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The Good Samaritan and Traffic on the Road to Jericho†

By Ted Bergstrom*

This paper studies a version of the Volunteer's Dilemma in which players sequentially observe someone in trouble and decide whether to help. Where preferences are identical, we show that if the frequency with which potential helpers appear is above some threshold, then as frequency of appearance increases, the probability that any individual stops diminishes, but the expected waiting time for help to appear is constant. Where costs of stopping differ among individuals, as the frequency of appearance increases, the expected waiting time for help to appear decreases, even though the probability that any individual stops diminishes. (*JEL* D62, D63, D64, H41)

> *A certain man went down from Jerusalem to Jericho, and fell among thieves, which stripped him of his raiment, and wounded him, and departed, leaving him half dead. And by chance there came down a certain priest that way: and when he saw him, he passed by on the other side. And likewise a Levite, when he was at the place, came and looked on him, and passed by on the other side. But a certain Samaritan, as he journeyed, came where he was: and when he saw him, he had compassion on him, and went to him, and bound up his wounds, pouring in oil and wine, and set him on his own beast, and brought him to an inn, and took care of him.*
> — Parable of the Good Samaritan, New Testament, Luke 10: 30–34

For many tasks, the efforts of a few individuals are sufficient to serve a large population. One sentinel can alert an entire community. A few vigilant individuals are sufficient to investigate and report on the honesty of a vendor or the usefulness of a consumer good. Blood donations by a small fraction of the population are sufficient to serve a large community. These examples suggest the possibility of significant returns to scale from the formation of large groups and communities. But there is a countervailing force. The potential increasing returns to group size may be offset by the free rider problem that arises when voluntary actions of a single individual would relieve others of the need to take action.

This conundrum was dramatized by a newspaper account (Gansberg 1964) describing the murder of Kitty Genovese on the streets of New York City. The story reports that she screamed for help as her killer stalked and stabbed her. According to the story, 38 neighbors heard the commotion, but none came to her aid and none

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called the police. Newspaper pundits (Rosenthal 1999 took this story as evidence that urban residents lived in a world of apathy and alienation.[1]

Social psychologists Darley and Latané (1968) suggested that people in densely populated areas may be less likely to take helpful actions, not because of apathy or alienation, but because of what they call the "bystander effect." If people who observe someone in trouble believe that the problem is visible to many others, they believe that their own action is unlikely to be necessary, because one of the others will do it.

Diekmann (1985), a sociologist, constructed a simple and elegant game called the "Volunteer's Dilemma" to model this strategic interaction. In the Volunteer's Dilemma, n players move simultaneously. Each player has the option of taking a costly action, *help*. If no player helps, then all get a payoff of 0. Players who choose *help* receive net payoffs of $b - c > 0$. If at least one player chooses *help*, then players who chose not to help receive payoffs of $b > b - c$. The Volunteer's Dilemma has no symmetric pure strategy equilibria, and it has a unique symmetric mixed-strategy equilibrium, in which every player chooses help with probability p where $0 < p < 1$. Diekmann shows that, not surprisingly, as the number of players increases, the equilibrium probability that any single player volunteers diminishes. More remarkably, he found that in symmetric equilibrium, the probability that *nobody* volunteers *increases* with the number of players.

The parable of the Volunteer's Dilemma has emerged as an archetypical lens through which economists (Harrington 2001; Murnighan, Kim, and Metzger 1995; and Osborne 2004), sociologists (Diekmann 1985, Weesie 1993, and Weesie and Franzen 1998), and biologists (Archetti 2009, 2011; Eshel and Motro 1988) examine the effects of group size on strategic interactions. In its simplest form this parable suggests that, because increased group size leads to reduced production of public goods, there will be selection against large groups of humans and other animals. But the question arises whether this remarkable conclusion continues to hold as the model is generalized in reasonable ways. The original Volunteer's Dilemma assumes that all n players have identical payoff functions and that players move simultaneously, with no knowledge of other players' moves.

This paper explores an alternative "Volunteer's Dilemma," in which it is natural for players to move sequentially rather than simultaneously. We also allow the degree of sympathy and the cost of helping to differ between individuals. In the resulting model, it remains true that individuals in larger groups are less likely to provide a public good, but increases in group size do not reduce, and typically increase the likelihood that someone will provide the good. This paper offers a fresh look at the familiar "Parable of the Good Samaritan," by applying simple game theory to the riddle: "Who will help an unfortunate person when everybody believes that somebody else is likely to do the job?"

With this model, we explore the outcomes of sympathy-driven behavior and probe the relation between efficiency and ethical norms. This model offers a theoretical explanation for claims that people are thought to be more helpful in less

[1] Later investigations indicate that the newspaper accounts of neighbors' behavior were highly inaccurate. According to Manning, Levine, and Collins (2007), "there is no evidence for the presence of 38 witnesses, or that witnesses observed the murder, or that witnesses remained inactive."

populous places, but the model also predicts that help is likely to arrive more quickly in more densely populated places.

I. The Plight of a Troubled Traveler

Driving along a lonely road, you come upon a stalled car and a motorist who appears to have run out of gas. You consider stopping to offer help, although this may cost you several minutes and some extra driving. Would your decision be different if the road were more heavily traveled? If you were to run out of gas, would you prefer that it be a busy street or a lonely road?

Let us develop our understanding by means of a simple game-theoretic model: cars approach a stranded motorist's location according to a random Poisson process with arrival rate λ. Passing travelers are sympathetic to this motorist's plight, but stopping is costly and they believe that other potential helpers will arrive in the future. Every passing traveler attaches a cost $c > 0$ to stopping to help, and a psychic cost of vw to the prospect that the stranded motorist must wait for an expected length of time w before being rescued.

In deciding whether to stop, passersby compare the cost c of stopping to the psychic cost of not stopping. Where w is the expected amount of time that the stranded motorist must wait for the next passerby to stop, a passing motorist will choose to stop if $c < vw$. If a motorist expects all future passersby to stop, then the expected waiting time for the stranded motorist will be

$$w = \int_0^\infty t\lambda e^{-\lambda t}\, dt = \frac{1}{\lambda}. \tag{1}$$

It follows that all travelers would stop if $c < vw = v/\lambda$. Thus, on little-traveled roads, where $\lambda < \frac{v}{c}$, in a Nash equilibrium, every passing motorist would stop, and the expected waiting time for a stranded motorist would be $1/\lambda$, which decreases as traffic density increases.

