Cyber-Insurance Revisited

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Rainer Böhme
rainer.boehme@inf.tu-dresden.de

Department of Computer Science
Institute for System Architecture
01062 Dresden, Germany

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Structure of the Talk

1. Literature review
   Why cyber-insurance is a good idea to tackle IT security risks
   Incentives · Market situation · Theories

2. Contribution of this paper
   Explaining immature supply of cyber-insurance with concentration in relevant equipment markets
   Model · Results · Interpretation
Welfare Effects of a Market for Cyber-Insurance

**Subjective rationality**

- **Transfer of risk**
  Exchange of uncertain future costs to fixed expenses at present

- **Manageability**
  Constant liquidity prevents undue shortages and crises

- **Quantification**
  Premiums form a metric for the value (≠cost) of security strength

**Substantial rationality**

- **Incentives to innovate**
  More secure technologies pay off in lower premiums
  Buzzword: Total cost of ownership

- **Incentives to implement**
  Effective security measures in reasonable scope

- **Infosec R&D**
  Evaluation and code reviews, information sharing

Immature Market for Cyber-Insurance

**Share**

- **AIG 70%**
  - about 2,500 contracts

- Others: Chubb, Lloyds, St. Paul, Zurich, Hartford, Ace u.a.

**Comparison**

- **billion USD premiums 2002**
  - general business liability
  - cyber-insurance

**Forecast**

- **billion USD**
  - optimistic forecast
  - prudent forecast

- **Worldwide losses 2003:**
  - about 13 billion USD (worms & viruses)
  - about 226 billion USD (all attacks)

- **Revenue 2002:**
  - 60–120 M USD

**Sources:**
Liability unsolved

Losses occur nevertheless: instead of the originator, the aggrieved party could demand coverage.

“New risks” lack actuarial data

Early satellite starts got coverage as well.

High probability of loss

You can even insure warships at wartime.

Difficulty to substantiate claims

Probably – can be interpreted as combination of residual juridical risk together with high transaction costs ...

Cyber-risks are accumulation risks

Market concentration causes correlation of claims.

Ref.: Schneier 2004, Borch 1995, Knowledge@Wharton 2001 (via news.com), CSO Magazine 2002
Recall: Economic Causes for Monoculture

Network externalities
Utility of a system increases with its market share, i.e., with the number of users of compatible devices (Metcalfe’s law)

Negligible marginal costs
Low costs for additional output (e.g., copy of a software CD) enables strategic pricing and fosters predatory competition

Dependencies in complementary markets
Third-party vendors of supplementary products first support the dominant platform and thus contribute to increase its attraction

**Links to relevant literature**

Varian 2000, Anderson 2001, and others

- product liability → insurance market → software quality
  - +

Kim, Chen & Mukhopadhyay, 2004 (WISE)

- product liability → software quality
  - ×
  - market structure

Our approach:

- market structure → insurance market → software quality
  - ×
Implications of Market Structure

Consequences for insurance companies?

- Concentrated market structure
- Little diversity of installed systems
- Identical vulnerabilities
- Networking
- Strategic adversaries
- Concurrent losses
Explaining immature supply of cyber-insurance with concentration in equipment markets

Model · Results · Interpretation
Economics of Insurance

- calculation of premiums
- adverse selection

- moral hazard
- life
- indemnity
- compound risk model
- individual risk model
Portfolio of $n$ independent Bernoulli-risks with probability of loss $p$. Expected total claim amount $E(L)$ follows a Binomial distribution $\mathcal{B}(n,p)$.

Premium must comprise additional safety loading to finance safety capital $c$, so that the probability of ruin of the insurance company keeps below a defined upper bound $\varepsilon$. 
Indemnity Insurance for Correlated Risks

**Single-Factor-Model**

Total probability of loss $p = const$

- Individual loss variables
- Systemic risk (e.g., virus attack)
- Correlation $\rho$

Formulation as composition of two Binomial distributions depending on $\rho$, $n$, and $\rho$. $\rho = .00$, $\rho = .15$, $\rho = .30$
Two-State Model of Income

Indifference curves according to CRRA utility function

- Individuals prefer
  - lower expected income
  - under certainty
  to
  - higher expected income
  - under uncertainty

\[ p = 0.05 \]

\[ \sigma = 2 \]
**Upper bounds for correlation of claims** $\rho$

<table>
<thead>
<tr>
<th>Risk $p$</th>
<th>$l_0 = {0.2, 1.0, 5.0}$</th>
<th>Moderate ($\sigma=1$)</th>
<th>Strong ($\sigma=3$)</th>
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<td>1.00, 0.73, 0.18</td>
<td>1.00, 1.00, 0.60</td>
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</tbody>
</table>

**No problem**
- Coverage for perils with high probability of loss
- High risk averse individuals

**Problem**
- “Small policies” against unlikely losses

These are the mass market products that could deliver liquidity and volume to form a mature market for cyber-insurance.
Results 2: Advantage of Diversification

Comparison of two example platforms ...

Dominant platform $D$
- Total probability of loss $p$
- Large portfolio size ($n \to \infty$)
- Correlation of losses $\rho > 0$

Alternative platform $A$
- Total probability of loss $p$
- Finite portfolio size $n$
- No correlation of losses (plausible for virus contagion)
Conditional Advantage of Diversification

Premium $\pi$

Portfolio size of alternative platform $n$

$\pi_{\rho=0}$

$\pi_{\rho=0.01}$

$\pi_{\rho=0.05}$

$\pi_{\rho=0.1}$

$\pi_{\rho=0.2}$

$n_{\min} = 22$

$n_{\min} = 80$

$n_{\min} = 200$

$n_{\min} = 5000$

$p = 0.1$

Dominant $D$

Alternative $A$
Comparison of two example platforms ...

Dominant platform $D$
- Total probability of loss $\rho$
- Large portfolio size ($n \to \infty$)
- Correlation of losses $\rho > 0$

Alternative platform $\mathcal{A}$
- Total probability of loss $\rho$
- Finite portfolio size $n$
- No correlation of losses (plausible for virus contagion)

Result: A minimum portfolio size of $\mathcal{A}$ is required before insurance premiums fall below the level of $D$.  

Market entry barrier
Frame: Favorable economic effects
Cyber-insurance moderates IT security investment, reduces residual risk, and creates incentives for R&D.

Thesis 1: Shortage of supply due to market structure
Though demand for cyber-insurance exists, a monoculture of installed systems may thwart a market equilibrium.

Thesis 2: Reciprocity of interventions
Since market structure in the equipment market and conditions for cyber-insurance are linked, regulatory policies supporting cyber-insurance might cause a shift in market shares.
Does cyber-insurance, as pricing mechanism for security properties, outweigh the strong drivers to market concentration?
Limitations
CYBER-INSURANCE REVISITED

Supply-side model
- Naive selection of Bernoulli risks
- Measure of dependence (correlation) unrealistic
- Individual risk approach hinders empirical substantiation

Demand-side model
- Partial coverage not regarded
- Restricted to one class of utility functions (CRRA)
- Difficulty to quantify losses left out

Comparison of platforms
- Market position is likely to influence total probability of loss
- Inclusion of transaction and monitoring costs might reveal advantages for the market leader (Metcalf ... again!)

Further interdisciplinary research needed
"A trusted component or system is one which you can insure."

Ross Anderson, ESORICS 1994

Shown here:
Rainer Böhme
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Thanks for your attention.