < 0$, and the eigenvalue in direction of $Q_{x=0}$ is
$c - d$.
The eigenvalue of $(0,1)$ in direction of $Q_{y=1}$ is $\dfrac{\beta_2}{2} - \alpha$, and the eigenvalue in direction of $Q_{x=0}$ is
$d - c$.
The eigenvalue of $(1,0)$ in direction of $Q_{y=0}$ is $\alpha + \gamma_1 - \gamma_2$, and the eigenvalue in direction of $Q_{x=1}$ is
$a - d$.
The eigenvalue of $(1,1)$ in direction of $Q_{y=1}$ is $\alpha - \dfrac{\beta_2 - \beta_1}{2} + \gamma_1 - \gamma_2$, and the eigenvalue in direction of
$Q_{x=1}$ *is $d - a$.*

Notice that at most two fixed points can be simultaneously attractive. In particular, if $d \leq a$ (i.e. R dominates NR, that is, prospective offenders will always find it convenient to attack), then only the fixed points $(0,1)$ (*Surrender Scenario*: No potential victims self-protect, all offenders attack) and $(1,1)$ (*All-Round Fight Scenario*: All potential victims self-protect, all offenders attack) in the side $Q_{y=1}$ can be attractive. Specifically, they will be simultaneosly attractive if:

$$
\alpha > \frac{\beta_2}{2} \quad \text{and} \quad \gamma_1 < \gamma_2 + \beta_2 - \beta_1 - \alpha \tag{8}
$$

---

[1]In particular, no fixed point exists if $d \neq a, c$ while if $d = a$ or $d = c$, then one of the two edges is point-wise fixed.

If $d \geq c$ (i.e. NR dominates R, that is, prospective offenders will never want to attack), then only the fixed points $(0,0)$ (*Peace Scenario*: No potential victims self-protect, no prospective offenders attack) and $(1,0)$ (*Deterrence Scenario*: All potential victims self-protect, no prospective offenders attack) in the side $Q_{y=0}$ can be attractive, and they are simultaneously attractive if:

$$\gamma_1 < \gamma_2 - \alpha \tag{9}$$

If $a < d < c$, then only the fixed points $(0,1)$ and $(1,0)$ can be attractive, and they are simultaneously attractive if:

$$\gamma_2 - \gamma_1 > \alpha > \frac{\beta_2}{2} \tag{10}$$

Figures 1-3 show some trajectories of the dynamics (7) in the cases where, respectively, the couples of fixed points $(0,1)$ and $(1,1)$, $(0,0)$ and $(1,0)$, $(0,1)$ and $(1,0)$ are attractive.

Notice that all fixed points can be simultaneosly sources or saddles. This is the case if:

$$a < d < c \quad \text{and} \quad \gamma_2 - \gamma_1 < \alpha < \frac{\beta_2}{2}$$

In this case, all of the trajectories that start in the interior of Q tend to a limit cycle or, as in Figure 4, to the boundary of Q, indefinitely rotating anti-clockwise. This is the 'typical' behaviour that emerged in the Cressman et al. (1998) model.

[Insert Figures 1-4 about here]