Where traffic is frequent enough that $\lambda > v/c$, there cannot be a Nash equilibrium in which everyone stops, nor can there be an equilibrium in which no one stops. The only symmetric Nash equilibrium is a mixed strategy equilibrium in which each passing traveler stops with probability p, where $0 < p < 1$. The appearance of a driver who will stop and help is then a Poisson process with arrival probability λp. Each passing traveler then realizes that if she does not stop, the stranded motorist faces an expected waiting time of

$$w = \frac{1}{\lambda p}. \tag{2}$$

In a symmetric mixed-strategy Nash equilibrium, all passing travelers must be indifferent between stopping and not stopping. This occurs if $c = vw$ or equivalently if

$$w = \frac{c}{v}. \tag{3}$$

From equation (3), we see that when $\lambda > v/c$, the expected waiting time for a stalled motorist is independent of the density of traffic on the highway.

From equations (2) and (3), it follows that in equilibrium,

$$p = \frac{1}{\lambda}\left(\frac{v}{c}\right). \tag{4}$$

Thus, the equilibrium probability p that a motorist will stop is inversely proportional to traffic density λ. It follows that the effect of an increase in traffic density on expected waiting time is exactly offset by a reduction in the probability that a traveler will stop, and hence expected waiting time remains constant as traffic density increases.

These results are summarized as follows:

PROPOSITION 1: *If all travelers have the same cost ratio, c/v, and if the arrival of traffic is a Poisson process with arrival rate λ, then in symmetric Nash equilibrium:*

(*i*) *Over the range of traffic densities such that $\lambda < v/c$, all passing travelers will stop and so the expected waiting time for rescue decreases with traffic density.*

(*ii*) *Over the range of traffic densities such that $\lambda > v/c$, there is a unique mixed strategy Nash equilibrium such that as traffic density increases:*
- *the probability p that a car will stop declines.*
- *the expected waiting time for a stranded motorist does not change.*

On busy roads, even though the expected waiting time for help to arrive does not change with traffic density, a stranded motorist might believe that drivers in urban areas are less generous, because the expected number of cars that pass by before someone offers help increases with traffic density. Specifically, we have:

REMARK 1: *In symmetric Nash equilibrium where all travelers have cost ratio c/v, the expected number of cars to drive past a stranded motorist before one of them stops to help is equal to*

$$\lambda\frac{c}{v} - 1. \tag{5}$$

PROOF OF REMARK 1:

Where p is the probability that any motorist will stop, the probability that help first arrives at time t is $\lambda p e^{-\lambda p t}$, and if help first arrives at time t, the expected number of motorists to pass by without stopping is $(1-p)\lambda t$. Therefore, the expected number of motorists to pass before help arrives must be

$$\begin{aligned}\int_{\ell}^{\infty}(1-p)\lambda t\,\lambda p e^{-p\lambda t}\,dt &= (1-p)\lambda\int_{\ell}^{\infty}(\lambda p)te^{-\lambda p t}\,dt \\ &= \frac{1-p}{p}.\end{aligned} \tag{6}$$

From equation (4), it follows that in equilibrium,

$$\frac{1-p}{p} = \frac{\lambda c - v}{v} = \lambda \frac{c}{v} - 1. \tag{7}$$

Hence, the expected number of cars to pass by before help arrives is $\lambda \frac{c}{v} - 1$.

II. When Costs and Sympathies Differ

Now let us add realism by allowing travelers to differ in their costs of stopping and in their sympathy for the plight of strangers. Attention to these differences leads to qualitatively different conclusions and to interesting comparative statics that are not found when passing travelers are identical. In equilibrium, for this model, all consumers choose pure strategies, and the expected waiting time for a stranded motorist decreases as traffic density increases.

A. *Passing Strangers and Incomplete Information*

We model the situation as a symmetric game of incomplete information. All passing travelers are aware of the density λ of traffic, and they know their own ratios c/v of the cost of stopping to the value they place on a stranded motorist's time. They do not know the cost ratios of other travelers, but they share a common belief that the cost ratio c/v of each subsequent passerby is an independent random draw from a continuous distribution, $F(\cdot)$, with density function, $f(\cdot)$.

A strategy for any passing motorist is a mapping from his or her own cost ratio c/v to one of the two actions *Stop* and *Don't stop*. If w is the equilibrium expected waiting time for a stranded traveler, then all motorists for whom $c < vw$ will stop and those for whom $c > vw$ will not stop. Therefore, in equilibrium, the probability that a random passing motorist will stop must be

$$p = F\left(\frac{c}{v}\right) = F(w). \tag{8}$$

If the probability that any traveler will stop is p, then the Poisson arrival rate of passersby who will stop is λp, and the expected waiting time for the stranded motorist is

$$w = \frac{1}{\lambda p}. \tag{9}$$

Since the stopping probability p and the expected waiting time w must satisfy equations (8) and (9), it follows that in Nash equilibrium,

$$wF(w) = \frac{1}{\lambda}. \tag{10}$$

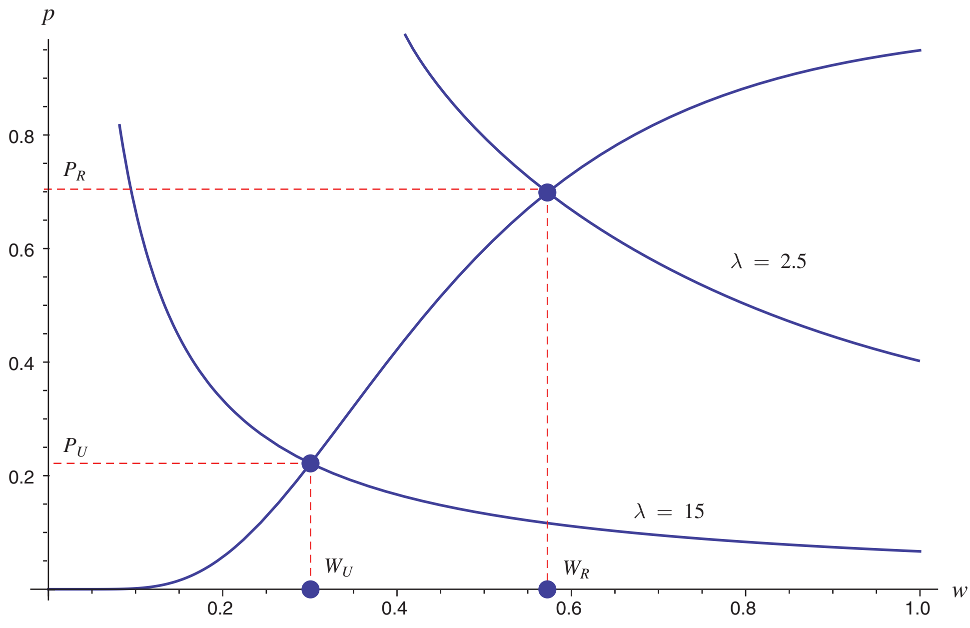

Figure 1. Traffic Density and Waiting Time with Varying Costs

From equation (10), we deduce that:

PROPOSITION 2: *If the distribution function F of cost ratios is continuous, then for any arrival rate λ, there is a unique equilibrium expected waiting time $w(\lambda)$ for a stranded motorist, and $w(\lambda)$ is a decreasing function of λ.*

PROOF:

Since $wF(w)$ is a continuous increasing function that ranges from 0 to ∞ as w ranges from 0 to ∞, there must be exactly one solution to equation (10) for any λ. Since the left side of equation (10) is increasing in w and the right side is decreasing in λ, it must be that this solution is decreasing in λ.

Thus, we see from Proposition 2 that if some passersby are kinder or less busy than others, you are better off running out of gas on a busy street than on a lonely road.

Figure 1 shows the effect of traffic density on the equilibrium stopping threshold and expected waiting time for a stranded traveler. The horizontal axis plots the stranded motorist's expected waiting time, while the vertical axis shows the probability that a random passerby will stop. The upward-sloping curve is a "stopping-response curve," showing the probability p that a random passerby will stop if the expected waiting time is w. A passerby with cost ratio c/v will stop if $c/v < w$. Therefore, the stopping-response curve is just the graph of the cumulative density, $F(w)$. The curve drawn in this figure is the cumulative distribution function of a log normal distribution with mean $1/2$.[2]

[2]The diagram was drawn with *Mathematica* for a distribution in which the logarithm of c/v has mean $\mu = \log(1/2) - 1/8$ and standard deviation $\sigma = 1/2$. The resulting log normal distribution has mean $1/2 = e^{(\mu+\sigma^2/2)}$ and standard deviation $(1/2)\sqrt{e^{1/4} - 1} = e^{(\mu+\sigma^2/2)}\sqrt{e^{\sigma^2} - 1}$.

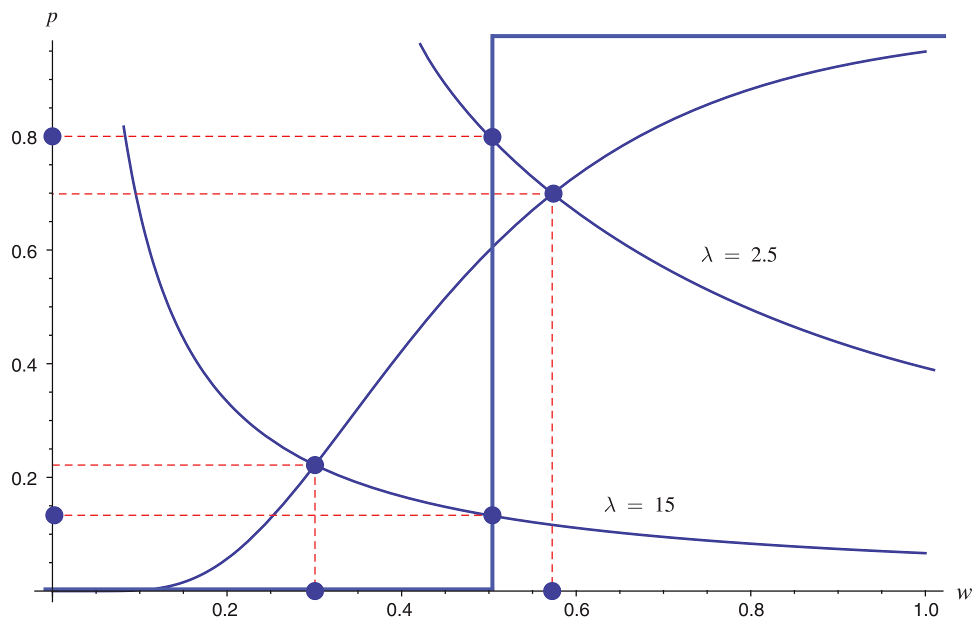

FIGURE 2. EQUILIBRIUM WITH UNIFORM AND VARYING COSTS

The figure shows two downward-sloping "expected waiting-time curves." These curves relate the expected waiting-time $w = 1/\lambda p$ of a stranded motorist on a road with density λ to the probability p that a random passerby will stop. The higher of these two curves is drawn for a "rural" highway with relatively low traffic density, $\lambda = 2.5$. The lower downward-sloping curve is drawn for an "urban" highway with higher traffic density, $\lambda = 15$. For each of the two highways, the equilibrium outcome is found at the intersection of the stopping-response curve with the corresponding expected waiting-time curve. For this example, the graph shows that a random passerby on an urban highway is less likely to stop than on a rural highway, but because travelers pass by more often, the expected waiting time for the stranded motorist is shorter on the urban than on the rural highway.

Figure 2 compares the equilibria described in Figure 1 to equilibria in the case where all travelers have identical cost ratios with the same mean, $c/v = 1/2$. The downward-sloping curves show the expected waiting-time function, $w = 1/\lambda p$, for two alternative traffic densities, $\lambda = 2.5$ and for $\lambda = 15$. The smooth upward-sloping curve is the same as that shown in Figure 1, while the thick piecewise linear "curve" shows the stopping-response correspondence for the case of uniform cost ratios. As this curve shows, if expected waiting time is $w < 1/2$, no motorists would stop. If $w > 1/2$, all motorists would stop and if $w = 1/2$, all motorists are indifferent between stopping and not stopping.

As Figure 2 shows, when all travelers have identical cost ratios, the downward-sloping curves must intersect the stopping-response curve in its vertical section, with an expected waiting time of $w = 1/2$. Thus, the equilibrium adjustment to a change in λ must take the form of an offsetting change in the mixed-strategy probability p so that $w = 1/\lambda p$ is the same on the quiet rural road as on the busy urban highway.

