Risk Perception, Psychology and Economics of Information Security: A multi methodological exploration

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Agenda

• Case study outline
• Economics and information privacy
• Risk assessment exercise
• Perceptions of Risk
• Psychometric Paradigm
• Cultural Theory of Risk
• Risk assessment exercise revisited
• Multi-methodological research design
The setting

Greek Ministry of Finance introduces the “taxpayer card”

What is it? A smart card that we can use with every purchase we make to collect receipts

Use: People collect receipts and earn a tax deduction

Why? Shops often sell products without issuing a receipt, thus evading income tax and VAT!
Taxpayer card

Long-term objectives: A preamble to a system of fully electronic invoices and receipts. Taxpayer card to be substituted by a National ID smart card

Technical implementation: Bank-owned POS terminals and banks’ digital networks will be used. Only date and sum recorded

Privacy issue: Whoever has access to these data can build a purchase behaviour profile for each consumer. Retailers, banks, government could use these data
Issues

How big the tax benefit should be to convince people to get and use the card?

– More tax deduction => more use => less tax evasion
– Less tax deduction => less cost

What system architecture would provide the best privacy protection for consumers?

– Challenge: to provide the best protection you can provide without raising the cost of the system and without diminishing system usability

Which of the above is more important?
What do people say...?

An obvious solution: Ask...

- Surveys show that people are concerned about privacy and consider it to be an important factor in their online decision making
  - e.g. Jupiter Research 2002
  - “Almost 70% of consumers worry their privacy is at risk”
  - Conclusion: “Privacy/Security concerns will cost $25 billions in US online sales” by 2006.

It’s hard to make predictions, especially about the future!
Reality test

- People give away their personal info for as small an incentive as earning a few cents
  - Anecdotic evidence (reported by A. Acquisti)
    “Ask 100 people if they care about privacy and 85 will say yes. Ask those same 100 people if they'll give you a DNA sample just to get a free Big Mac, and 85 will say yes.” Austin Hill
  - Experiments have confirmed this claim
    - Berendt, Gunther and Spiekermann, “Privacy in e-commerce: stated preferences vs. actual behavior”, CACM 48(4), April 2005

Conclusion: Surveys are not reliable. A better research strategy is needed.
Research Intervention

• **Lack of theory**
  No “Digital Privacy Price Theory” can be found in the literature

• **Methodological challenges**
  A socio-technical system requires a multi-disciplinary socio-technical approach

  Different disciplines entail different epistemologies and, thus, different methodologies
Discipline A: Economics

• **Privacy is about trade-offs:**
  – Revealing personal information in exchange for some benefit
    • Financial benefit (e.g. price deduction)
    • Personalised services
    • ???

• ...and trade-offs is the realm of economics
Privacy Economics

• Since the early 1980s
  – Regulation vs. Deregulation debate

• In the 1990s
  – IT explosion

• After 2001
  – Internet economy
  – Social Networking Sites
  – Data mining / Recommendation systems
  – Advanced surveillance technology
Theoretical approach

A Theory of Transactions Privacy

The model

A transaction (e.g. online purchase) occurs iff

\[ v_A + v_B + w_A + w_B \geq 0 \]

- \( v_A \): Consumer’s transaction utility
- \( w_A \): Consumer’s utility (or loss) when personal info is revealed
- \( v_B \): Transaction utility for agent B (e.g. seller)
- \( w_B \): Agent’s B utility from using consumer’s personal information
Use and limitations

• These models allow the study of public policy and regulation
  – e.g., authors conclude that “bargaining flexibility” could enhance welfare by facilitating transactions that might not other-ways occur.

```
A transaction occurs iff
v_A + v_B + w_A + w_B ≥ 0
```

“In theory there is no difference between theory and practice, but in practice there is”
Empirical approach (1)

• **Calculate the cost of privacy breaches**
  – H1: A company suffers a loss in market value whenever a privacy breach is announced
  – Method: Regression analysis
  – Acquisti et al. showed that there is a correlation between privacy breaches and short-term market value

• **Problem solved?**
  – Too many undetermined factors
  – No justification (Why?). \( \text{Correlation} \neq \text{Causation} \)

“study indicates that chemicals used in non-stick frying pans could raise cholesterol levels in children”

- Blood samples taken from 12000 children
- They found a correlation between perfluoroalkyl acid and cholesterol in blood samples
- …they didn’t check if children were eating too many potato chips and other fried, cholesterol-rich, food!!
  - Source: http://www.bbc.co.uk/news/health-11201956
- Actually, researchers said: “…children's heart health was at greater risk from what goes into the frying pan … than from what the lining of the frying pan is made of.”, but that phrase was “neglected” in most news reports.
I used to think correlation implied causation.

