On the Direction of Innovation

Hugo Hopenhayn
University of California at Los Angeles

Francesco Squintani
University of Warwick

Introduction

- Innovation resources unequally distributed across different research areas
- Some areas become more fashionable than others and attract more attention
    - In the 80's leading patent classes in Chemical industry
    - Starting 1995 the areas of computing and electronics surpassed all others by far
- Dot.com bubble is usually viewed as a sign of excessive concentration
- Examples suggest innovation resources might be misallocated across areas
- I examine some possible sources of misallocation

Plan for the Talk

Is there a bias to high return (hot) areas?

Is there a bias towards easy problems?

Rush for the gold?

Plan for the Talk

Is there a bias to high return (hot) areas?

Is there a bias towards easy problems?

Rush for the gold?

Series of Examples
Final unifying framework
Some numerical results

Basic Example

- 2 possible innovations $z_L < z_H$ (cold/hot)
- Social and private value
- 2 innovators
- One time assignment (L,H), (H,H)
- Probabilities: p with one and $q > p$ with two

Is there a bias to hot areas?

Assignment	p_L	p_H	Profits 1	Profits 2	total value
(L,H)	p	p	pz_L	pz_H	$p(z_L + z_H)$
(H,H)	0	q	$qz_H/2$	$qz_H/2$	qz_H
Difference			$\Delta\pi_1 = qz_H/2 - pz_L$	$\Delta\pi_2 = qz_H/2 - pz_H$	$\Delta V = qz_H - p(z_L + z_H)$

Is there a bias to hot areas?

Assignment	p_L	p_H	Profits 1	Profits 2	total value
(L,H)	p	p	pz_L	pz_H	$p(z_L + z_H)$
(H,H)	0	q	$qz_H/2$	$qz_H/2$	qz_H
Difference			$\Delta\pi_1 = qz_H/2 - pz_L$	$\Delta\pi_2 = qz_H/2 - pz_H$	$\Delta V = qz_H - p(z_L + z_H)$

- It is optimal to have both in H when $\Delta V > 0$

Is there a bias to hot areas?

Assignment	p_L	p_H	Profits 1	Profits 2	total value
(L,H)	p	p	pz_L	pz_H	$p(z_L + z_H)$
(H,H)	0	q	$qz_H/2$	$qz_H/2$	qz_H
Difference			$\Delta\pi_1 = qz_H/2 - pz_L$	$\Delta\pi_2 = qz_H/2 - pz_H$	$\Delta V = qz_H - p(z_L + z_H)$

- It is optimal to have both in H when $\Delta V > 0$
- The market will have both in H when $\Delta\pi_1 > 0$

Is there a bias to hot areas?

Assignment	p_L	p_H	Profits 1	Profits 2	total value
(L,H)	p	p	pz_L	pz_H	$p(z_L + z_H)$
(H,H)	0	q	$qz_H/2$	$qz_H/2$	qz_H
Difference			$\Delta\pi_1 = qz_H/2 - pz_L$	$\Delta\pi_2 = qz_H/2 - pz_H$	$\Delta V = qz_H - p(z_L + z_H)$

- It is optimal to have both in H when $\Delta V > 0$
- The market will have both in H when $\Delta\pi_1 > 0$
- Whenever $\Delta V > 0$, then $\Delta\pi_1 > 0$

Is there a bias to hot areas?

Assignment	p_L	p_H	Profits 1	Profits 2	total value
(L,H)	p	p	pz_L	pz_H	$p(z_L + z_H)$
(H,H)	0	q	$qz_H/2$	$qz_H/2$	qz_H
Difference			$\Delta\pi_1 = qz_H/2 - pz_L$	$\Delta\pi_2 = qz_H/2 - pz_H$	$\Delta V = qz_H - p(z_L + z_H)$

- It is optimal to have both in H when $\Delta V > 0$
- The market will have both in H when $\Delta\pi_1 > 0$
- Whenever $\Delta V > 0$, then $\Delta\pi_1 > 0$
- If $q - p < p$ (decreasing returns/duplication/congestion/crowding out):
  - $\Delta\pi_2 < 0$ (pecuniary externality)

Is there a bias to hot areas?