Figure 1. $\alpha > \beta_2/2$ and $\gamma_1 < \gamma_2 + \beta_2 - \beta_1 - \alpha$; $d<a$. **Surrender vs. All-Round Fight scenarios.**
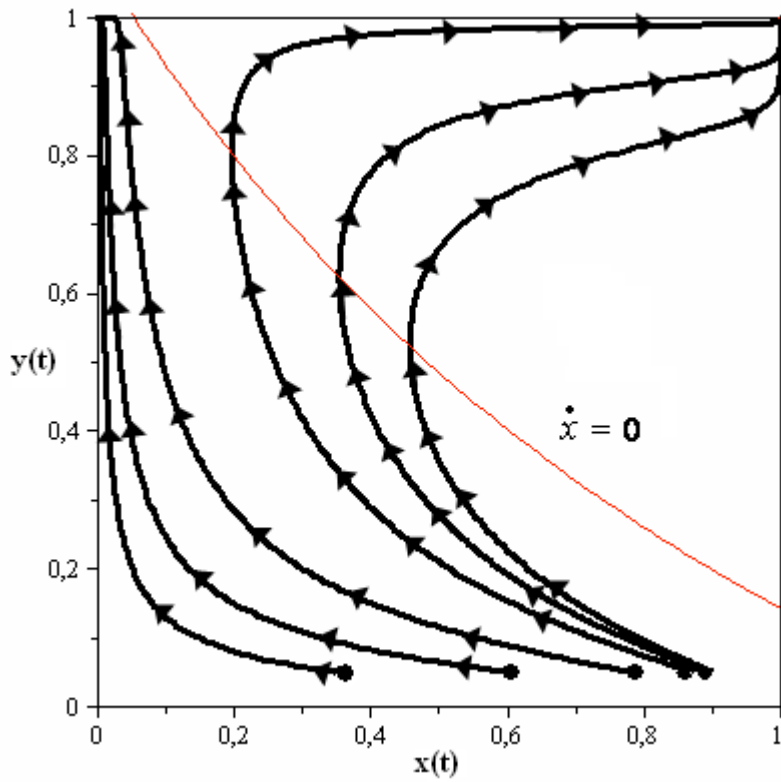
Figure 2. $d>c$ and $\gamma_1 < \gamma_2 - \alpha$. **Peace vs. Deterrence scenarios.**
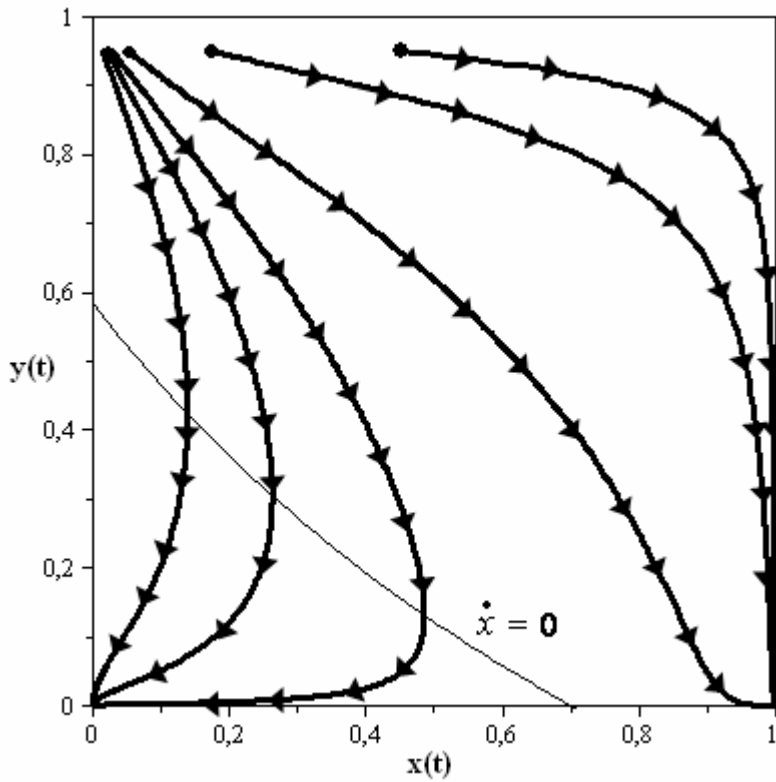
Figure 3. *a<d<c* and $\gamma_2 - \gamma_1 > \alpha$, $\alpha > \beta_2/2$. **Surrender vs. Deterrence scenarios.**
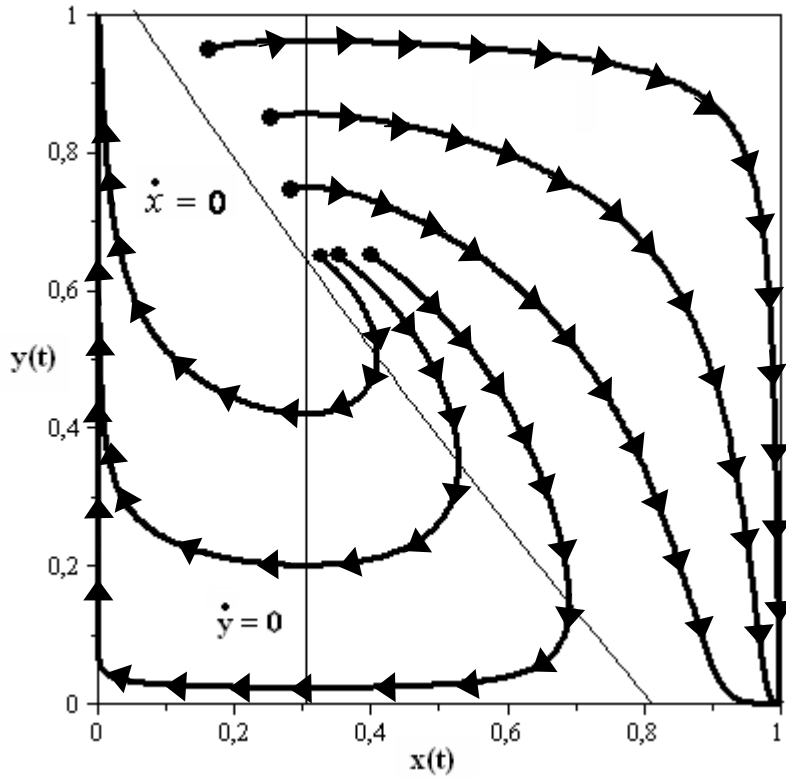
Figure 4. *a<d<c* and $\gamma_2 - \gamma_1 < \alpha$, $\alpha < \beta_2/2$. **Convergence to a limit hypercycle.**
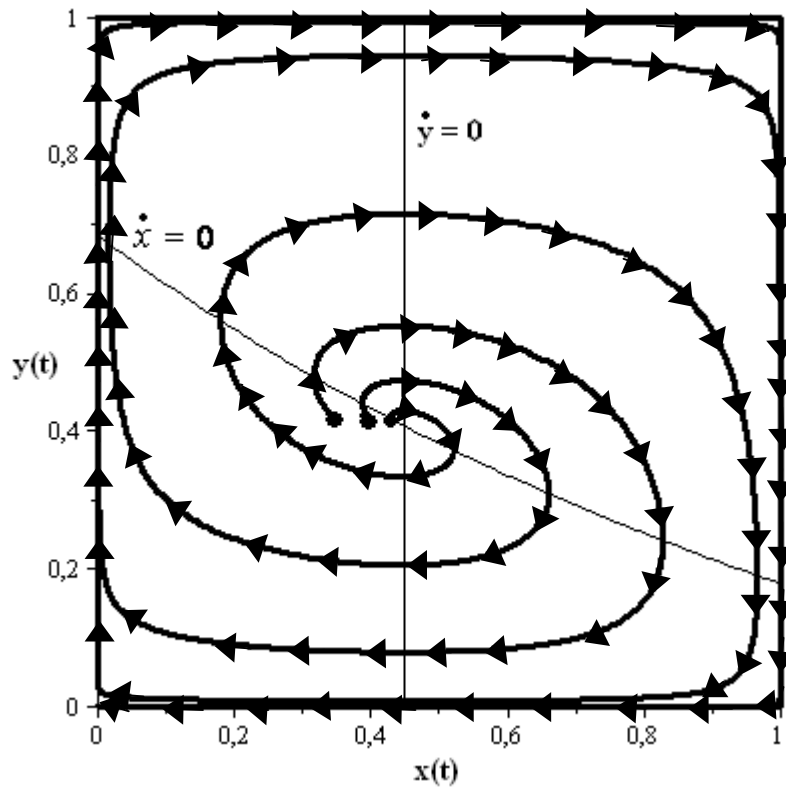
4.3 Interpretation of the results