Then I took a statistics class. Now I don't.

Sounds like the class helped.

Well, maybe.
Empirical approach (2)

Regression, Logit or similar approach (…post-mortem):

\[ Y = a_0 + a_1FB + a_2C + a_3R + u_i \]

- \( Y \): Use it or not (0,1)
- \( FB \): Financial Benefit
- \( C \): Cost of using it
- \( R \): privacy Risk
- \( u_i \): undetermined

- Revealed preferences
- Rational choice hypothesis
- It’s all about *perceptions*
Experimental

  - Measuring WTA (Willingness to Accept) and WTP (Willingness to Pay)
  - They offered real VISA gift cards that could be used to purchase goods.
    - $10 untractable
    - $12 tractable
- Condition 1: They were given a choice
- Condition 2: They were given random cards and, then, they were asked if they wanted to exchange them
  - Exchange the tractable with an untractable and vice versa.
Gift card experiment

- 66% of those who had a choice selected the tractable $12 card
  - ...but choices were affected by the order in which the two cards were presented!
  - When the $12 card was presented first, 73% chose it.
  - When presented second, 58% chose it.
  - Regression analysis validated the hypothesis that the order of presentation is important.
Gift card experiment

• 60% of those that were given the $10 card kept it when offered an exchange with a $12 card.
  – The percentage didn’t change when the offer was raised to $14

• Endowment effect is very strong. Price is almost irrelevant!

The authors conclude that “…the value of privacy … is highly malleable and sensitive to non-normative conditions.”
A little experiment of our own.
Actual data

• Cancer
  – 1/5667. 1487 fatalities

• Accidents and disasters of all kinds
  – 1/7070. 1192 fatalities

• Suicide
  – 1/16687. 505 fatalities (No 1 single cause)

• Deathly virus infection
  – 1/48433 (all viruses, including HIV). 174 fatalities

• Cardiac arrest
  – 1/601,948. 14 fatalities.

Source: European Mortality Database. UK residents, in year 2007, aged 35-44.
• **Living close to a nuclear plant**
  – 1952-2010: 63 people have died in only 4 fatal accidents.
  – Nearby residents were affected in only one case (Cernobyl)
  – No serious accidents in the UK
  – 442 power plants operating world-wide

• **Driving a car**
  – 1,612 people in cars lost their life in UK in one year (2006 data). 1/36,512 in a single year. 1/462 lifetime.
  – UK is considered very safe for driving. US 1/193.
Actual data

• **Using a ladder**
  – 3% of all fatal accidents
  – 1/8,689 (lifetime)

• **Smoking**
  – On average, smokers live 10 years less.
  – A 55 year-old non-smoker has 1/1000 chances to die from lung cancer in the next ten years
  – A 55 year-old smoker has 1/30 chances

• **Sailing**
  – Sailing is very safe. Safer than canoeing!
  – 1/440,000 chances in one year
  – US data, 2008. 11 million people are sailing in the US; 25 deaths on sailing boats (not all caused by sailing accidents)
...an old experiment

  – They asked educated people to rate 40 risks
  – Compared with the actual mortality data they found that certain risks were systematically overrated, whilst others were underrated

• The issue isn’t that perceptions don’t match “actual” risks; it’s that there is a systematic bias
Perceptions of risk

• Why are they important?
  – People’s behaviour is determined by their *perception of risk*, not by actual probabilities
    • Anyway, who believes in probabilities?!

Note: I don’t believe there is such thing as ‘actual risk’. Read “The Black Swan: The impact of highly improbable”, by Prof. Nassim Nicolas Taleb
How lethal is perception bias?