$z_H = 30$, $z_L = 16$
$p = 1/2$, $q = 2/3$

Assignment	p_L	p_H	Profits 1	Profits 2	total value
(L,H)	1/2	1/2	8	15	23
(H,H)	0	2/3	10	10	20
Difference			2	-5	-3

Is there a bias to hot areas?

$z_H = 30$, $z_L = 16$
$p = 1/2$, $q = 2/3$

Assignment	p_L	p_H	Profits 1	Profits 2	total value
(L,H)	1/2	1/2	8	15	23
(H,H)	0	2/3	10	10	20
Difference			2	-5	-3

- When innovator moves from L to H
  - Gets 2 extra (10-8)
  - Other innovator's value decreases by 5 (15-10)
  - Total value falls by 3
- Pecuniary externality

Can the opposite happen?

- 4 innovators
- Probabilities: $p_1 = 1/2$, $p_2 = 3/4$, $p_3 = 1$
- Assignments to consider:
  - 2 in each (LL,HH)
  - 1 in L and 3 in H (L,HHH)

Too Conservative?

Assignment	p_L	p_H	Profits in L	Profits in H	total value
(LL,HH)	3/4	3/4			
(L,HHH)					
Difference					

Too Conservative?

Assignment	p_L	p_H	Profits in L	Profits in H	total value
(LL,HH)	3/4	3/4	$\frac{3}{8}z_L$	$\frac{3}{8}z_H$	$\frac{3}{8}(z_L + z_H)$
(L,HHH)					
Difference					

Too Conservative?

Assignment	p_L	p_H	Profits in L	Profits in H	total value
(LL,HH)	3/4	3/4	$\frac{3}{8}z_L$	$\frac{3}{8}z_H$	$\frac{3}{8}(z_L + z_H)$
(L,HHH)	$\frac{1}{2}$	1			
Difference					

Too Conservative?

Assignment	p_L	p_H	Profits in L	Profits in H	total value
(LL,HH)	3/4	3/4	$\frac{3}{8}z_L$	$\frac{3}{8}z_H$	$\frac{3}{8}(z_L + z_H)$
(L,HHH)	$\frac{1}{2}$	1	$\frac{1}{2}z_L$	$\frac{1}{3}z_H$	$\frac{1}{2}z_L + z_H$
Difference					

Too Conservative?

Assignment	p_L	p_H	Profits in L	Profits in H	total value
(LL,HH)	3/4	3/4	$\frac{3}{8}z_L$	$\frac{3}{8}z_H$	$\frac{3}{8}(z_L + z_H)$
(L,HHH)	$\frac{1}{2}$	1	$\frac{1}{2}z_L$	$\frac{1}{3}z_H$	$\frac{1}{2}z_L + z_H$
Difference			$\frac{1}{8}z_L$		

Too Conservative?

Assignment	p_L	p_H	Profits in L	Profits in H	total value
(LL,HH)	$3/4$	$3/4$	$\frac{3}{8}z_L$	$\frac{3}{8}z_H$	$\frac{3}{8}(z_L + z_H)$
(L,HHH)	$\frac{1}{2}$	1	$\frac{1}{2}z_L$	$\frac{1}{3}z_H$	$\frac{1}{2}z_L + z_H$
Difference			$\frac{1}{8}z_L$	$-2 \times \frac{1}{24}z_H$	

Too Conservative?

