The Ecology of Defensive Medicine and Malpractice Litigation

Angelo Antoci
Alessandro Fiori Maccioni
Paolo Russu

Department of Economics and Business (DiSea)
University of Sassari

Motivation

Describe via evolutionary game theory:

- medical malpractice litigation by patients
- defensive medicine by physicians

Explain the paradoxical positive relation between clinical safety and litigation rates, suggested by empirical data.

Suggest public policies aimed at improving efficiency in the healthcare system.

What is Defensive Medicine?

'Positive' defensive medicine consists of the superfluous medical practices that physicians provides (in addition to the standard medical care) with the solely purpose of protecting themselves against malpractice liability claims.

⇒ Tancredi and Barondess, 1978; Kessler and McClellan, 1996

⇒ example: prescription of unnecessary therapies, drugs, tests, surgery, hospital stay...

Empirical Literature 1/2

- The medical liability system costs 2–10% of healthcare spending in the U.S.
  $\Rightarrow$ Mello et al. 2010
- U.S. surgeons face a claim almost certainly and pay an indemnity with 70% probability throughout their career
  $\Rightarrow$ Jena et al. 2011

Data from Empirical Literature 2/2

- Defensive medical practices are widespread, especially in Surgery, Obstetrics and Gynecology
  $\Rightarrow$ Currie & MacLeod 2008, Studdert et al. 2005, Dubay et al. 2001
- Increasing trends in malpractice claims despite safety improvements
  $\Rightarrow$ Anesthesiology: Cheney et al. 2006, Peng & Smedstad 2000, Kohn et al. 2000

Analysis of Economic Literature 1/2

In classical economics:

- providing medical services is a principal-agent problem
  $\Rightarrow$ Arrow 1963
- focus on market failures due to asymmetric information
- physicians don't perfectly fit the neoclassical theory of firms
  $\Rightarrow$ for a review: McGuire 2000

Analysis of Economic Literature 2/2

Physicians can practice defensive medicine:

- also for reputational or competition concerns
  $\Rightarrow$ Quinn 1998, Madarasz 2012, Allard et al. 2009, Ma & McGuire 1997
- also under-providing services to the high severity patients
  $\Rightarrow$ Fees 2012, Ellis 1998, Ma 1994, Ellis & McGuire 1986

Welfare analyses of defensive medicine are proposed by Olbrich (2008) and Gal-Or (1999).

The Model

We propose an evolutionary game between a population of physicians and one of patients.

$\Rightarrow$ descriptive model of defensive behavior by physicians and of litigious behavior by patients.

Time is continuous. In every instant, many random pairwise encounters take place between physicians and patients.

Players choose the strategy without knowing ex ante their opponents' choice.

The One-Shot Defensive Medicine Game

A physician provides a risky treatment to a patient.

The treatment fails with probability p; if that happens, the patient suffers a damage R and can litigate at a cost C_L, or not litigate.

The physician can do defensive medicine (defend) at a cost C_D, causing the patient a harm H, or not defend at a cost $C_{ND} < C_D$.

The physician loses a litigation with probability q_D or q_{ND} respectively if defended or not, with $q_D < q_{ND}$.

The physician pays to the patient R if losing the litigation, or receives K if winning.

The One-Shot Defensive Medicine Game

Physician: \ Patient:	Litigate	Not Litigate
Defend	$-H-p[C_L+(R+K)(1-q_D)]$ $-C_D-p[R\,q_D-K(1-q_D)]$	$-H-R\,p$ $-C_D$
Not Defend	$-p[C_L+(R+K)(1-q_{ND})]$ $-C_{ND}-p[R\,q_{ND}-K(1-q_{ND})]$	$-R\,p$ $-C_{ND}$

Evolutionary Dynamics

The dynamical system is defined in the unit square:

$$S : \{(d, l) \in [0, 1]^2\}$$

where:

- $d(t)$: share of physicians playing defensive strategy
- $l(t)$: share of patients playing litigious strategy

The evolutionary dynamics are given by the replicator equations:

$$\begin{aligned} \dot{d} &= d\,[\Pi_D(l) - \Pi_{PH}] = d\,(1-d)\,[\Pi_D(l) - \Pi_{ND}(l)] \\ \dot{l} &= l\,[\Pi_L(d) - \Pi_{PA}] = l\,(1-l)\,[\Pi_L(d) - \Pi_{NL}(d)] \end{aligned}$$

The adoption rate of a strategy varies proportionally to: its current adoption rate, and to intra-population payoff differentials.