1,595

After 9/11 car traffic increased as people were afraid of planes. As a consequence car crashes increased. The number of Americans killed in car crashes as a direct result of the switch from planes to cars was 1,595.
Risk compensation

• Study on car safety measures
  – The number of automobile-related deaths in the UK went up after seatbelt legislation was introduced!
    • People feel “protected” and become careless.
  – In Oslo a study of the driving behaviour of taxi drivers found that drivers who drove taxis with ABS technology drove significantly closer to the car in front!
  – Over the three years of study 747 accidents were recorded, and there were more accidents involving cars with ABS than cars without
Factors affecting risk perception

- Psychometric paradigm
  - Psychological factors

- Cultural theory
  - Beliefs and attitudes
Heuristics and biases

• **Representativeness**
  – Insensibility to sample size, variance, etc.

• **Availability heuristic**
  – Most influenced by events that can be more easily brought to mind

• **Anchoring and adjustment heuristic**
  – Hold on to known information

• **Affect heuristic**
  – The affect heuristic is a heuristic in which current affect (feeling) influences decisions
Representativeness

• People judge the probability or frequency of a hypothesis by considering how much the hypothesis resembles available data
  – They look for data that confirm their hypothesis and ignore those that disconfirm their beliefs
  – People are “probability blind”. They don’t understand the significance of sample size, variance, and sample representativeness

The Rule of Typical Things

– First proposed by Nobel Laureates Amos Tversky and Daniel Kahneman
Linda

Linda is thirty-one years old, single, outspoken, and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in anti-nuclear demonstrations. How likely is that she:

1. is a teacher in elementary school?
2. works in a bookstore and takes yoga classes?
3. is active in the feminist movement?
4. is a psychiatric social worker?
5. is a bank teller?
6. is an insurance salesperson?
7. is a bank teller and active in the feminist movement?

Rank from most to least likely
Availability heuristic

- People predict the frequency of an event, or a proportion within a population, based on how easily an example can be brought to mind.

- Example:
  - A person argues that cigarette smoking is not unhealthy because her grandfather smoked three packs of cigarettes a day and lived to be 100.
  - The grandfather's health could simply be an unusual case that does not speak to the health of smokers in general.

- Experiment. In 60 sec…
  - Find words in the form _ _ _ _ _ n _
  - Find words in the form _ _ _ _ i n g
  - 2.9 vs. 6.4
Anchoring and adjustment

• If you’re given a number as a starting point, even an absurd one, your estimation will be based on this number.

• Example:
  – A group of people was asked if Gandhi was older or younger than 140 when he died. The answer is obvious. Then, they were asked how old was he when he died? The average guess was 67.
  – Another group was asked if Gandhi was older or younger than 9 when he died. The average guess was 55.

  Marketing people know this rule and use it quite effectively
Affect heuristic

• If an activity is associated with a pleasant image, or if it offers satisfaction, then risks are ignored and vice versa.

• Example:
  – Cancer vs. diabetes
  – Nuclear power vs. automobiles

• A risk analyst would calculate risk and benefit independently and compare them. If there is more benefit than risk, then we can live with it.

• But the perception of risk and the perception of benefit are not unrelated!
Affect heuristic

A
Nuclear Power
Positive Affect

Information says “Benefit is high”
Risk inferred to be low

B
Nuclear Power
Positive Affect

Information says “Risk is low”
Benefits inferred to be high

C
Nuclear Power
Negative Affect

Information says “Benefit is low”
Risk inferred to be high

D
Nuclear Power
Negative Affect

Information says “Risk is high”
Benefit inferred to be low
Other biases

• **Asymmetry between gains and loses**
  – People are risk averse with respect to gains
  – People will be risk-seeking about losses, preferring to hope for the chance of losing nothing rather than taking a sure, but smaller, loss
  – Remember the gift card experiment

• **Herding**
  – People follow what others are doing
Expert biases

- Experts are not necessarily any better at estimating probabilities than lay people
  - Experts were often overconfident in the exactness of their estimates.
  - They, just as lay people, are influenced by small samples. They often repeat an experiment until the results match their expectations.
Ranking risks

• **Dread vs. Not Dread**
  – Dreadful risks are overestimated

• **Known vs. Unknown**
  – New risks are overestimated
  – Common risks are often neglected
The Dread Factor