B. *Mean-Preserving Spreads and Expected Waiting Time*

Rothschild and Stiglitz (1970) defined the notion of a *mean-preserving spread* to capture the idea of "taking weight from the center of a probability distribution and shifting it to the tails, while keeping the mean of the distribution constant."[3] Diamond and Stiglitz (1974) define a distribution function G to be a *simple mean-preserving spread* of a distribution function F if the two distribution functions have the same mean, and if they are related by a single crossing property such that for some $\hat{x}$, $G(\hat{x}) = F(\hat{x})$, while if $x < \hat{x}$, then $G(x) > F(x)$, and if $x > \hat{x}$, then $G(x) < F(x)$.[4]

The log-normal distribution shown in Figure 2 is a simple mean-preserving spread of the distribution in which all travelers have the same cost ratio. In this example, we see that travelers on the rural road have a longer expected waiting time with the spread-out distribution than with the concentrated distribution, while travelers on the more heavily traveled urban road would have a shorter expected waiting time with the more spread-out distribution. This observation illustrates a much more general result. Broadly speaking, greater dispersion of the distribution of cost ratios *reduces* the expected waiting time of stranded motorists on heavily traveled roads and *increases* their expected waiting time on less traveled roads. More formally, we have:

PROPOSITION 3: *Let the distribution function G be a simple mean-preserving spread of the distribution function F, with a single crossing point at* $\hat{x}$. *Let* $\hat{\lambda} = 1/\big(\hat{x}F(\hat{x})\big)$. *Then on roads where* $\lambda < \hat{\lambda}$, *equilibrium waiting time for the stranded motorist is longer if the distribution of cost ratios is G than if it is F. If* $\lambda > \hat{\lambda}$, *then equilibrium waiting time for the stranded motorist is shorter if the distribution is G than if it is F.*

PROOF:

Let $w_F(\lambda)$ and $w_G(\lambda)$ be equilibrium waiting times with the distributions F and G, respectively. Suppose that $\lambda > \hat{\lambda}$. Then

$$w_F(\lambda)F\big(w_F(\lambda)\big) = \frac{1}{\lambda} < \frac{1}{\hat{\lambda}} = \hat{x}F(\hat{x}).$$

Since $zF(z)$ is strictly increasing in z, it follows that $w_F(\lambda) < \hat{x}$, and hence $G\big(w_F(\lambda)\big) > F\big(w_F(\lambda)\big)$. Therefore,

$$w_F(\lambda)G\big(w_F(\lambda)\big) > w_F(\lambda)F\big(w_F(\lambda)\big) = 1/\lambda = w_G(\lambda)G\big(w_G(\lambda)\big).$$

[3] Formally, a random variable Y is a mean-preserving spread of the random variable X if and only if Y is equal in distribution to $X + Z$ for some random variable Z such that $E(Z|X) = 0$ for all values of X.

[4] In general, the crossing point of the two distributions need not necessarily be the same as their common mean. Diamond and Stiglitz show that every simple mean-preserving spread is a mean-preserving spread, but not every mean-preserving spread is a simple mean-preserving spread.

Since $G(w_G(\lambda)) > 0$, it follows that $w_F(\lambda) > w_G(\lambda)$.

A similar argument shows that if $\lambda < \hat{\lambda}$, then $G(w_F(\lambda)) < F(w_G(\lambda))$ and $w_F(\lambda) < w_G(\lambda)$.

III. Ethical Guidelines for When to Help

Perhaps the priest and the Levite who hurried past the injured traveler had good excuses. Maybe they had important things to do and realized that if they did not stop, someone less busy would soon be likely to appear and perform the rescue.

If for some travelers it is much less costly to stop than for others, it is not necessarily efficient for all travelers to stop every time that they encounter someone in distress. Efficiency may be better served by a convention that passing travelers should stop if and only if their costs fall below some threshold level.

Since stopping costs of passing travelers are not likely to be transparent to others, such a rule could not be enforced by external sanctions. But it seems worthwhile to consider the kind of "ethical" rule that, if widely adopted, would lead to socially efficient behavior in this environment.

Experimental evidence (Andreoni, Harbaugh, and Vesterlund 2008) suggests that people often act by self-imposed ethical rules that dictate behaving sympathetically toward others. Feddersen and Sandroni (2006) suggest that the fact that large numbers of citizens bother to vote, although there is only a negligible chance that a single vote will be decisive, is best explained by their adherence to ethical rules.

Harsanyi (1977) argues that it is common for a person to "have moral preferences, which may or may not have much influence on his everyday behavior but will guide his thinking in those—possibly very rare—moments when he forces a special impersonal and impartial attitude, that is, a moral attitude, upon himself." These moral preferences, Harsanyi suggests, are best described by *rule utilitarianism* and the *equiprobable model of moral value judgments,* which is the view that individuals should abide by a general rule that each would prefer all members of society to obey if everyone had the same probability of being assigned to each possible social position.[5]

In general social environments where individual preferences and abilities are widely divergent, application of Harsanyi's equiprobable model of moral judgments is problematic.[6] But in the parable of the Road to Jericho, it seems fairly realistic

[5] Harsanyi acknowledges that this view bears similarities to Rawls' "veil of ignorance" (Rawls 1971) (and to Kant's "categorical imperative (Kant 1993)). In comparing his theory to that of Rawls, Harsanyi says "the main difference is that Rawls makes the technical mistake of basing his analysis on a highly irrational decision rule, the maximin principle." Comparing his theory to that of Kant, Harsanyi says "Kant believed that morality is based on a categorical imperative so that anybody who is willing to listen to the voice of reason must obey the commands of morality." Harsanyi disagrees and takes the view that "All we can prove by rational arguments is that anybody who wants to serve our common human interests in a rational manner must obey these commands" (Harsanyi 1977).

[6] Even if we endow individuals with empathetic preferences that assess their utility for being cast in the role of others with very different make-up, these empathetic preferences and the weights placed on utilities in alternative persona are likely to differ from person to person. Binmore (1994, 299) remarks that "Behind Harsanyi's veil of ignorance, people forget *everything* that might make them different." Thus, as Binmore suggests, "Harsanyi's agents put their actual empathetic preferences aside … they need to construct new empathic preferences." In Binmore's description, this leads Harsanyi to construct an "*ideal observer*" who has full information about everybody's personal characteristics.

to assume some simple symmetries that lead to straightforward calculation of an ethical ideal that offers useful insight into the nature of socially approved behavioral rules.