Assignment	p_L	p_H	Profits in L	Profits in H	total value
(LL,HH)	3/4	3/4	$\frac{3}{8}z_L$	$\frac{3}{8}z_H$	$\frac{3}{8}(z_L + z_H)$
(L,HHH)	$\frac{1}{2}$	1	$\frac{1}{2}z_L$	$\frac{1}{3}z_H$	$\frac{1}{2}z_L + z_H$
Difference			$\frac{1}{8}z_L$	$-2 \times \frac{1}{24}z_H$	$\frac{1}{4}(z_H - z_L)$

Too Conservative?

Assignment	p_L	p_H	Profits in L	Profits in H	total value
(LL,HH)	3/4	3/4	$\frac{3}{8} z_L$	$\frac{3}{8} z_H$	$\frac{3}{4}(z_L + z_H)$
(L,HHH)	1/2	1	$\frac{1}{2} z_L$	$\frac{1}{3} z_H$	$\frac{1}{2} z_L + z_H$
Difference			$\frac{1}{8} z_L$	-2 $\times \frac{1}{24} z_H$	$\frac{1}{4}(z_H - z_L)$

- (L, HHH) maximizes total value

Too Conservative?

Assignment	p_L	p_H	Profits in L	Profits in H	total value
(LL,HH)	3/4	3/4	$\frac{3}{8}z_L$	$\frac{3}{8}z_H$	$\frac{3}{4}(z_L + z_H)$
(L,HHH)	1/2	1	$\frac{1}{2}z_L$	$\frac{1}{3}z_H$	$\frac{1}{2}z_L + z_H$
Difference			$\frac{1}{8}z_L$	-2 $\times$ $\frac{1}{24}z_H$	$\frac{1}{4}(z_H - z_L)$

- (L, HHH) maximizes total value
- Changes in profits for mover: $\frac{1}{3}z_H - \frac{3}{8}z_L$
  - Negative if z_L is close to z_H

Too Conservative?

Assignment	p_L	p_H	Profits in L	Profits in H	total value
(LL,HH)	3/4	3/4	$\frac{3}{8}z_L$	$\frac{3}{8}z_H$	$\frac{3}{4}(z_L + z_H)$
(L,HHH)	1/2	1	$\frac{1}{2}z_L$	$\frac{1}{3}z_H$	$\frac{1}{2}z_L + z_H$
Difference			$\frac{1}{8}z_L$	-2 $\times \frac{1}{24}z_H$	$\frac{1}{4}(z_H - z_L)$

- (L, HHH) maximizes total value
- Changes in profits for mover: $\frac{1}{3}z_H - \frac{3}{8}z_L$
  - Negative if z_L is close to z_H
- Pecuniary externalities: $\frac{1}{8}z_L - \frac{1}{12}z_H$

General Insight

- Market will in general assign innovation resources inefficiently
- Pecuniary external effect from congestion/crowding out
  - Differential rent dissipation/value burning with congestion
- Bias depends on relative size of pecuniary effects
- If stronger in more crowded areas then bias to hot areas.
- Depends on $P(m)$. Satisfied in standard cases.

Go for the Low Hanging Fruit?

- 2 innovators
- 2 Innovations (L, H) and $z_L = z_H = z$
- Probabilities: $p_L = (0.9, 1)$, $p_H = (1/5, 1/3)$

Bias to the low hanging fruit

Assignment	p_L	p_H	Profits		total value
			Innovator 1	Innovator 2	
(H,L)	0.9	0.2	$0.2z$	$0.9z$	$1.1z$
(L,L)	1	0	$0.5z$	$0.5z$	z
			$0.3z$	$-0.4z$	$-0.1z$

Bias to the low hanging fruit

Assignment	p_L	p_H	Profits		total value
			Innovator 1	Innovator 2	
(H,L)	0.9	0.2	$0.2z$	$0.9z$	$1.1z$
(L,L)	1	0	$0.5z$	$0.5z$	z
			$0.3z$	$-0.4z$	$-0.1z$

- Outcome: (L,L)
- Not Efficient
- External effect: $-0.4z$

Rush for the Gold?