Sign of the time derivatives 1/2

For $d \neq 0, 1$, the sign of $\dot{d}$ depends on:

$$\Pi_D(I) - \Pi_{ND}(I) = pI(q_{ND} - q_D)(R + K) - C_D + C_{ND}$$

$\Rightarrow$ payoff differential of physicians positively related to I

$\Rightarrow$ payoff of defending improves when litigious patients <u>increase</u>

Sign of the time derivatives 2/2

For $l \neq 0, 1$, the sign of $\dot{l}$ depends on:

$$\Pi_L(d) - \Pi_{NL}(d) = p\{(R + K)[(q_D - q_{ND})d + q_{ND}] - K - C_L\}$$

$\Rightarrow$ payoff differential of litigious patients positively related to d

$\Rightarrow$ payoff of litigating improves when defensive physicians decrease

Evolutionary Dynamics

From the replicator equations, the time derivative $\dot{d}$ is equal to zero if either $d = 0, 1$ or:

$$l = l^* = \frac{C_D - C_{ND}}{p(q_{ND} - q_D)(R + K)}$$

Similarly, $\dot{l} = 0$ if either $d = 0, 1$ or:

$$d = d^* = \frac{Rq_{ND} - K(1 - q_{ND}) - C_L}{(q_{ND} - q_D)(R + K)}$$

The vertices $(0, 0), (1, 0), (0, 1), (1, 1)$ are always stationary states, and so is (d^*, l^*) if existing within the square S.

Dynamic regime with internal Nash equilibrium

It results $I^* > 0$ always, and $I^* < 1$ if:

$$C_D - C_{ND} < p(q_{ND} - q_D)(R + K)$$

It results $d^* > 0$ if:

$$C_L < Rq_{ND} - K(1 - q_{ND})$$

It results $d^* < 1$ if:

$$C_L > Rq_D - K(1 - q_D)$$

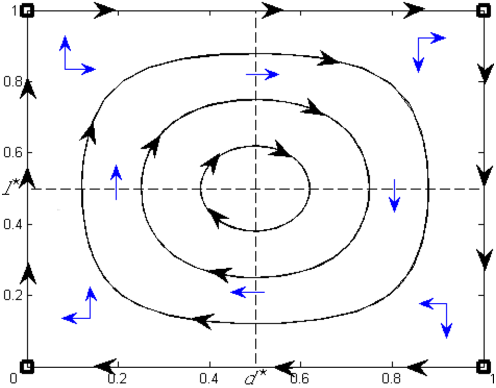
If these inequalities hold:

$\rightarrow$ the interior stationary state (d^*, I^*) exists within S

$\rightarrow$ no attractive stationary state exists

Dynamic regime with internal Nash equilibrium

$S : \{(d, l) \in [0, 1]^2\}$



Payoff of defensive strategy improves when litigious patients increase

Payoff of litigious strategy improves when defensive physicians decrease

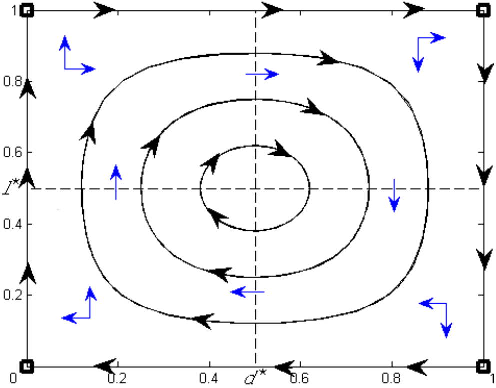
⇒ payoff differentials change sign in the four quadrants

⇒ no dominant strategy exists

⇒ predator-prey cycles

Dynamic regime with internal Nash equilibrium

$S : \{(d, l) \in [0,1]^2\}$



Properties of (d^*, l^*):

$\Rightarrow$ internal Nash equilibrium

$\Rightarrow$ stable (in Lyapunov sense)

(see Weibull 1997, Hofbauer & Sigmund 1988)