• Dread
  – Uncontrollable
  – Global catastrophic
  – Consequences fatal
  – Affecting future generations
  – Involuntary
  – Large number of casualties in one incident

• Not Dread
  – Controllable
  – Not global catastrophic
  – Not lethal
  – Short-term effects
  – Voluntary
The Unknown Factor

- **Unknown**
  - Not observable
  - Unknown to those exposed
  - Effect delayed
  - New risk
  - Unknown to science

- **Known**
  - Observable
  - Known to those exposed
  - Immediate effect
  - Old risk
  - Known to science
Examples

- **Unknown, Dread**
  - Living close to a nuclear plant
  - Earthquakes

- **Known, Not Dread**
  - Driving a car
  - Smoking
  - Sunbathing

- **Unknown, Not Dread**
  - Food preservatives

- **Known, Dread**
  - Crime
Categorization of 81 risks

Factor 2
Unknown risk

- Lastrile
- Microwave Ovens
- Water Fluoridation
- Saccharin
- Water Chlorination
- Coal Tar Hairdyes
- Oral Contraceptives
- VAium
- IUD
- Darvon
- Nitrates
- Polyvinyl chloride
- Chloride Diagnostic X-Rays
- Antibiotics
- Rubber Mfg.
- Dietrich
- Lead Paint
- Caffeine
- Aspirin
- Vaccines

Factor 1
Dread risk

- Skateboards
- Power Mowers
- Snowmobiles
- Trampolines
- Home Swimming Pools
- Downhill Skiing
- Recreational Boating
- Electric Wir & Appl (Shock)
- Elevators
- Electric Wir & Appl (Fires)
- Bicycles
- Bridges
- Fireworks
- Alcohol Accidents
- Auto Racing
- Auto Accidents
- Coal Mining Accidents
- Coal Mining (Disease)
- LNG Storage & Transport
- Large Dams
- SkyScaper Fires
- Construction
- Sport Parachutes
- General Aviation
- High Construction
- Railroad Collisions
- Commercial Aviation
- Nuclear Weapons (War)
- Nerve Gas Accidents

- Auto Exhaust (CO)
- D-CON
- Coal Mining (Disease)
- Uranium Mining
- Trichloroethylene
- Pesticides
- PCBs
- Satellite Crashes
- Mercury
- DDT
- Fossil Fuels
- Coal Burning (Pollution)
- DNA Technology
- SST
- Radioactive Waste
- Nuclear Reactor Accidents
- Nuclear Weapons Fallout
Cultural Theory

• **Two dimensions:**
  – Grid: Constrained by social role or not
  – Group: Bounded by feelings of solidarity or not

• **Four ways of life:**
  – Hierarchical
  – Individualist
  – Egalitarian
  – Fatalist

• **Each way of life corresponds to a specific social structure and a particular outlook on risk.**

First proposed by Mary Douglas and Aaron Wildasky
Grid / Group topology

- Grid
- Fatalism
- Individualism
- Egalitarianism
- Hierarchy
- Group
For example…

- Egalitarians have high interest and high identification regarding group relations, but they dislike social relations that are shaped by social differences or hierarchical structures.
- Individualists have both low sympathy for hierarchic structures and low sympathy for group attachment.
Cultural Theory

• Biases
  – Egalitarians are assumed to oppose risks that will affect many people or future generations
  – Hierarchists are assumed to accept risks as long as decisions about those risks are justified by authorities or experts
  – Fatalists try not know and not worry about things they believe they can do nothing about
  – Individualists perceive risk as opportunity. They fear risks that could limit their freedom
<table>
<thead>
<tr>
<th>Risk Issue</th>
<th>Individualism</th>
<th>Hierarchy</th>
<th>Egalitarianism</th>
<th>Fatalism</th>
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<td>Genetic engineering</td>
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<td>Nuclear power</td>
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<td>Mugging</td>
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<tr>
<td>Accidents at home</td>
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<td>Ozone depletion</td>
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<td>Car driving</td>
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<td>Alcoholic drinks</td>
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</table>
The white-male effect

• In all relevant studies, nonwhites rate risks higher than whites and women believe risks are more serious than men