The results of section 4.2 are difficult to read and to interpret in their abstract mathematical formulation. In this section, we provide a systematic interpretation and a commentary.

The social dynamics of the model basically generates three different regimes, one of which further divides into two distinct sub-regimes. They are identified by the relative magnitude of the returns of the various options for prospective offenders. In particular, they are indexed by the relative position of the 'free' parameter d (the return to not attacking for prospective offenders) with respect to the payoffs for the other situations, for which, as noticed above, we have that $c>b>a$: The return for attacking when no potential victim self-protects (c) is higher than the return to attacking when only one potential victim self-protects (b), which in turn is higher than the return to attacking when both potential victims self-protect (a).

The first regime is identified by the condition $d \leq a$: By giving up attacking, prospective offenders get less than they would be getting in the worst possible conditions when attacking, namely, when facing all self-protecting potential victims. In this case, offenders will have a strong incentive to attack, and this is in fact what they will do. This could be caused by the low return to other illegal activities, or by the paucity of alternative legal forms of income, such as unemployment benefits. We thus call this regime the *No Way Out* regime: No matter what happens, offenders will be up for crime. Under these conditions, there may be at most two alternative long-run equilibria: The one where potential victims give up defending themselves (the Surrender scenario), and the one where they resist (the All Round Fight scenario). If both have to exist, condition (8) must hold: Namely, protection must be relatively costly with respect to (expected) damage without protection, but not costly enough to overcome both relative physical and psychological damage. If protection is by all means cheap ($\alpha<\beta_2/2$), then the All Round Fight is the sole possibility; if, on the contrary, it is extremely expensive ($\alpha>\beta_2-\beta_1 + \gamma_2-\gamma_1$), then Surrender will emerge. When costs lie in the range prescribed by (8), which equilibrium is reached depends on initial conditions, namely, on the initial distribution of behavioral types across the two populations, provided that parameters are such that both equilibria exist (see above). If they do exist, then, we will end up in the Surrender scenario if the initial share of aggressive offenders is large enough, and if the initial share of self-protective victims is small enough. In this case, attacks will be relatively frequent, to an extent that even self-protective victims will eventually give up protection in that it is not (cost-)effective enough to shield them significantly against a plethora of very active

offenders (a result that is somewhat reminescent of Ehrlich and Becker, 1972). On the contrary, when in the initial situation most victims self-protect (and attacks are again very common in that attacking is so much more convenient for offenders than not doing so), the few ones who don't are attacked so often that they will find it convenient (i.e., cost-effective), to protect themselves as well. Depending on what is the 'traditional' (i.e. culturally inherited) orientation of potential victims, then, in the No Way Our Regime we will witness convergence toward the Surrender or toward the All Round Fight Scenario. Clearly, the relative amplitude of the two attraction basins depends on the characteristics of the payoff structure of the potential victims: For a given initial distribution of shares of behavioral types of victims and offenders, the higher the cost of self-protection, the lower the relative demage from attack in case of no protection (as compared to the self-protection case), and the lower the relative negative externality from the other victim's choice of self-protection when the victim under exam chooses the no protection option, the wider the configuration of initial conditions for which the Surrender scenario will emerge, and vice versa for the All Round Fight Scenario (Figure 1).