Let us consider a society in which all persons travel with the same frequency, all are equally likely to be stranded, and all are equally likely to encounter a stranded motorist on any road. The costs of stopping to perform a rescue differ from occasion to occasion, but for all individuals, let us assume that on each occasion that one encounters a stranded motorist, the cost of stopping is a random draw from the same distribution function, $F(c)$. For all persons, we assume that the cost of being stranded without help for a time period of length t is vt.

In this environment, an ethical rule consists of a criterion that determines whether or not one should stop to help if one encounters a stranded motorist on a road with traffic density λ when one's cost of stopping is c. This rule, if adopted by all community members, will determine each person's expected costs from being stranded along the road, and expected costs from stopping to help others who are stranded.

The ethical rule that we seek is one that is efficient in the sense that the expected total costs of each community member would be minimized if all adhered to this rule. It is easy to see that for each λ, such a rule would set a threshold level of costs c^* such that motorists with stopping costs lower than c^* should stop and those with costs higher than c^* should pass by without stopping. If all individuals abide by this rule, then for any stranded motorist on a road with traffic density λ, the Poisson arrival rate of a motorist who will help is $\lambda F(c^*)$ and expected waiting time is $1/\lambda F(c^*)$. The expected total cost of each incident of a stranded motorist includes the expected waiting cost for the stranded motorist and the expected cost c for the first passerby who has a cost below the threshold c^*. Where ℓ is the lower bound of the support of the cost distribution, this total is

$$\frac{\int_{\ell}^{c^*} cf(c)\, dc}{F(c^*)} + \frac{v}{\lambda F(c^*)}. \tag{11}$$

Given our symmetry assumptions, all individuals bear the same expected total cost. Therefore, the expected costs of all community members would be minimized by a rule that set a stopping threshold of c^*, where c^* minimizes expression (11). We will call a rule with this stopping threshold an *ideal ethical stopping rule*.[7]

Differentiating expression (11) with respect to c^* yields the first-order necessary condition:

$$c^* - \frac{\int_{\ell}^{c^*} cf(c)\, dc}{F(c^*)} = \frac{v}{\lambda F(c^*)}. \tag{12}$$

[7] We follow Harsanyi (1977) by supposing that rule-driven ethical behavior is based on *empathy* rather than *sympathy*. As Binmore (1994, 54–67) explains, this logical distinction was made much earlier in Adam Smith's *Theory of Moral Sentiments* (Smith 2002, 10–11). Empathy is the ability to imagine oneself in another's situation, while sympathy is to feel the sorrows and joys of others. Thus, our model of an ideal ethical rule does not assume that individual utilities are guided by sympathy toward others, but rather by a preference for a rule that one would wish all to follow if everyone has an equal chance of being cast in each possible role.

Equation (12) has a straightforward interpretation as a marginal efficiency condition. This equation requires that for a traveler with costs equal to the threshold c^*, the difference between c^* and the expected cost of the next traveler who would be required to stop is equal to the expected additional cost of waiting borne by the stranded traveler if the current passerby does not stop.

Proposition 4, which is proved in the Appendix, shows if all community members follow an ideal ethical stopping rule, then as traffic density increases, individual passersby will be less likely to stop, but the average waiting time for help to arrive will diminish.

PROPOSITION 4: *In the symmetric community described in this section*, *if the entire population abides by an ideal ethical stopping rule*, *then:*

(*i*) *on busier roads*, *the probability that a randomly selected passerby will stop is lower*;

(*ii*) *if the distribution F of costs is log-concave*, *then on busier roads*, *the expected waiting time for help to arrive for a stranded traveler is lower*.

The assumption that the cumulative distribution function F is log-concave is not a strong requirement. Essentially, all commonly known distribution functions have log-concave cumulative distribution functions. Log-concavity of the density function is sufficient but not necessary for log-concavity of the distribution function (Bagnoli and Bergstrom 2005).[8]

Having found a socially efficient cost threshold for potential helpers, we can ask how this ethical rule might be expressed in common language. An interesting candidate rule is: "treat the misfortune of others as if it were your own." A passing motorist who practiced this rule would stop whenever his cost of stopping was less than the expected cost of further waiting to the stranded motorist. If travelers all abide this rule and have a stopping cost threshold $\bar{c}$, the probability that a passing motorist will stop is $F(\bar{c})$, and the expected waiting cost to a stranded motorist would be $v/\lambda F(\bar{c})$. Therefore the cost threshold $\bar{c}$ would be an equilibrium for motorists abiding by the rule "treat the misfortune of others as your own" only if

$$\bar{c} = \frac{v}{\lambda F(\bar{c})}. \tag{13}$$

Comparing equation (13) with equation (12) leads us to conclude that:

PROPOSITION 5: *In the symmetric society posited in this section*, *if travelers applied the rule "act as if the misfortune of a stranded traveler is your own*,*" they would stop* less *frequently than if they applied the ideal ethical stopping rule.*

[8] For example, the log-normal distribution does not have a log-concave density function, but has a log-concave distribution function (Bagnoli and Bergstrom 2005).

PROOF:

Define $G(c) = c - \frac{v}{\lambda F(c)}$. From equations (12) and (13) it follows that

$$G(c^*) - G(\overline{c}) = \frac{\int_{\ell}^{c^*} cf(c)\, dc}{F(c^*)} > 0.$$

Since G is an increasing function of c, it follows that $c^* > \overline{c}$. A higher stopping threshold implies that each passing traveler is more likely to stop.

There is a simple explanation of the result of Proposition 5. The benefits that one confers on others by stopping to help include not only the benefit to the stranded individual, but also the benefit to another traveler who otherwise would have felt obliged to stop and perform a rescue. If travelers take only the former effect into account, they underestimate the total benefits that their action confers on others.

IV. Publicly Supported Rescue Patrols

Community members may decide to support publicly funded highway patrols that cruise the streets and help any stranded travelers that they encounter. The presence of such patrols will typically shorten the expected waiting time for those in need of help. This effect is weakened by the fact that public patrols typically "crowd out" some private rescues. However, this crowding out also has the beneficial effect of reducing total costs borne by private travelers stopping to help a stranded motorist.