- Innovators can be reallocated after discovery
- Cost of switching $c \geq 0$
- Same technology as in our first example: $0 < p < q$
- Eventually both discovered. No discounting
- Alternative allocations:
  1. Both innovators on H until discovery then switch to L.
  2. One in each. After first discovery both on remaining.

Rush for the Gold?

Initial assign		prob	Payoffs		total value
			Innovator 1 (L)	Innovator 2 (H)	
(L, H)					
(H, H)	Expected payoffs		$\frac{1}{2}(z_H + z_L) - c$	$\frac{1}{2}(z_H + z_L) - c$	$z_H + z_L - 2c$
Difference					

Rush for the Gold?

Initial assign		prob	Payoffs		total value
			Innovator 1 (L)	Innovator 2 (H)	
(L, H)	L discovered first	1/2			
(H, H)	Expected payoffs		$\frac{1}{2}(z_H + z_L) - c$	$\frac{1}{2}(z_H + z_L) - c$	$z_H + z_L - 2c$
Difference					

Rush for the Gold?

Initial assign		prob	Payoffs		total value
			Innovator 1 (L)	Innovator 2 (H)	
(L, H)	L discovered first	1/2	$z_L + \frac{1}{2} z_H - c$		
(H, H)	Expected payoffs		$\frac{1}{2}(z_H + z_L) - c$	$\frac{1}{2}(z_H + z_L) - c$	$z_H + z_L - 2c$
Difference					

Rush for the Gold?

Initial assign		prob	Payoffs		total value
			Innovator 1 (L)	Innovator 2 (H)	
(L, H)	L discovered first	1/2	$z_L + \frac{1}{2} z_H - c$	$\frac{1}{2} z_H$	
(H, H)	Expected payoffs		$\frac{1}{2}(z_H + z_L) - c$	$\frac{1}{2}(z_H + z_L) - c$	$z_H + z_L - 2c$
Difference					

Rush for the Gold?

Initial assign		prob	Payoffs		total value
			Innovator 1 (L)	Innovator 2 (H)	
(L, H)	L discovered first	1/2	$z_L + \frac{1}{2} z_H - c$	$\frac{1}{2} z_H$	
	H discovered first	1/2			
(H, H)	Expected payoffs		$\frac{1}{2}(z_H + z_L) - c$	$\frac{1}{2}(z_H + z_L) - c$	$z_H + z_L - 2c$
Difference					

Rush for the Gold?

Initial assign		prob	Payoffs		total value
			Innovator 1 (L)	Innovator 2 (H)	
(L, H)	L discovered first	1/2	$z_L + \frac{1}{2} z_H - c$	$\frac{1}{2} z_H$	
	H discovered first	1/2	$z_L / 2$		
(H, H)	Expected payoffs		$\frac{1}{2}\left(z_H + z_L\right) - c$	$\frac{1}{2}\left(z_H + z_L\right) - c$	$z_H + z_L - 2c$
Difference					

Rush for the Gold?

Initial assign		prob	Payoffs		total value
			Innovator 1 (L)	Innovator 2 (H)	
(L, H)	L discovered first	1/2	$z_L + \frac{1}{2} z_H - c$	$\frac{1}{2} z_H$	
	H discovered first	1/2	$z_L / 2$	$z_H + \frac{1}{2} z_L - c$	
(H, H)	Expected payoffs		$\frac{1}{2}\left(z_H + z_L\right) - c$	$\frac{1}{2}\left(z_H + z_L\right) - c$	$z_H + z_L - 2c$
Difference					

Rush for the Gold?

Initial assign		prob	Payoffs		total value
			Innovator 1 (L)	Innovator 2 (H)	
(L, H)	L discovered first	1/2	$z_L + \frac{1}{2} z_H - c$	$\frac{1}{2} z_H$	
	H discovered first	1/2	$z_L / 2$	$z_H + \frac{1}{2} z_L - c$	
	Expected payoffs				
(H, H)	Expected payoffs		$\frac{1}{2}\left(z_H + z_L\right) - c$	$\frac{1}{2}\left(z_H + z_L\right) - c$	$z_H + z_L - 2c$
Difference					

Rush for the Gold?