The second regime corresponds to the condition $d \geq c$: In this case, prospective offenders may always obtain from other activities at least as much as they get from attacking in the best possible conditions (i.e., facing no self-defense). They could be, for instance, the returns from other, relatively safe illegal activities, or even, again, legal sources of income that require some form of constant social monitoring that prevents an intense criminal activity (e.g. unemployment benefits conditional upon an intensive and compulsory lifelong learning program). We thus call this regime the *Outside Option* regime: Offenders are lured into other activities than attacking, legal or not. Here, the two possible long-run scenarios are Peace or Deterrence. If both have to exist, condition (9) must hold: The cost of self-protection must be lower than the relative negative externality from not protecting, so that there is at least one good reason to protect oneself in spite of the fact that offenders are relatively unwilling to attack; the negative feeling deriving from being exposed to damage whereas others aren't is large enough to make self-protection plausible. If, on the contrary, self-protection is relatively expensive with respect to the size of the psychological damage, only the Peace scenario will be possible. When (9) is met, once again, the eventual equilibrium depends upon the initial distribution of behavioral types in the two populations, and upon the characteristics of the payoff structure of victims. As attacking is not so rewarding, there will be relatively few offenders around (or at least, the share of offenders will decline rather quickly). If most victims do not self-protect, the possibility of being attacked is relatively remote, as the risk of attack is spread over a very large number of exposed victims; thus, eventually, no one will find it cost-effective to self-protect, and the Peace scenario will result. Conversely, if most

victims initially self-protect, even if there are relatively few offenders, not self-protecting causes a substantial exposure to attacks, and this eventually leads to choosing the self-protection option even if, overall, the number of offenders declines in time. If the cost of protection is relatively low, the relative damage from attack without protection is comparatively high and so is the relative negative externality from the other victim's self-protection choice in case of no protection, then the attraction basin of the Deterrence scenario will be relatively wide with respect of that of the Peace scenario, and vice versa (Figure 2).

The third, most complex and interesting regime, however, is found when $a < d < c$, i.e., when there is no obvious option for offenders. They have to choose whether or not to attack by careful evaluation of the contextual conditions: Sometimes offenders play tough, and sometimes not, depending on circumstances. Since the actual dynamic behavior in this regime basically depends on specific parametric conditions, we generally speak of a Critical Regime (in the sense that a suitable parameters change may bring about a substantial modification of the dynamic behaviour of the model, for instance through a bifurcation). In this case, we have two distinct sub-regimes. In the first, that we call Tug of War, the two stable scenarios are Surrender and Deterrence, again according to initial conditions and the victims' payoff structure; it is easy to reconstruct how the relative amplitude of the two attraction basins is determined by suitably adapting the arguments for the already discussed cases. However, in this case it is not necessarily true that both scenarios are equilibria. This only happens when (10) holds (Figure 3). Condition (10) basically requires that the cost of protection is relatively low when compared to the relative negative psychological externality from not protecting, and relatively high when compared to the (expected) damage when being attacked without protection. In this case, there is a tradeoff between the no protection and self-protection options that is driven by the psychological factor: Whereas material conditions would make it relatively reasonable not to protect (damage would be not large enough to make protection cost-effective), the psychological impact of being exposed is subtantial enough to make protection a viable choice. In this case, what will be the eventual scenario that emerges, Surrender or Deterrence, will basically depend on the quite complex interplay of *all* of the parameters of the model, including initial conditions (Figure 3). It should be clear now why we speak of Tug of War for this sub-regime: Either victims or offenders conquer the field depending on which factors 'pull' more strongly in the proper direction. And to further confirm this intuition, we have that, if α drops below $\beta_2/2$ (protection becomes relatively cheap in all respects), we will only have the Deterrence scenario as a possible equilibrium, whereas if α climbs above γ_2-γ_1 (protection becomes so expensive to overcome any kind of material or psychological damage), only the Surrender scenario

will result.

The second sub-regime, that we call Rock-Scissors-Paper, is found when the cost of protection is lower than the (expected) damage without protection, but higher than the negative psychological externality from no protection. In this case, we have a perpetually oscillating behavior, as in the original Cressman et al. (1998) model. It is interesting to discuss why in this case we have cyclic behaviour rather than convergence to a stable state: After all, as in the Tug or War sub-regime, here too we have a non trivial tradeoff between material and psychological costs. How come that the resulting social dynamics are so different? The answer lies in the relationship between relative costs and the interaction between the two victims. In the Rock-Scissors-Paper scenario, material damage is high and negative psychological externalities are low given the cost of protection. When the share of the victims that self-protect increases, attack becomes less rewarding for offenders and their share decreases; but once the frequency of attack gets diminishing to a significant degree, potential victims begin to disinvest in protection, provided that they are relatively less sensitive to the negative psychological externality of exposing themselves. But as this dis-investment dynamics generates a massive decrease of protected potential victims, new opportunities for prospective offenders arise and they start growing again relatively quickly, thus soliciting in turn a defensive response from victims that start investing in self-protection again, until the cycle is completed and a similar, new one begins (Figure 4). At this point it should be clear why we speak of a Rock-Scissors-Paper scenario: like in the famous game (and in its corresponding game-theoretic representation; see e.g. Friedman, 1991), there is a cyclic structure that prevents the equilibrium distribution to settle on a monomorphic equilibrium. In the Tug of War Dynamic Regime, instead, when we consider a similar situation, namely, an increasing number of self-protecting victims, the share of attacking offenders drops as well, but now, given that the sensitivity to negative psychological externalities is high and the level of material damage is relatively low (or better, it is cost-effectively covered by protection), victims are aware that most victims are self-protecting and therefore feel the psychological urge to maintain their shield against offenders; thus, because of the *psychological* link (that is to say, actual crimes decrease but fear does not, as in the Baltimore episode cited in section 2), the level of protection remains high and the social dynamics eventually converge to the Deterrence scenario.