On a highway with traffic rate λ, suppose that publicly funded rescue patrols arrive at a Poisson rate μ. If the fraction of ordinary passing travelers who will stop to aid a stranded motorist is $p(\mu, \lambda)$, then for a stranded motorist, the Poisson arrival rate of vehicles that will stop to help is $\mu + \lambda p(\mu, \lambda)$, and the expected waiting time for help to arrive is

$$(14) \qquad w = \frac{1}{\mu + \lambda p(\mu, \lambda)}.$$

If the expected waiting time is w, the fraction of the population that will choose to stop will be $p = F(w)$. Therefore, it must be that in equilibrium with Poisson arrival rate μ of rescue patrols on a highway with traffic density λ, the expected waiting time for a stranded motorist satisfies the equation

$$(15) \qquad w(\mu, \lambda) = \frac{1}{\mu + \lambda F\big(w(\mu, \lambda)\big)}.$$

From equation (15), we can derive the following conclusion. (A proof is found in the Appendix.)

PROPOSITION 6: *If the distribution F of stopping costs for private travelers is continuous, then, at an interior equilibrium, an increase in the arrival rate of a public* *rescue service will reduce expected waiting time for stranded travelers, but will also crowd out some private help.*

Equation (15) defines the function $w(\mu, \lambda)$ only implicitly. For most familiar forms of the distribution function, there is no simple closed-form expression for $w(\mu)$. There is, however, a simple closed-form solution for $w(\mu, \lambda)$ in the case where stopping costs have a Pareto distribution.

REMARK 2: *If the distribution function of stopping costs is defined by the Pareto distribution* $F(x) = 1 - \frac{A}{x}$ *over the range* $x \in [A, \infty)$, *then*

$$w(\mu, \lambda) = \frac{1 + \lambda A}{\mu + \lambda} \tag{16}$$

and

$$p(\mu, \lambda) = \frac{1 - A\mu}{1 + A\lambda}. \tag{17}$$

The extent of crowding out is

$$\lambda \frac{\partial p(\mu, \lambda)}{\partial \mu} = \frac{-\lambda A}{1 + \lambda A}. \tag{18}$$

Thus, with the Pareto distribution of stopping costs, the degree of crowding out of private rescues by a public rescue service is independent of μ *and increases continuously with the density of traffic. There is almost no crowding out with very thin traffic and almost full crowding out with very dense traffic.*

PROOF:

Equation (16) follows from equation (15) and the assumption that $F(w(\mu, \lambda)) = 1 - \frac{A}{w(\mu, \lambda)}$. Equation (17) follows from equation (16) and the fact that $p(\mu, \lambda) = F(w(\mu, \lambda))$. Equation (18) is immediate from differentiating equation (17).

V. Are Country Folk More Helpful than City Folk?

Many field studies in social psychology explore what Steblay (1987) calls the "rather simple hypothesis that 'country people are more helpful than city people.'" Steblay examines 65 studies, of which 46 support greater rural helpfulness, 9 support greater urban helpfulness, and 10 report no significant differences.

Amato (1983) conducted a series of field experiments in 55 randomly selected Australian communities stratified by size and isolation.[9] In each community, Amato

[9] About 1/4 of these communities came from each of the size ranges: $<$1,000, 1,000–5,000, 5,000–20,000, and $>$20,000.

and his co-workers staged a number of situations that tested the willingness of random passersby to help a stranger. One of Amato's staged events bears a close similarity to the Road to Jericho game. Amato (1983) described the setup as follows:

> *The episode began with the investigator walking along the sidewalk with a noticeable limp. A suitable pedestrian approaching from the opposite direction was selected to be the subject … the investigator would suddenly drop to the sidewalk with a cry of pain. Then while half kneeling, the investigator would reveal a heavily bandaged leg, with … bandage generously smeared with a fresh application of theatrical blood.*

A confederate observed whether the subject offered to help and scored the response of the subject on a scale of "pro-social responsiveness." Amato found that the percentage of individuals who offered to help the injured person declined steadily with population size, from a helping rate of about 50 percent in communities with populations below 5,000 to about 15 percent in larger cities. In another study (Amato 1981), Amato conducted the hurt-leg experiment in several small Northern California cities and also in San Francisco. His findings were similar to those for Australia. In the small Californian cities, 43 percent of the subjects offered to help and in San Francisco, 20 percent offered help.

Levine and his co-workers (Levine, et al. 1994; Levine, Reysen, and Ganz 2008) conducted two series of field experiments in a large number of small, medium, and large US cities, once in the early 1990s and again 13–15 years later. These experiments included an episode similar to Amato's hurt-leg experiment. Both studies found that in places with larger populations, people were less likely to help. Evidence from the first of these studies suggested that population density had a stronger effect than population size. In the second study, there was insufficient independent variation of size and density to allow them to statistically distinguish the effects of size from those of density.

Our theoretical model suggests that when the hurt-leg experiment is performed on more busily traveled sidewalks, the fraction of passersby who offer to help would be smaller, but that the average amount of time between offers to help would be shorter. As far as I know, none of these studies calculated the effects of a direct measure of the traffic rate on either the probability that an individual would stop, or on the average amount of time that the "victim" would have to wait for help.[10] While it is likely that the cities with larger population had more frequent pedestrian traffic on the sidewalks where the experiments were performed, this correlation is not likely to be perfect. Levine makes a partial correction for this effect by using population density as well as population size as a variable.

Suppose that we want to test the hypothesis that "big city life leads to public apathy and a lack of concern for the well-being of others." Our discussion suggests that it would not be sufficient simply to find whether "country people are more helpful than city people" by finding the relation between population size and probability of

[10] Amato (1983, 578) reports that he and his associates recorded pedestrian traffic rates at the sites of their experiments, but he does not appear to have related this observation to outcomes, nor does he estimate the expected waiting time before an injured pedestrian would receive help.

helping, nor would it be sufficient to find out whether people are less likely to stop on busier sidewalks. Our model has it that even if people everywhere have the same distribution of sympathies for others, those who travel on busy city sidewalks are less likely to stop than those on less busy small-town sidewalks. But this model also predicts that the average amount of time between offers of help would be smaller, the busier the sidewalk. If experimenters were to discover that the expected amount of time between offers of help is greater on the busy sidewalks of large cities, this evidence would suggest that those in big cities may tend to have less sympathy or higher costs of stopping than those in small towns.

