Timing Is Everything: How a U.S. Payment Regulation Helped Overcome a Network Barrier without a Mandate

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Overview

1. What are network economies?
2. Background on check processing
3. What was the Check 21 innovation?
4. Model Check 21 technology adoption
5. Estimate the size of the network economies
6. What general lessons can we learn?

Results Preview

The network economies are large and statistically significant:

A 1% increase in the regional adoption rate increases the probability of adoption by 2.91% each month

The estimated magnitude is large as

- Regional differences are measured in tens of percent and
- These are monthly rates, so the cumulative effect would be roughly 40% over a year

Various industry forecasters had predicted the transformation would take more than a decade, but most checks were cleared electronically within 5 years

- Murphy (2004)
- Capichin (2004)
- Eubanks (2004)

General Lessons Preview

How should network goods' regulators promote innovation?

- Without a nudge, the benefits of the innovation may be delayed
- Imposing a mandate is straightforward but can impose high costs to some parties
  - Expected winners will favor but
  - Expected losers will use their influence to fight it
  - *ex ante*, benefits and costs are uncertain so innovation may be delayed, particularly as there is always the option value of waiting for the next innovation
- Providing a "bridge" that facilitates voluntary adoption may speed the introduction of the new technology by jump-starting the network economies
  - The biggest winners can push on, accruing the benefits while incurring more of the startup costs
  - As costs fall and network economies rise, laggards willingly adopt

1. What Are Network Economies?

- Network externalities occur when the value of joining a network increases with network size
  - Large benefits possible (examples: telephones, operating systems, payment instruments)
  - Language is the oldest good with network economies
- But replacement of old technology (switching to a new network) can be difficult
  - Hold up problem: Lock-in of old technology becomes a barrier to new technology
- Consequently, there may be a role for market intervention

Key to Identification

- Goods and services with network economies frequently also have
  1. scale economies
  2. learning-by-doing, and
  3. rapid technological progress
- #1-3 could lead firms to adopt a new technology, but none of them would lead to large regional differences as would regional network economies