This key role of the negative psychological externalities deserves further discussion. It can be read in a twofold way: On the one hand, such externalities are related to the fear of being relatively more exposed than others to criminal attacks as other increase their level of protection; on the other hand, they are related to the consideration that the very fact that others are willing to increase their level of

protection is evidence of a threatening social environment, and this prompts further concern and anxiety. In the Cressman et al. (1998) model, the only non-trivial dynamic regime was cyclic behavior as in our Rock-Scissors-Paper scenario. Lack of consideration of the psychological externality (fear dimension), among other factors, did not allow to obtain the bi-stable Deterrence-Surrender dynamic regime that, as we shall see, is the more interesting from the point of view of welfare and policy analysis. Considering fear of crime as a possible key force behind the social dynamics, thus, does not simply add an extra element of realism to the model, but basically modifies its results and its descriptive and predictive power. On the basis of the previous analytical results, we are now ready to carry out some welfare and policy analysis.

5 Welfare and policy analysis

5.1 Welfare analysis

We begin by examining the average well-being of potential victims. The average well-being level is given by:

$$\overline{\Pi}(x,y) := x \cdot \Pi^P(x,y) + (1-x) \cdot \Pi^{NP}(x,y) \tag{11}$$

With reference to the various dynamic regimes defined in section 4, the following proposition holds.

Proposition 2

In the No Way Out regime (i.e. when $d \leq a$, so that R dominates NR), the fixed point $(0,1)$ (the Surrender senario) strictly Pareto-dominates $(1,1)$ (the All Round Fight scenario) – that is to say,

$\overline{\Pi}(0,1) > \overline{\Pi}(1,1)$ – *iff* $\gamma_1 > \dfrac{\beta_2}{2} - \alpha$.

In the Outside Option regime (i.e. when $d \geq c$, so that NR dominates R), the fixed point $(0,0)$ (the Peace scenario) always strictly Pareto-dominates $(1,0)$ (the Deterrence scenario).

In the Critical Regime (i.e. when $a < d < c$), the fixed point $(0,1)$ (the Surrender scenario) Pareto-dominates $(1,0)$ (the Deterrence scenario) iff $\gamma_1 > \dfrac{\beta_2 - \beta_1}{2} - \alpha$.

Using conditions (8)-(10), it is easy to check that, when there exist two attracting fixed points (bi-stable regimes), then the fixed point such that $x = 0$ (where all agents play NP, i.e. the non self-protected equilibrium) always Pareto-dominates the one such that $x = 1$ (where all agents play P, i.e., the self-protected equilibrium). Moreover, the fixed point such that $x = 0$ may Pareto dominate the one such that $x = 1$ even when the latter is the only attractive fixed point for the social dynamics.

Let us now try to understand better the meaning of the conditions found in Proposition 2. In the No Way Out regime, there are three parameters that count for welfare analysis: the cost of protection, the damage from attack in the absence of protection, and the psychological negative externality in the case of protection. In particular, it will be Pareto optimal for victims not to self-protect if the cost of protection exceeds the difference between the (expected) damage in the absence of protection, net of the psychological negative impact of others' protective choices when the victim self-protects. We can think of the latter quantity as *intrinsic* fear – that is, the fear that the victim feels even when she has done all she could to protect herself. When fear is intrinsic and protection is costly, and overall the two quantities overcome the expected damage without protection, there is little the victim can do to improve her position by self-protecting; as a consequence, giving up protection is the best self-serving choice.

In the Outside Option regime, there is no reason why victims should choose to self-protect, in that prospective offenders do not find it convenient to attack. The only reason why the Deterrence equilibrium may emerge in this scenario is that fear of being exposed by potential victims is strong enough to push the social dynamics toward self-protection in spite of the steady decline (and of the eventual disappearance) of criminal activity. As to the Critical regime, we find a condition for Pareto optimality of non-protection that is similar to the one for the No Way Out scenario, with the difference that now it is *less* restrictive: What is required now is that the cost of protection and the level of intrinsic fear be larger than the (expected) *incremental* damage from attack with lack of protection with respect to the damage from attack with protection. Then, unless victims have very much to lose from remaining unprotected from the offender attacks, if there is a high level of instrinsic fear and protection is relatively costly, it is likely that victims will be better off *without* self-protecting.