Initial assign		prob	Payoffs		total value
			Innovator 1 (L)	Innovator 2 (H)	
(L, H)	L discovered first	1/2	$z_L + \frac{1}{2} z_H - c$	$\frac{1}{2} z_H$	
	H discovered first	1/2	$z_L / 2$	$z_H + \frac{1}{2} z_L - c$	
	Expected payoffs		$\frac{3}{4} z_L + \frac{1}{4} z_H - \frac{1}{2} c$		
(H, H)	Expected payoffs		$\frac{1}{2} (z_H + z_L) - c$	$\frac{1}{2} (z_H + z_L) - c$	$z_H + z_L - 2c$
Difference					

Rush for the Gold?

Initial assign		prob	Payoffs		total value
			Innovator 1 (L)	Innovator 2 (H)	
(L, H)	L discovered first	1/2	$z_L + \frac{1}{2} z_H - c$	$\frac{1}{2} z_H$	
	H discovered first	1/2	$z_L/2$	$z_H + \frac{1}{2} z_L - c$	
	Expected payoffs		$\frac{3}{4} z_L + \frac{1}{4} z_H - \frac{1}{2} c$	$\frac{3}{4} z_H + \frac{1}{4} z_L - \frac{1}{2} c$	
(H, H)	Expected payoffs		$\frac{1}{2} (z_H + z_L) - c$	$\frac{1}{2} (z_H + z_L) - c$	$z_H + z_L - 2c$
Difference					

Rush for the Gold?

Initial assign		prob	Payoffs		total value
			Innovator 1 (L)	Innovator 2 (H)	
(L, H)	L discovered first	1/2	$z_L + \frac{1}{2} z_H - c$	$\frac{1}{2} z_H$	
	H discovered first	1/2	$z_L / 2$	$z_H + \frac{1}{2} z_L - c$	
	Expected payoffs		$\frac{3}{4} z_L + \frac{1}{4} z_H - \frac{1}{2} c$	$\frac{3}{4} z_H + \frac{1}{4} z_L - \frac{1}{2} c$	$z_H + z_L - c$
(H, H)	Expected payoffs		$\frac{1}{2} \left(z_H + z_L \right) - c$	$\frac{1}{2} \left(z_H + z_L \right) - c$	$z_H + z_L - 2c$
Difference					

Rush for the Gold?

Initial assign		prob	Payoffs		total value
			Innovator 1 (L)	Innovator 2 (H)	
(L, H)	L discovered first	1/2	$z_L + \frac{1}{2} z_H - c$	$\frac{1}{2} z_H$	
	H discovered first	1/2	$z_L / 2$	$z_H + \frac{1}{2} z_L - c$	
	Expected payoffs		$\frac{3}{4} z_L + \frac{1}{4} z_H - \frac{1}{2} c$	$\frac{3}{4} z_H + \frac{1}{4} z_L - \frac{1}{2} c$	$z_H + z_L - c$
(H, H)	Expected payoffs		$\frac{1}{2} (z_H + z_L) - c$	$\frac{1}{2} (z_H + z_L) - c$	$z_H + z_L - 2c$
Difference			$\frac{1}{4} (z_H - z_L) - \frac{1}{2} c$		

Rush for the Gold?

