## A brief introduction to economics Part IV

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Exercises

#### Outline

- Reading
- 2 Exercises
  - Exercise 1: antivirus software (still!)
  - Let's finish exercise 2: DDoS protection
- Market failures
  - Monopoly
  - Public goods
  - Asymmetric Information

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Notes

#### Reading Exercises

#### Reading reminder

- I have updated the economics lecture notes to discuss attitudes towards risk
- "Why information security is hard" linked to today's calendar
- Some people have requested more introductory economics reading
  - I've put two optional readings on Blackboard
  - Selected excerpts from *Intermediate Microeconomics*, Hal Varian
  - Selected exerpt from economics chapter, Security Engineering, Ross Anderson

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Reading Exercises Exercise 1: antivirus software (still!) Let's finish exercise 2: DDoS protectio

### Risk attitude example (take 3): antivirus software

- Suppose you have \$5,000 in wealth. You have the option to buy antivirus software for \$x.
- Outcomes available:
  - $\mathcal{O} = \{\text{hacked (decreases wealth by $2,000)}, \\ \text{not hacked (no change in wealth)}\}$
- Without AV software, probability of being hacked is 0.05 (P(hacked|no antivirus) = 0.05)
- With AV software, probability of being hacked is 0 (P(hacked|antivirus) = 0)
- Exercise 1a: How much would you pay for antivirus software if you were risk-neutral?
- Exercise 1b: How much would you pay for antivirus software if you were risk-averse and  $U(o) = \sqrt{o}$ ?
- Exercise 1c: For what values of x will the risk-averse buy and the risk-neutral not buy?

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## Reading Exercises Exercise 1: antivirus software (still!) Let's finish exercise 2: DDoS protection

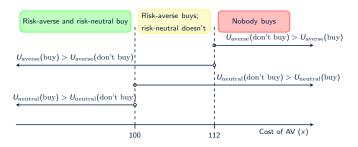
### Risk attitude example (take 2): antivirus software

- First question: what is the constraint that makes buying AV affordable?
- Recommended approach: draw out the table of outcomes and actions, along with probabilities
- Solve for x
- We'll go through it by hand; see the revised economics lecture notes for more information.

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Notes

# Reading Exercises Market failures Visualizing constraints Exercise 1: antivirus software (still!) Let's finish exercise 2: DDoS protection



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## Reading Exercises 1: antivirus software (still!) Let's finish exercise 2: DDoS protection Another example

- Modeling real-world situations using rational choice theory is a fundamental skill
- There usually is no single "correct" model; instead you must justify your choices for approximating reality
- This includes a statement of the limitations of the model, so that we are clear on its shortcomings
- Let's practice together on a newsworthy topic

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## Reading Exercise 1: antivirus software (still!) Let's finish exercise 2: DDoS protection GoDaddy, world's largest web hosting provider, hacked?

	Water Papers   Hor Topics   Dissellands   Review   NewSeleters	Search ZDNet Q.  Log In   Acin ZDNet
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E Like	By Zock Whitaker for Zero Day   September 10, 2012 22.22 GMT (15:22 PDT)  #Follow @zockwhitzaker	OpenNet: IDA's new minimum service standards untain
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	Everyone at GoDaddy com is working to restore all sixes affected by this outage as soon as possible.	news is breaking. Are you ready? This newsletter has only the most important tech news nothing etse.  Statiscribe: Now

Source: http://www.zdnet.com/anonymous-hacker-claims-godaddy-attack-outage-hits-millions-7000003925/

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Reading Exercises

Exercise 1: antivirus software (still!)
Let's finish exercise 2: DDoS protection

#### Turns out GoDaddy experienced a non-malicious outage



Source: http://www.cnn.com/2012/09/11/tech/mobile/godaddy-response-outage/index.html

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Exercises
Market failures

Exercise 1: antivirus software (still!) Let's finish exercise 2: DDoS protection

#### Exercise 2: let's model a security investment decision

- Suppose GoDaddy is approached by a security firm XYZSec offering a "DDoS protection" product
- XYZSec claims to be able to eradicate DDoS threats using a shared-bandwidth pool, will sell for \$100,000.
- Your task: model GoDaddy's security investment choice using rational choice theory
  - What are the outcomes?
  - What are the actions?