5.2 Public security expenses

Given the previous welfare analysis, how can public administration act in order to implement an optimal allocation? The answer seems pretty clear: It should try to reduce self-protective expenses of

potential victims in order to curb psychological negative externalities (i.e., in order to thwart the social dynamics of fear). This goal may be reached by taxing victims (and possibly discriminating between self-protecting and non self-protecting ones), and using the revenues to provide public security: In other words, we are now in the position to study the publicly vs. privately provided protection dilemma and its welfare implications. With public intervention, the payoff matrices (1-2) become, respectively:

$$
\begin{array}{ccccc}
 & R, P_b & R, NP_b & NR, P_b & NR, NP_b \\
P_a & -\alpha - \dfrac{1}{2}\beta_1 - \gamma_1 - \tau_1 & -\alpha - \tau_1 & -\alpha - \gamma_1 - \tau_1 & -\alpha - \tau_1 \\
NP_a & -\beta_2 - \gamma_2 - \tau_2 & -\dfrac{1}{2}\beta_2 - \tau_2 & -\gamma_2 - \tau_2 & 0 - \tau_2
\end{array}
\qquad (12)
$$

$$
\begin{array}{ccccc}
 & P_a, P_b & P_a, NP_b & NP_a, P_b & NP_a, NP_b \\
R & a-p & b-p & b-p & c-p \\
NR & d & d & d & d
\end{array}
\qquad (13)
$$

where τ_1 and τ_2, with $\tau_1 \geq \tau_2 > 0$, are tax rates, and $p > 0$ captures the effect of the public security expenses by the public administration.

We remark that, as *p* grows, the dynamic regime may shift from No Way Out to Outside Option (going through the intermediate Critical regime where no offender strategy is dominant). Therefore, for a high enough *p*, all trajectories of the social dynamics will converge toward the edge of *Q* such that *y=0* (all prospective offenders choose not to attack). At this point, the issue becomes that of preventing the fixed point $(x, y) = (1,0)$ (the Deterrence scenario) from becoming attractive – that is to say, to prevent the possibility that victims keep on buying self-protection in spite of the fact that there is no risk of being attacked. This latter, Pareto inefficient scenario is indeed quite possible, in that victims could fail to understand that the lack of attacks is not due to their self-protection but to the publicly provided security.

We moreover remark that, setting $\tau_1 = \tau_2$, that is, taxing in a non-discriminatory way both self-protecting and non-protecting victims, public intervention does not affect in any way the payoff differential between the two strategies, and thus cannot have an impact on the dynamic properties of the social dynamics , including the possibility of preventing convergence toward the inefficient equilibrium with private protection. In order to prevent the Deterrence scenario (the (1,0) fixed point)

from becoming attractive, thus, it is necessary to introduce discriminatory taxation, i.e., increasing τ_1 (while keeping τ_2 constant). In this way, it becomes possible to shape the social dynamics in order to implement the no self-protection optimal equilibrium (the Peace scenario $(x,y)=(0,0)$) as a globally attractive limit equilibrium outcome.

Clearly, these remarks only tell us that, contrary to the Cressman et al. (1998) model, in our model the investment in public security *may* lead to a Pareto improvement, depending on the actual values of τ_1 and τ_2 that are necessary to secure a high enough level of public intervention (a high enough value of *p*). It could be interesting to analyze this aspect of the model as an optimal control problem for the public administration; we intende to explore this avenue for future research in a subsequent paper.

6 Conclusions

In this paper we have shown – on the basis of a simple social dynamics governing the evolution of strategic protection choices of boundedly rational potential victims facing the threat of prospective offenders in a large population with random matching – that fear of exposure to criminal threats may actually condition choices even in the face of objective evidence of declining crime rates, and thereby cause the eventual selection of a Pareto inefficient equilibrium with self-protection. We have also shown that a suitable strategy of provision of public security financed through discriminatory taxation of self-protective expenses may actually overcome this problem and drive the social dynamics toward the efficient no protection equilibrium. In our model, then, we do not obtain, as in Cressman et al. (1998), a crowding-out result such that the net impact of public spending on the actual social dynamics is neutral and the economy keeps on cycling between phases of high and low criminal activity with varying levels of self-protection (although stable cycles are possible also in our model for suitable parameter values); quite to the contrary, it can be extremely effective in implementing the social optimum, in that it acts primarily on the intangible dimension, that is, on the social dynamics of fear. It is our contention that, in order to discover and understand this subtle socio-psychological mechanisms, we need to develop a much more interdisciplinary perspective on the issues of self-protection and on the analysis of the relative economic and social effects of alternative policies. This calls for a formidable amount of work, in that it is necessary to acquire a profound knowledge of very different streams of literature and of alternative methodological approaches, and to become able to combine

them in creative and fruitful ways into suitable analytical frameworks. We hope that this will become a widely sought objective in future research.

References

Amendola G. (1997), *La città postmoderna: magie e paure della metropoli contemporanea*, Latenza, Bari.

Amendola G. (2003), *Paure in città*, Liguori, Naples.

Antoci A., Bartolini S. (1999), "Negative Externalities as the Engine of Growth in an Evolutionary Context", Nota di Lavoro 83.99, FEEM, Milan.

Antoci A., Bartolini S. (2004), "Negative Externalities, Defensive Expenditures, and Labour Supply in an Evolutionary Context", *Environment and Development Economics* 9, 591-612.

Antoci A., Sacco P.L. (1995), "A Public Contracting Evolutionary Game with Corruption", *Journal of Economics* 61, 89-122.