Initial assign		prob	Payoffs		total value
			Innovator 1 (L)	Innovator 2 (H)	
(L, H)	L discovered first	1/2	$z_L + \frac{1}{2}z_H - c$	$\frac{1}{2}z_H$	
	H discovered first	1/2	$z_L/2$	$z_H + \frac{1}{2}z_L - c$	
	Expected payoffs		$\frac{3}{4}z_L + \frac{1}{4}z_H - \frac{1}{2}c$	$\frac{3}{4}z_H + \frac{1}{4}z_L - \frac{1}{2}c$	$z_H + z_L - c$
(H, H)	Expected payoffs		$\frac{1}{2}(z_H + z_L) - c$	$\frac{1}{2}(z_H + z_L) - c$	$z_H + z_L - 2c$
Difference			$\frac{1}{4}(z_H - z_L) - \frac{1}{2}c$	$-\frac{1}{4}(z_H - z_L) - \frac{1}{2}c$	

Rush for the Gold?

Initial assign		prob	Payoffs		total value
			Innovator 1 (L)	Innovator 2 (H)	
(L, H)	L discovered first	1/2	$z_L + \frac{1}{2} z_H - c$	$\frac{1}{2} z_H$	
	H discovered first	1/2	$z_L / 2$	$z_H + \frac{1}{2} z_L - c$	
	Expected payoffs		$\frac{3}{4} z_L + \frac{1}{4} z_H - \frac{1}{2} c$	$\frac{3}{4} z_H + \frac{1}{4} z_L - \frac{1}{2} c$	$z_H + z_L - c$
(H, H)	Expected payoffs		$\frac{1}{2} (z_H + z_L) - c$	$\frac{1}{2} (z_H + z_L) - c$	$z_H + z_L - 2c$
Difference			$\frac{1}{4} (z_H - z_L) - \frac{1}{2} c$	$-\frac{1}{4} (z_H - z_L) - \frac{1}{2} c$	$-c$

Rush for the Gold?

Initial assign		prob	Payoffs		total value
			Innovator 1 (L)	Innovator 2 (H)	
(L, H)	L discovered first	1/2	$z_L + \frac{1}{2} z_H - c$	$\frac{1}{2} z_H$	
	H discovered first	1/2	$z_L / 2$	$z_H + \frac{1}{2} z_L - c$	
	Expected payoffs		$\frac{3}{4} z_L + \frac{1}{4} z_H - \frac{1}{2} c$	$\frac{3}{4} z_H + \frac{1}{4} z_L - \frac{1}{2} c$	$z_H + z_L - c$
(H, H)	Expected payoffs		$\frac{1}{2} (z_H + z_L) - c$	$\frac{1}{2} (z_H + z_L) - c$	$z_H + z_L - 2c$
Difference			$\frac{1}{4} (z_H - z_L) - \frac{1}{2} c$	$-\frac{1}{4} (z_H - z_L) - \frac{1}{2} c$	$-c$

Rush for the Gold?

Initial assign		prob	Payoffs		total value
			Innovator 1 (L)	Innovator 2 (H)	
(L, H)	L discovered first	1/2	$z_L + \frac{1}{2} z_H - c$	$\frac{1}{2} z_H$	
	H discovered first	1/2	$z_L / 2$	$z_H + \frac{1}{2} z_L - c$	
	Expected payoffs		$\frac{3}{4} z_L + \frac{1}{4} z_H - \frac{1}{2} c$	$\frac{3}{4} z_H + \frac{1}{4} z_L - \frac{1}{2} c$	$z_H + z_L - c$
(H, H)	Expected payoffs		$\frac{1}{2} (z_H + z_L) - c$	$\frac{1}{2} (z_H + z_L) - c$	$z_H + z_L - 2c$
Difference			$\frac{1}{4} (z_H - z_L) - \frac{1}{2} c$	$-\frac{1}{4} (z_H - z_L) - \frac{1}{2} c$	$-c$

- Socially inefficient to rush for the gold

Rush for the Gold?