Comparative statics of the interior equilibrium

	d^*	l^*
$\nearrow p$	$\leftrightarrow$	$\searrow$
$\nearrow q_{ND}$	$\nearrow$	$\searrow$
$\nearrow q_D$	$\nearrow$	$\nearrow$
$\nearrow R$	$\nearrow$	$\searrow$
$\nearrow K$	$\searrow$	$\searrow$
$\nearrow C_{ND}$	$\leftrightarrow$	$\searrow$
$\nearrow C_D$	$\leftrightarrow$	$\nearrow$
$\nearrow C_L$	$\searrow$	$\leftrightarrow$

Effects on the interior equilibrium coordinates d^* and l^* of an increase in parameters, estimated from partial derivatives.

Paradoxically:

d^* is independent from p, C_D and C_{ND}

l^* is independent from C_L

Conditions that define the dynamic regimes

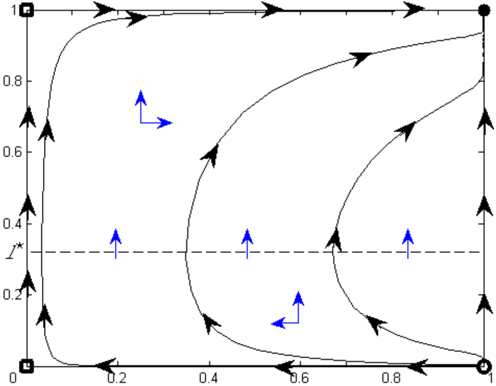
Conditions for the internal Nash equilibrium:

$$\begin{aligned} C_D - C_{ND} &< p(q_{ND} - q_D)(R + K) \\ C_L &< Rq_{ND} - K(1 - q_{ND}) \\ C_L &> Rq_D - K(1 - q_D) \end{aligned}$$

If any of the previous conditions holds with opposite inequality sign a unique globally attractive stationary state exists, which can be either $(1, 1)$, $(0, 0)$ or $(0, 1)$.

Dynamic Regime with Nash Equilibrium (1,1)

$S : \{(d, l) \in [0,1]^2\}$



Conditions:

$$C_D - C_{ND} < p(q_{ND} - q_D)(R + K)$$

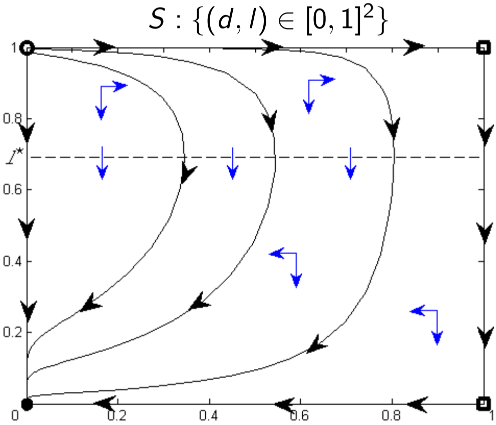
$$C_L < Rq_D - K(1 - q_D)$$

Properties of $(1,1)$:

$\rightarrow$ pure strategy Nash equilibrium

$\rightarrow$ globally attractive

Dynamic Regimes with Nash Equilibrium (0,0)



Conditions:

$$C_D - C_{ND} < p(q_{ND} - q_D)(R + K)$$

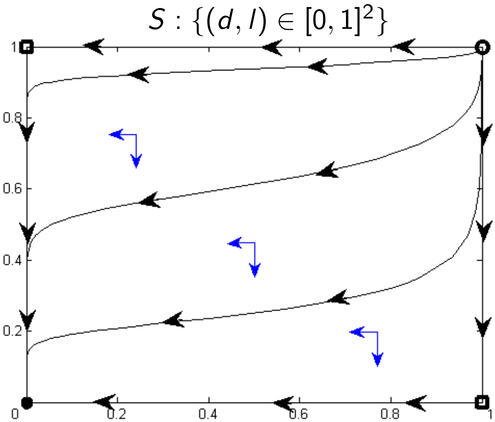
$$C_L > Rq_{ND} - K(1 - q_{ND})$$

Properties of $(0, 0)$:

→ pure strategy Nash equilibrium

→ globally attractive

Dynamic Regimes with Nash Equilibrium (0,0)