• Initially attributed to race
  – Beware of the correlation vs. causation mix-up

• In a 2005 survey designed to study the white male effect it was found that only a subset of males had this attitude

• They were better-educated, wealthier and more politically conservative

• Also, they were disproportionally individualists or hierarchists
Risk rating exercise ...again

Let’s do the same experiment again.
Actual data

• **Riding a bicycle**
  – Very safe. Nevertheless, there were 9 fatal accidents in the UK (2007)

• **AIDS**
  – 1/122,130. 69 fatalities

• **Heart disease**
  – 1/8,142. 1035 fatalities

• **Earthquake**
  – Not in the UK!

• **Being shut by a criminal**
  – Only 8 deaths (other types of murder not included).

*Source: European Mortality Database. UK residents, in year 2007, aged 35-44.*
Actual data

• **Visiting Bagdad**
  – 3,000 civilian fatalities in all Iraq in 2009 out of a population of 31 million. Compare all traffic accidents in UK (2007, including pedestrians and 12 “animal riders”): 3,633
  – Safer than commuting in the UK

• **Swimming**
  – Only 130 fatalities in the UK. 746 in Greece (1/14,745)

• **Decorating a Christmas tree**
  – About 1,000 are injured in the UK every year. 350 of them by Christmas tree lights –related accidents
Actual data

• **Using the microwave oven**
  – Near zero. Some kids injured by eggs that exploded in the microwave oven. Several non-accidental incidents. (We don’t consider putting your cat in the microwave oven an “accident”, and, most certainly, we won’t blame the microwaves.)

• **Boarding an airplane**
  – 16 fatal accidents per million hours of general aviation. Odds of being killed:
    – In top 25 airlines, 1/9.2 million
    – In lower 25 airlines, 1/843,744

• Source: http://www.planecrashinfo.com/cause.htm
The Tax-payer Card

Back to research design
...with a little help from SSM

We can’t study a system we haven’t defined

- **Customers**: Tax-payers, Tax authorities
- **Actors**: Tax-payers, Retailers, Banks, Tax authorities
- **Transformation**: Receipts => Taxation data
- **Worldview**: eGov a panacea for the ineffectiveness of the Greek public administration
- **Owner**: Ministry of Finance
- **Environment**: ICT providers, Data protection authority, Political parties, Church (!)
Objective: Effectiveness

• Focus on the role of the tax-payer

• For the system to be effective:
  – Tax-payers should get the card and use it, i.e.
    • Trust it
    • Like it
    • Understand it
**Conceptual model**

- **Tax-payer**
- **Card**
- **Beliefs/Biases**
  - Influence decision
  - Unique
- **Cost/benefit**
  - Decides to use it
- **Risk perception**
  - Negative effect
- **Benefit / Alternative cost**
  - Positive effect
Methodological challenges

• Revealing preferences
  – Classical economics
  – Typical method: Regression analysis

• Identifying psychological biases
  – Psychology
  – Typical methods: Surveys, Experiments

• Identifying cultural biases
  – Sociology
  – Typical methods: Surveys, Interviews, Ethnographic methods

• Information technology
  – Information Systems
  – Typical methods: Abstraction/simulation/prototyping
Research design

• Phase A:
  – Survey A: Create a sample, using a questionnaire that measures cultural and psychological characteristics.
  – Survey B: See who uses it. Analyse their privacy risk perception
    • Threat perception, vulnerability perception, impact perception
    • Compare with experts view (interviews with experts)
    • Factor analysis
Research design

• **Phase B:**
  – Survey C: How much they have used it? What benefit did they gain? What the alternative cost would have been?
  – Control: compare sample data with those of the Ministry of Finance
Research design

- **Phase C:**
  - Regression analysis
    - \( U = f(TB, PR) \)
    - Control variables: CT, ...
  - Interviews
    - Why...
    - Statistics provide the data, but to give meaning to the data, you must employ qualitative methods.

- **Results:**
  - Expected....
Conclusions

• A case study was presented and different views were analysed
  – Economics
  – Psychology
  – Sociology

• We can’t limit ourselves by the epistemology and methodology of a single discipline

• After all, the problem defines the method and not vice versa
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Discussion...