Initial assign		prob	Payoffs		total value
			Innovator 1 (L)	Innovator 2 (H)	
(L, H)	L discovered first	1/2	$z_L + \frac{1}{2}z_H - c$	$\frac{1}{2}z_H$	
	H discovered first	1/2	$z_L/2$	$z_H + \frac{1}{2}z_L - c$	
	Expected payoffs		$\frac{3}{4}z_L + \frac{1}{4}z_H - \frac{1}{2}c$	$\frac{3}{4}z_H + \frac{1}{4}z_L - \frac{1}{2}c$	$z_H + z_L - c$
(H, H)	Expected payoffs		$\frac{1}{2}(z_H + z_L) - c$	$\frac{1}{2}(z_H + z_L) - c$	$z_H + z_L - 2c$
Difference			$\frac{1}{4}(z_H - z_L) - \frac{1}{2}c$	$-\frac{1}{4}(z_H - z_L) - \frac{1}{2}c$	$-c$

- Socially inefficient to rush for the gold
- The market will rush for the gold if $c < \frac{1}{2}(z_H - z_L)$

Rush for the Gold?

Initial assign		prob	Payoffs		total value
			Innovator 1 (L)	Innovator 2 (H)	
(L, H)	L discovered first	1/2	$z_L + \frac{1}{2} z_H - c$	$\frac{1}{2} z_H$	
	H discovered first	1/2	$z_L / 2$	$z_H + \frac{1}{2} z_L - c$	
	Expected payoffs		$\frac{3}{4} z_L + \frac{1}{4} z_H - \frac{1}{2} c$	$\frac{3}{4} z_H + \frac{1}{4} z_L - \frac{1}{2} c$	$z_H + z_L - c$
(H, H)	Expected payoffs		$\frac{1}{2} (z_H + z_L) - c$	$\frac{1}{2} (z_H + z_L) - c$	$z_H + z_L - 2c$
Difference			$\frac{1}{4} (z_H - z_L) - \frac{1}{2} c$	$-\frac{1}{4} (z_H - z_L) - \frac{1}{2} c$	$-c$

- Socially inefficient to rush for the gold
- The market will rush for the gold if $c < \frac{1}{2} (z_H - z_L)$
- Pecuniary externality: $-\frac{1}{4} (z_H - z_L) - \frac{1}{2} c$
- Similar effects for low hanging fruit

Summary External Effects

<table>
<tr><th rowspan="2">Source</th><th colspan="2">Direction of Bias</th></tr>
<tr><th>High and low z</th><th>Different $p's$</th></tr>
<tr><td rowspan="2">Congestion/market stealing</td><td>Could go either way</td><td rowspan="2">Low hanging fruit</td></tr>
<tr><td>Under usual assumptions to hot areas</td></tr>
<tr><td>Duplication cost externalities</td><td>Hot areas</td><td>Low hanging fruit</td></tr>
<tr><td>Returns on future innovations</td><td>Hot areas</td><td>Low hanging fruit</td></tr>
</table>

General Dynamic Model

- Values: $z_1 \leq z_2, ..., \leq z_N$
- Assignment $m(z)$
- Continuous arrival of new problems $F(z)$
- Probability of innovation with m innovators: $P(m(z)) = \exp(-\lambda m)$
- Flow λM exit of solved problems
- All above some threshold z_0
- Compare Market vs Efficient assignment

Market vs Efficient

	Market	Efficient
Assignment	Excessive concentration in hot areas	More balanced assignment
Opportunities available	Less attractive alternatives left	More attractive alternatives left
Turnover of innovators	Excessively high	More moderate
Flow of Value	$\lambda M z_0$	$\lambda M E\left(z \mid z \geq z_0\right) - D\left(c\right)$
Efficient/Market value	over 3.5 for $c = 1$ million	
	close to 6 as $c \to 0$	

Final Remarks

- Market can misallocate innovation resources
- Found new sources of market failure:
  - Congestion
  - Excess turnover
  - Run for the gold
- The costs can be large
- Source of Market Failure: Lack of property rights over "problems"
- Patents do not address this sort of market failure