Antoci A., Sacco P.L. (2002), "The Emergence of Deontological Codes in Public Administration", *Journal of Mathematical Sociology* 26, 271-308.

Antoci A., Sacco P.L., Vanin P. (2007), "Social Capital Accumulation and the Evolution of Social Participation", *Journal of Socio-Economics* 36, 128-143.

Bartel A.P. (1975), "An Analysis of Firm Demand for Protection Against Crime", *Journal of Legal Studies* 4, 443-478.

Baumer T.L. (1979), "Research on Fear of Crime in the United States", *Victimology* 3, 254-264.

Becker G.S. (1968), "Crime and Punishment: An Economic Approach", *Journal of Political Economy* 76, 169-217.

Ben-Shahar O., Harel A. (1995), "Blaming the Victim: Optimal Incentives for Private Precautions Against Crime", *Journal of Law, Economics and Organization* 7, 434-455.

Bier V.M., Oliveros S., Samuelson L. (2007), "Choosing What to Protect", *Risk Analysis* 27, 607-620.

Björnerstedt J., Weibull J.W. (1995), "Nash Equilibrium and Evolution by Imitation", in K.J. Arrow, E. Colombatto, M. Perlman and K. Schmidt (eds.), The Rational Foundations of Economic Behaviour, IEA/Macmillan, London, 155-171.

Blakely E., Snyder M. (1997), *Fortress America: Gated Communities in the United States*, Brookings

Institution Press, Washington DC.

Bowles S., Jayadev A. (2006), "Guard Labor", *Journal of Development Economics* 79, 328-348.

Box S., Hale C., Andrews G. (1988), "Explaining Fear of Crime", *British Journal of Criminology* 28, 340-356.

Braithwaite J. (2000), "The New Regulatory State and the Transformation of Criminology", *British Journal of Criminology* 40, 222-238.

Briys E., Schlesinger H. (1990), "Risk Aversion and the Propensities for Self-Insurance and Self-Protection", *Southern Economic Journal* 57, 458-467.

Caldeira T. (2001), *City of Walls. Crime, Segregation, and Citizenship*, UCLA Press, Los Angeles.

Clotfelter C.T. (1977), "Public Services, Private Substitutes, and the Demand for Protection Against Crime", *American Economic Review* 67, 867-877.

Cressman R., Morrison W.G., Wen J.-F. (1998), "On the Evolutionary Dynamics of Crime", *Canadian Journal of Economics* 31, 1101-1117.

Csikszentmihalyi M. (1990), *Flow: The Psychology of Optimal Experience*, Harper and Row, New York.

Davis M. (1998), *Ecology of Fear*: *Los Angeles and the Imagination of Disaster*, Vintage Books, New York.

Dionne G., Eeckhoudt L. (1985), "Self-Insurance, Self-Protection and Increased Risk Aversion", *Economics Letters* 17, 39-42.

Ehrlich I. (1996), "Crime, Punishment, and the Market for Offenses", *Journal of Economic Perspectives* 10, 43-67.

Ehrlich, I., Becker, G.S. (1972), "Market Insurance, Self-Insurance, and Self-Protection", *Journal of Political Economy* 80, 623-648.

Ellin N. (1997), *Architecture of Fear*, Princeton Architectural Press, Princeton.

Ellin N. (2001), "Thresholds of Fear: Embracing the Urban Shadow", *Urban Studies* 38, 869-883.

Farrall S., Bannister J., Ditton J. (2000), "Social Psychology and the Fear of Crime", *British Journal of Criminology* 40, 399-413.

Felson M., Cohen L.E. (1980), "Human Ecology and Crime . A Routine Activity Approach", *Human Ecology* 8, 389-406.

Frantz K. (2001), "Gated Communities in Metro Phoenix (Arizona): neuer Trend in der US amerikanischen Stadtlandschaft", *Geographische Rundschau* 53, 12-18.

Friedman D. (1991), "Evolutionary Games in Economics", Econometrica 59, 637-666.

Gabriel G., Greve W. (2003), "Psychology of Fear of Crime: Conceptual and Methodological Perspectives", *British Journal of Criminology* 43, 600-614.

Gibson C.L., Zhao J., Lovrich N.P., Gaffney M.J. (2002), "Social Integration, Individual Perceptions of Collective Efficacy, and Fear of Crime in Three Cities", *Justice Quarterly* 19, 537-564.

Hausken K. (2006), "Income, Interdependence, and Substitution Effects Affecting Incentives for Security Investment", *Journal of Accounting and Public Policy* 25, 629-665.

Heal G., Kunreuther H. (2007), "Modelling Interdependent Risk", *Risk Analysis* 27, 621-634.

Hermann P. (2009), "City Crime May Be Down, But Fear Endures", *The Baltimore Sun*, May 29.

Hofbauer J., Sigmund K. (1988), *The Theory of Evolution and Dynamical Systems*, Cambridge University Press, London.

Jackson J. (2008), "A Psychological Perspective on Vulnerability in the Fear of Crime", *Psychology, Crime, and Law* 15, 365-390.