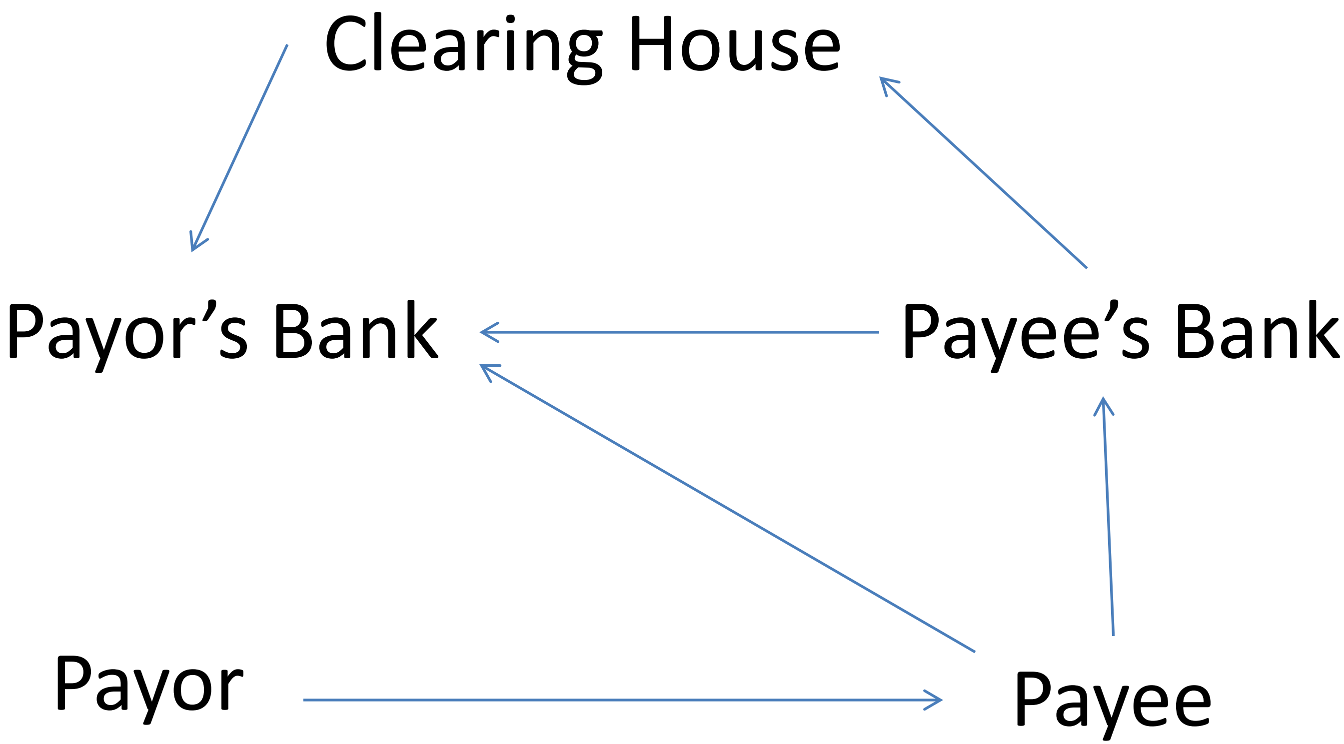
Related empirical work

- Previous banking and payments studies look at the network externality benefits to end-users
  - Saloner and Shepard (1995) ATMs
    - Network benefits are internalized by firms
  - Gowrisankaran and Stavins (2004)
    - Would/could the ACH network replace the check network?
- Irwin and Klenow (1994) - semiconductors
  - Can be strong learning-by-doing spillovers
- Goolsbee and Klenow (2002) - home computer adoption
  - look at learning by doing and network spillovers