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Reading Exercise Exercise 1: antivirus software (still!) Let's finish exercise 2: DDoS protection

#### Exercise 2: Actions-outcomes table

- $o_1 = no outage, o_2 = outage$
- a<sub>1</sub>=buy DDoS service, a<sub>2</sub>=don't buy

		outcome o <sub>1</sub>	outcome	02	
Action	$U(o_1)$	$P(o_1 action)$	$U(o_2)$	$P(o_2 action)$	E[U(action)]
a <sub>1</sub>	-\$100,000	.99999	-\$100,000+outage cost?	.00001	?
a <sub>2</sub>	0	.99999 - $P(DDoS)$ ?	outage cost?	$.00001 + P(\mathrm{DDoS})$	?

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Reading Exercises Exercise 1: antivirus software (still!) Let's finish exercise 2: DDoS protection

#### Exercise 2: Calculate the effectiveness of DDoS prevention

- Suppose that GoDaddy expects an outage would cost them \$10 million to deal with.
- How well must XYZSecurity's DDoS prevention system work in order to be worth the cost? (Hint: use the action-outcome table from the last slide)
- State the assumptions that you must make for the model to work, and qualitatively assess whether or not they are reasonable

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#### Exercise 2: Calculate the effectiveness of DDoS prevention

• My answer:  $P(DDoS) \ge .001$ • Solution details: see whiteboard

My assumptions

• Exercise on your own: suppose that P(DDoS) = .0005. How expensive must an outage be in order to justify the \$100,000 investment?

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Reading Exercises Market failures Monopoly Public goods

#### First Fundamental Theorem of Welfare Economics

#### Definition

(First Fundamental Theorem of Welfare Economics) Any competitive equilibrium leads to a Pareto efficient allocation of resources.

- This definition begs the question: under what circumstances do we get competitive equilibrium?
  - Assume complete markets (perfect information, no transaction costs)
  - Assume price-taking behavior (infinite buyers and sellers, no barriers to entry)
- Now we will discuss market failures, and explain why information security suffers from many of them

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Exercise Market failure

Public goods Asymmetric Inform

#### How monopolists behave

- ullet In a market with a single supplier, the supplier isn't forced to sell at the point where S(p\*)=D(p\*)
- Monopolist can choose the price to sell at that maximizes expected revenue

$$\arg\max_{p^m} p^m \cdot D(p^m)$$

- Can also choose to restrict supply to maximize expected revenue
- Can you think of an example industry where there are few enough competitors to set the prices?

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Public goods Asymmetric Information

## Apple e-Book price fixing

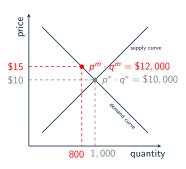


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Reading Exercises Market failures

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ercises Public goods

#### Monopolists can select prices to maximize revenue



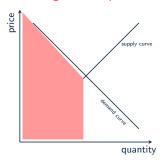
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Exercises
Market failures

Public goods

#### Monopolists can select prices to maximize revenue

#### Price discrimination charges different prices to maximize revenue



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Exercises Market failures Monopoly
Public goods
Asymmetric Information

- Most goods can be privately consumed (e.g., cars, food)
- But somethings can't be privately consumed (e.g., national defense, grazing commons)
- Public goods have two characteristics that make them hard to allocate efficiently
  - Non-rivalrous: individual consumption does not reduce what's available to others
  - Non-excludable: no practical way to exclude people from consuming
- Public goods tend to be delivered at less than what is socially optimal

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Reading Exercises Monopoly Public goods

#### The IT sector faces inherent impediments to competition

- Network effects tends toward dominant platforms
- Technology makes tracking (and price discrimination easier)
- Information goods have practically zero marginal cost
- Information goods are also non-rivalrous, firms use DRM to make them excludable

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#### Reading Exercises

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## Information Asymmetries

equilibrium market price p>0





 $E(s \mid p) \longrightarrow \overline{p}$   $\downarrow \qquad \qquad \downarrow$ security  $s \approx \text{cost}$ 



)

willingness to pay:  $p^* = \tfrac{3}{2}s$  unknown security:  $\overline{p} = \tfrac{3}{2}E\left(s\mid p\right)$ 

uniform distribution:  $\overline{p} = \frac{3}{2} \cdot \frac{p}{2} = \frac{3}{4}p < p$ !

ightarrow The market for secure products collapses Akerlof, 1970; Anderson, 2001

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