VI. Related Theoretical Work

In Diekmann's (1985) Volunteer's Dilemma, the payoff to a player who offers help does not depend on whether anyone else offers help. Harrington (2001) generalizes Diekmann's model to allow the possibility that the cost of helping depends on whether one is the only player to help. In Harrington's model, as in Diekmann's, if nobody else helps, then a player will get a higher payoff from helping than from not helping, but if somebody else helps, a player will get a higher payoff from not helping. In Harrington's model, as in Diekmann's, the symmetric Nash equilibrium probability that nobody helps increases with the size of the group.[11]

In Diekmann's Volunteer's Dilemma, if there are multiple offers to help, everyone who offers must bear the cost of helping, even though the efforts of a single helper would suffice. In some real-world situations, there is a coordinating mechanism such that if there is more than one volunteer, just one will be selected to bear the cost of taking action. Weesie and Franzen (1998) and Bergstrom and Leo (2015) study this "coordinated volunteer's dilemma." They show that in the coordinated volunteer's dilemma, although there is more likely to be at least one volunteer than there is without coordination, it is still the case that, in symmetric equilibrium, the probability of an outcome with no volunteers increases with group size.

Weesie (1993) characterized the full set of Nash equilibria, including asymmetric equilibria, both for symmetric and asymmetric versions of the Volunteer's Dilemma with complete information. Weesie (1994) also presented a version of the Volunteer's Dilemma with incomplete information. Players know their own costs and all believe that the costs of other players are independent draws from a commonly-known uniform distribution. For this distribution, he shows that in equilibrium, the probability that nobody acts is increasing in n for small n and decreasing in n for large n. Xu (2001) considers a similar model and finds similar results.

Barbieri and Malueg (2014) study a broader class of games in which the amount of a public good provided to a group is determined by the maximum effort, "Best Shot," made by a group member. This generalizes the Volunteer's Dilemma in which effort levels can take only one of two values, zero or one. Barbieri and Malueg find the mixed strategy equilibria for symmetric, complete information Best Shot games. Their results for the complete information game are qualitatively similar to those

[11] Harrington evidently developed his model independently of Diekmann's 1985 model, which was not widely known, at least to economists, when Harrington wrote his 2001 paper.

for the discrete Volunteer's Dilemma. As the number of active players increases, individuals stochastically reduce their efforts and the realized maximum effort is also stochastically reduced. Barbieri and Malueg go on to analyze symmetric games in which the costs of effort differ, and where players' own costs are private information. For these games, the symmetric equilibrium is in pure strategies. In equilibrium, as the number of players increase, individual contribution functions are point wise reduced, but players' payoffs are increased. Barbieri and Malueg also show that greater heterogeneity of the group increases players' payoffs.

In a paper called "Dragon Slaying and Ballroom Dancing," Bliss and Nalebuff (1984) analyze a variant of the Volunteer's Dilemma, in which players can observe each other's behavior and can wait for one of the other players to volunteer. They model this as a symmetric game of incomplete information, in which players know their own costs and have common priors over the distribution of costs for other players. Delayed benefits (and costs) are discounted at a uniform rate. They model this as a war-of-attrition game, with a unique ex ante symmetric equilibrium in which a strategy for any player is the time at which he would take action if nobody else has yet done so.[12] In equilibrium, the player with lowest costs is first to act. In the Bliss-Nalebuff model, as group size increases, the waiting time chosen by each type will increase. But, despite the fact that in larger groups, each type of would choose to wait longer before acting, the equilibrium expected payoff for each type increases as group size increases. Weesie (1994) studied a variant of the Volunteer's Dilemma that is similar to that of Bliss and Nalebuff, but differs in the details of the cost structure and cost distribution. For this game, Weesie finds that for each type of player, the waiting time until volunteering increases with group size and the probability that no player volunteers also increases with group size.

Biologists have found the Volunteer's Dilemma to be a useful tool for studying the dynamics of the size of animal herds and groups. Shapira and Eshel (2000) examine an n-player war-of-attrition model, similar to that of Bliss and Nalebuff. They motivate this model by the predicament of penguins on an ice floe, who hesitate to jump into the water and catch some fish because of the danger of being eaten by a leopard seal. If a single penguin dives in, the rest will know whether there is a seal or not. The longer the penguins wait, the hungrier they get and the more likely they are to die of starvation. Shapira and Eshel find that in their model, the equilibrium survival probability of any individual is independent of group size.

Archetti (2009, 2011) explores the implications of the Volunteer's Dilemma for optimal group size for vertebrates and also for bacteria. Groups of animals often rely on alarm calls as defense against predators. Action by a single group member may be sufficient to alert the entire group. Giving the alarm has significant costs, however, because the predator is more likely to focus on the animal who raised the alarm. If the standard Volunteer's Dilemma model is applied, this suggests that alarms would be raised less frequently in large groups than in small groups. Archetti argues that this effect is mitigated if members of the group are close genetic relatives

[12] The authors suggest that this game could describe the awkward period before some couple is first to start dancing in a ballroom full of shy dancers, or the period before someone makes the effort to open a window in an overheated lecture hall.

and hence, according to the principles of kin-selection theory, act as if they valued the survival of other group members.

VII. Conclusion

Increased population density offers the technical possibility of greater economies of scale because public goods provided by a few individuals can benefit all of their neighbors. But these economies of scale may be subverted by the free rider problem. This is dramatized in the Volunteer's Dilemma model, where players with identical costs and preferences must simultaneously decide whether to volunteer help. In the Volunteer's Dilemma game, each player would take a socially beneficial action if she knew that no one else would do it, but in the symmetric equilibrium, when players account for the probability that somebody else will do it, the probability that *nobody* takes action increases with group size.

While the fable of the Volunteer's Dilemma suggests a strong disadvantage of the formation of larger groups, this paper studies a realistic setting for group interaction in which more densely clustered groups perform better, rather than worse, in providing voluntary services.

The Road to Jericho game explores the effects of relaxing the Volunteer's Dilemma assumption of simultaneity of moves, both with and without the assumption of identical preferences. In this game, motorists sequentially observe a stranded traveler and must decide whether to stop and help or to leave the problem for the next passerby. In this model, with identical agents, as traffic becomes more frequent, the equilibrium probability that any individual will help decreases, but for the stranded traveler, the expected waiting time before the arrival of help remains constant. When costs of stopping differ among individuals, we find that, although individuals are less likely to help where traffic is more dense, a stranded traveler faces a shorter expected waiting time for help to arrive because potential helpers arrive more frequently.