Jones T., Newburn T. (2002), "The Transformation of Policing? Understanding Current Trends in Policing Systems", *British Journal of Criminology* 42, 129-146.

Jullien B., Salanie B., Salanie F. (1999), "Should More Risk-Averse Agents Exert More Effort?", *The Geneva Risk and Insurance Review* 24, 19-28.

Katzman M.T. (1980), "The Contribution of Crime to Urban Decline", *Urban Studies* 17, 277-286.

Kennedy D.M. (1997), "Pulling Levels: Chronic Offenders, High-Crime Settings, and a Theory of Prevention", *Valparaiso University Law Review* 31, 449-484.

Lakdawalla D., Zanjani G. (2006), "Insurance, Self-Protection, and the Economics of Terrorism", *Journal of Public Economics* 89, 1891-1905.

Landman K., Schönteich M. (2002), "Urban Fortresses. Gated Communities as a Reaction to Crime", *African Security Review* 11, 71-85

Lee K. (1998), "Risk Aversion and Self-Insurance-cum-Protection", *Journal of Risk and Uncertainty* 17, 139-150.

Loader I. (2001), "Consumer Culture and the Commodification of Policing and Security", *Sociology* 33, 373-392.

Muermann A., Kunreuther H. (2008), "Self-Protection and Insurance with Interdependencies", *Journal of Risk and Uncertainty* 36, 103-123.

Newburn T. (2001), "The Commodification of Policing: Security Networks in the Late Modern City", *Urban Studies* 38, 829-848.

O'Malley P. (1999), "Volatile and Contradictory Punishment", *Theoretical Criminology* 3, 175-196.

Pantazis C. (2000), " 'Fear of Crime', Vulnerability and Poverty", *British Journal of Criminology* 40, 414-436.

Reiss A.J. Jr. (1986), "Why Are Communities Important in Understanding Crime?", in A.J. Reiss Jr. and M. Tonry (eds.), *Crime and Justice*, volume 8, University of Chicago Press, Chicago, 1-33.

Riger S., Lavrakas P.J. (1981), "Community Ties: Patterns of Attachment and Social Interaction in Urban Neighborhoods", *American Journal of Community Psychology* 9, 55-66.

Rizzo, M.J. (1979), "The Cost of Crime to Victims: An Empirical Analysis", *Journal of Legal Studies* 8, 177-205.

Rosenbaum D.P. (1988), "Community Crime Prevention: A Review and Synthesis of the Literature", *Justice Quarterly* 5, 323-395.

Rotker S. (2002), *Citizens of Fear. Urban Violence in Latin America*, Rutgers University Press, Piscataway NJ.

Sacco P.L. (1995), "Comment to Björnerstedt and Weibull", in K.J. Arrow, E. Colombatto, M. Perlman and K. Schmidt (eds.), The Rational Foundations of Economic Behaviour, IEA/Macmillan, London, 172-181.

Sampson R.J., Groves W.B. (1989), "Community Structure and Crime: Testing Social-Disorganization Theory", *American Journal of Sociology* 94, 774-802.

Sampson R.J., Raudenbush S., Earls F. (1997), "Neighbourhoods and Violent Crime: A Multilevel Study of Collective Efficacy", *Science* 277, 918-924.

Sampson R.J., Raudenbush S. (1999), "Systematic Social Observation of Public Spaces: A New Look at Disorder in Urban Neighbourhoods", *American Journal of Sociology* 105, 603-651.

Schlag K. (1998), "Why Imitate, and If So, How? A Boundedly Rational Approach to Multi-armed Bandits", *Journal of Economic Theory* 78, 130-156.

Shaw C., McKay H. (1969), *Juvenile Delinquency and Urban Areas*, revised edition, University of Chicago Press, Chicago.

Shortland R.L., Hayward S.C., Young C., Signorella M.L., Mindingall K., Rovine M.J., Danowitz E.F. (1979), "Fear of Crime in Residential Communities", *Criminology* 17, 34-45.

Silverman E., Della-Giustina J. (2001), "Urban Policing and the Fear of Crime", *Urban Studies* 38, 941-957.

van Dijk J.J.M. (1994), "Understanding Crime Rates. On the Interactions Between the Rational Choices of Victims and Offenders", *British Journal of Criminology* 34, 105-121.

Warr M., Ellison C.G. (2000), "Rethinking Social Reactions to Crime: Personal and Altruistic Fear in

Family Households", *American Journal of Sociology* 106, 551-578.

Webster C., Glasze G., Frantz K. (2002), "The Global Spread of Gated Communities", *Environment and Planning B* 29, 315-320.

Weibull J. (1995), *Evolutionary Game Theory*, Mit Press, Cambridge Mass.

Zedner L. (2006), "Policing Before and After the Police", *British Journal of Criminology* 46, 78-96.

Zhuang J., Bier V.M. (2007), "Balancing Terrorism and Natural Disasters - Defensive Strategy with Endogenous Attacker Effort", *Operations Research* 55, 976-991.

Ziegenhagen E.A., Brosnan D. (1990), "Citizen Recourse to Self-Protection: Structural, Attitudinal and Experimental Factors", *Criminal Justice Policy Review* 4, 91-104.

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