Conditions:

$$C_D - C_{ND} > p(q_{ND} - q_D)(R + K)$$

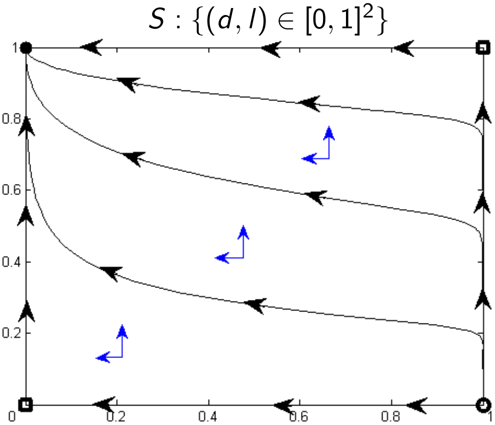
$$C_L > Rq_{ND} - K(1 - q_{ND})$$

Properties of $(0,0)$:

$\rightarrow$ pure strategy Nash equilibrium

$\rightarrow$ globally attractive

Dynamic Regimes with Nash Equilibrium (0,1)



Conditions:

$C_D - C_{ND} > p(q_{ND} - q_D)(R + K)$

$C_L < Rq_D - K(1 - q_D)$

Properties of $(0, 1)$:

$\rightarrow$ pure strategy Nash equilibrium

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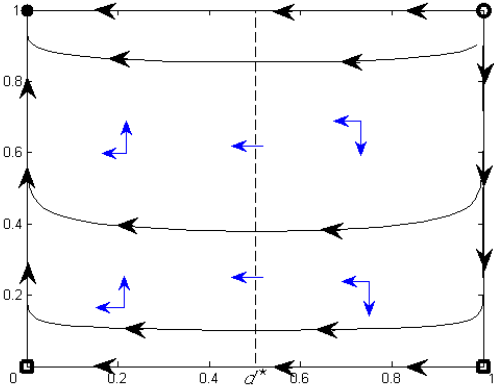
Dynamic Regimes with Nash Equilibrium (0,1)

$S : \{(d, l) \in [0,1]^2\}$



Conditions:

$C_D - C_{ND} > p(q_{ND} - q_D)(R + K)$

$C_L > Rq_D - K(1 - q_D)$

$C_L < Rq_{ND} - K(1 - q_{ND})$

Properties of $(0, 1)$:

$\rightarrow$ pure strategy Nash equilibrium

$\rightarrow$ globally attractive

Welfare Analysis

We compare stationary states of the game in terms of welfare, as measured by population average payoffs $\Pi_{PH}(d, l)$ and $\Pi_{PA}(d, l)$.

We find that, when (d^*, l^*) exists, it is Pareto-dominated by $(0, 0)$ if defensive medicine has no direct benefit to patients (i.e. $H \geq 0$):

- $\Pi_{PH}(0, 0) > \Pi_{PH}(d^*, l^*)$ always holds
- $\Pi_{PA}(0, 0) > \Pi_{PA}(d^*, l^*)$ holds for $H \geq 0$

Similarly, when $(1, 1)$ is attractive, it is Pareto-dominated by $(0, 0)$ for sufficiently high ratios H/p.

Proof that $(0, 0)$ is more efficient than (d^*, l^*) if $H \geq 0$

Proof:

$$\Pi_{PH}(0,0) = \Pi_{ND}(0) = -C_{ND}$$

$$\Pi_{PH}(d^*, l^*) = \Pi_D(l^*) = \Pi_{ND}(l^*) = -C_{ND} - l^* p[Rq_{ND} - K(1 - q_{ND})]$$

$$\Pi_{PA}(0,0) = \Pi_{NL}(0) = -Rp$$

$$\Pi_{PA}(d^*, l^*) = \Pi_L(d^*) = \Pi_{NL}(d^*) = -Rp - Hd^*$$

$\Rightarrow$ the first term in red is always negative

$\Rightarrow$ the second term in red is negative for $H \geq 0$

Policy Implications

⇒ policy makers should consider the overall underlying dynamics of defensive medicine and malpractice litigation

⇒ clinical advances and legal reforms can have unexpected long term consequences, due to predator-prey relations

⇒ increasing clinical safety can increase the risk for doctors of being sued by patients, when accidents occur

⇒ perfect cooperation can be the optimal solution, but it can't be reached without public intervention