The simplicity of the Road to Jericho model allows for sharp comparative statics results. In addition to determining the effects of population density on probabilities of helping, we find that a mean-preserving spread of the probability distribution of stopping costs for potential helpers reduces expected waiting time where traffic is dense and increases expected waiting time where traffic is sparse. With this model, we also show the partial crowding-out effects of governmentally provided highway patrols that offer assistance to stranded travelers. This model also offers an explanation for why it is commonly believed that "country people are more helpful than city people" and suggests that this view may be based on a misreading of the evidence.

The Road to Jericho model is a convenient testing ground for the application of Harsanyi's (1977) rule-based ethics where all could agree on a behavioral rule that all should abide by. For the setting of this model, it is not so unrealistic to draw a veil of ignorance over the question of who will be needing help and also over what will be a person's cost of helping at the time she encounters a person in need. We show that this leads to a simple optimization problem whose solution yields an interesting ethical rule.

Ariel Rubinstein maintains that:

> *Game theory is about a collection of fables. Are fables useful or not? In some sense, you can say that they are useful, because good fables can give you some new insight into the world and allow you to think about a situation differently. But fables are not useful in the sense of giving you advice about what to do tomorrow …*(Rubinstein 2012)

While our fable of a traveler in distress, taken literally, may seem to have narrow application, I believe that it offers insight into a large number of similar situations where people encounter an unsatisfactory state of affairs and must decide whether to fix the problem or leave it for someone who will encounter it later. I will consider this paper successful if it meets Rubenstein's criterion for a good fable: bringing new insight to common situations and allowing one to think about them differently.

Appendix: Proofs of Propositions

Our proof of the second assertion of Proposition 4 uses the following lemma, which is proved in Bagnoli and Bergstrom (2005).

LEMMA 1: *Suppose that the distribution function F is log-concave. Then the function*

$$\delta(x) = x - \frac{\int_{\ell}^{x} tf(t)\, dt}{F(x)}$$

is monotone increasing in x.

PROOF OF PROPOSITION 4:

Let $c^*(\lambda)$ be the ethical ideal stopping threshold when the Poisson arrival rate of traffic is λ. From equation (12), it follows that

$$c^*(\lambda)F\left(c^*(\lambda)\right) - \int_{\ell}^{c^*(\lambda)} cf(c)\, dc = \frac{v}{\lambda}. \tag{A1}$$

Differentiating both sides of equation (A1) with respect to λ and rearranging terms, we find that

$$c^{*\prime}(\lambda) = -\frac{v}{\lambda^2 F\left(c^*(\lambda)\right)} < 0. \tag{A2}$$

The effect of traffic density on the probability that any single passerby will stop is therefore

$$\frac{d}{d\lambda} F\left(c^*(\lambda)\right) = f\left(c^*(\lambda)\right)c'(\lambda) = -\left(\frac{v}{\lambda^2}\right)\frac{f\left(c^*(\lambda)\right)}{F\left(c^*(\lambda)\right)} < 0. \tag{A3}$$

This proves the first assertion of the theorem.

Let $w(\lambda) = 1/\lambda F\big(c^*(\lambda)\big)$ be the expected waiting time for a stranded traveler if passing travelers stop when and only when their their stopping costs are below $c^*(\lambda)$. Let us define

$$\text{(A4)} \qquad \delta(c^*) = c^* - \frac{\int_{\ell}^{c^*} cf(c)\,dc}{F(c^*)}.$$

From equations (12) and (A4), it follows that

$$\text{(A5)} \qquad \delta\big(c^*(\lambda)\big) = vw(\lambda).$$

From equation (A5), it follows that

$$\text{(A6)} \qquad w'(\lambda) = \frac{1}{v}\,\delta'\big(c^*(\lambda)\big)c^{*\prime}(\lambda).$$

According to Lemma 1, the assumption that F is log-concave implies that $\delta'\big(c^*(\lambda)\big) > 0$. According to expression (A2), it must be that $c^{*\prime}(\lambda) < 0$. Therefore, equation (A6) implies that $w'(\lambda) < 0$. It follows that the more dense traffic is on the road, the shorter the equilibrium expected waiting time for a stranded traveler. ∎

PROOF OF PROPOSITION 6:

Let us normalize the sympathy variable v so that $v = 1$, and hence $vw = w$ is the psychic cost of leaving a motorist stranded for an expected length of time w. We assume that the cost of stopping for private travelers is a random variable with distribution function $F(\cdot)$ and density function f defined on the interval $[\ell, \infty)$. Then it follows from equation (14) that at an interior equilibrium where some, but not all, private travelers will stop, the equilibrium expected waiting time for a motorist in trouble is $w(\mu, \lambda) = w$, where

$$\text{(A7)} \qquad w = \frac{1}{\mu + \lambda F\big(w\big)},$$

or equivalently,

$$\text{(A8)} \qquad w\mu + \lambda wF\big(w\big) = 1.$$

For all $\lambda > 0$, the expression on the left side of equation (A8) is strictly increasing in w and in μ. For all $\lambda > 0$, and all $\mu \geq 0$, the value of this expression ranges from 0 to ∞ as w ranges from 0 to ∞. Therefore, for all $\lambda > 0$ and all $\mu \geq 0$, equation (A8) has a unique solution for w. This solution implicitly defines the function $w(\mu, \lambda)$ representing equilibrium waiting time on a road with traffic rate λ and arrival rate μ of public rescue vehicles. Differentiating equation (A8) and rearranging terms, we find that the marginal effect of the rate of rescue patrolling on expected waiting time is

$$\text{(A9)} \qquad \frac{\partial w(\mu, \lambda)}{\partial \mu} = \frac{-w(\mu)}{\mu + \lambda\big(F\big(w(\mu)\big) + wf\big(w(\mu)\big)\big)} < 0,$$

where $p(\mu, \lambda)$ is the equilibrium probability that a private traveler will stop, and the expected arrival rate of private travelers who will stop is $\lambda p(\mu, \lambda) = \lambda F\big(w(\mu, \lambda)\big)$. Therefore, the rate at which public patrols crowd out private help is

$$\text{(A10)} \qquad \lambda \frac{\partial p(\mu, \lambda)}{\partial \mu} = \lambda f\big(w(\mu, \lambda)\big) \frac{\partial w(\mu, \lambda)}{\partial \mu}$$

$$= \frac{-\lambda wf\big(w(\mu)\big)}{\mu + \lambda\big(F\big(w(\mu)\big) + wf\big(w(\mu)\big)\big)}.$$

Proposition 6 follows from equations (A9) and (A10). ∎

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