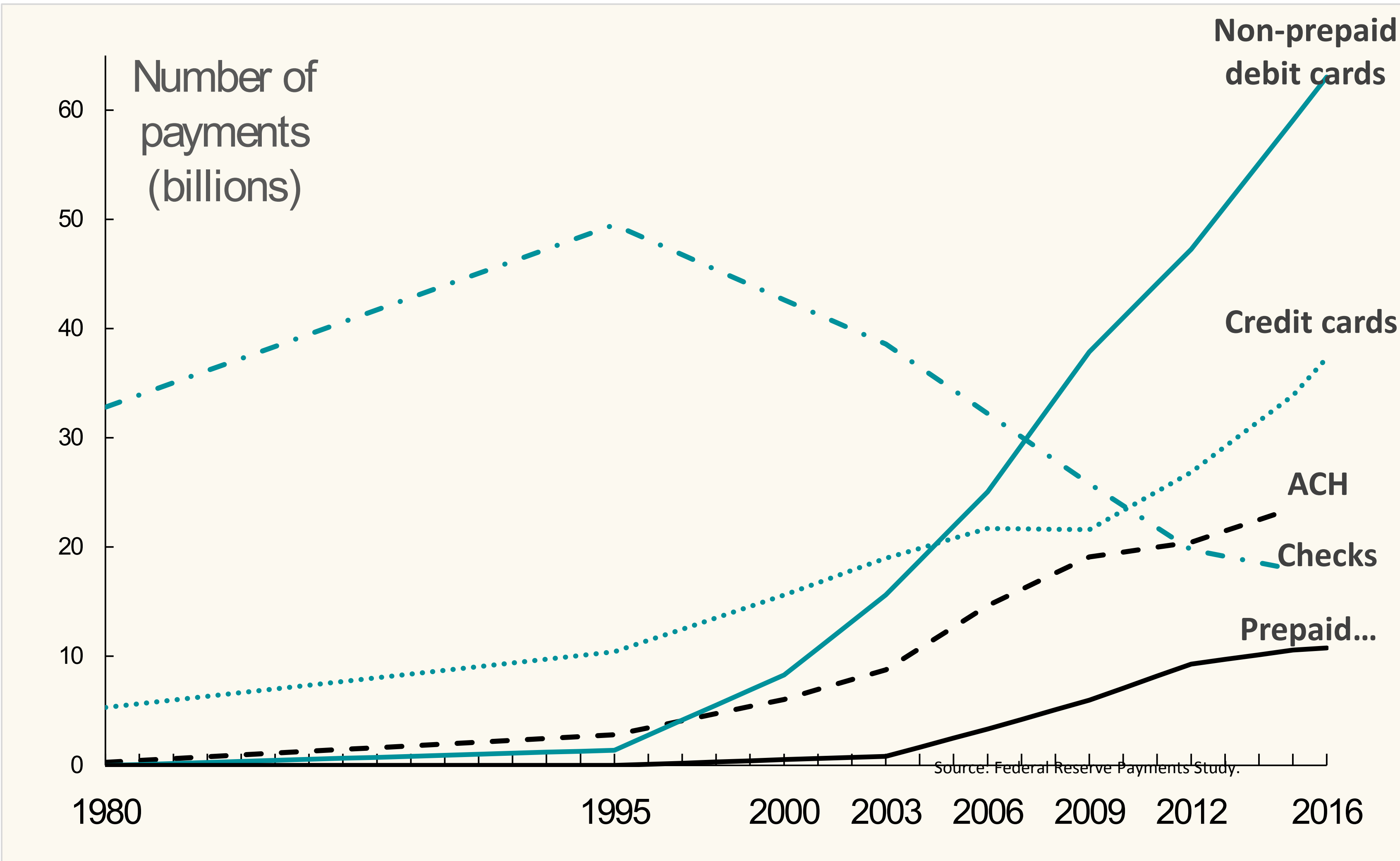
2. Background on check processing

- Only 4 key types of information on a check
  - Payor account number
  - Payee account number
  - Dollar amount
  - Date
- Since the early 1960s, most checks had MICR ("magnetic ink character recognition") so could easily have been converted to electronic processing from a technical standpoint ***except***…
- The Uniform Commercial Code (UCC) only required the payee bank to release the funds when it received the original paper check item

Clearing Paths



Checks market share has declined, but still a major payment instrument



3. What was the Check 21 "innovation"?

Congress could have forced banks to accept "electronic presentment" as of a given date

- Large banks tended to favor (also banks receiving lots of deposits)
- Small banks didn't expect much benefit and feared higher costs (also banks paying lots of checks)

Instead Congress created a "substitute check," a paper copy of the original check

- Payor banks could still insist on receiving a paper check, but they could no longer insist on getting the original paper instrument
- This allowed banks to choose whether to switch or not

4. Model of Check 21 Technology Adoption

$$a_{it} = \begin{cases} 1 & \text{if bank } i \text{ adopts at } t, \\ 0 & \text{otherwise.} \end{cases}$$

Net present value of adoption at t is the discounted sum of future benefits minus a one-time adoption cost.

$$\text{NPV}(t) = \sum_{s=0}^{\infty} \delta^s f_{it+s} - q_{it}$$

At each period t, the rule is adopt if $\text{NPV}(t) > \delta \text{NPV}(t+1)$

i.e.

$$\sum_{s=0}^{\infty} \delta^s f_{it+s} - q_{it} > \delta\left(\sum_{s=0}^{\infty} \delta^s f_{it+1+s} - q_{it+1}\right)$$

Model (cont'd)

The maximization reduces to finding the earliest t such that

$$f_{it} > q_{it} - \delta q_{it+1}$$

Definitions:

Let the number of counterparties in a bank's network be N_i

Let $A_{it-1} = \sum_{j \in N_i} a_{jt-1}$ be the number of adoptees,

v_{it} be total checks, and

p_t, s_t, and e_t are the prices for paper, substitute, and electronic deposit, respectively

The Model (cont'd)

For simplicity assume an equal number of checks are collected from each counterparty. Then, expenditure is

$$c_{it}(a_{it}) = \left(\frac{v_{it}}{N_i}\right)\left(e_t a_{it} A_{it-1} + s_t a_{it}(N_i - A_{it-1}) + p_t(1-a_{it})N_i\right)$$

and the net benefit of adopting is

$$f_{it} \equiv c_{it}(0) - c_{it}(1) = \left(\frac{v_{it}}{N_i}\right)\left(p_t N_i - e_t A_{it-1} - s_t(N_i - A_{it-1})\right)$$

$$= v_{it}\left(p_t - e_t\left(\frac{A_{it-1}}{N_i}\right) - s_t\left(\frac{N_i - A_{it-1}}{N_i}\right)\right)$$

Switch if depositing paper costs more than a weighted average of electronic and substitute check receivers

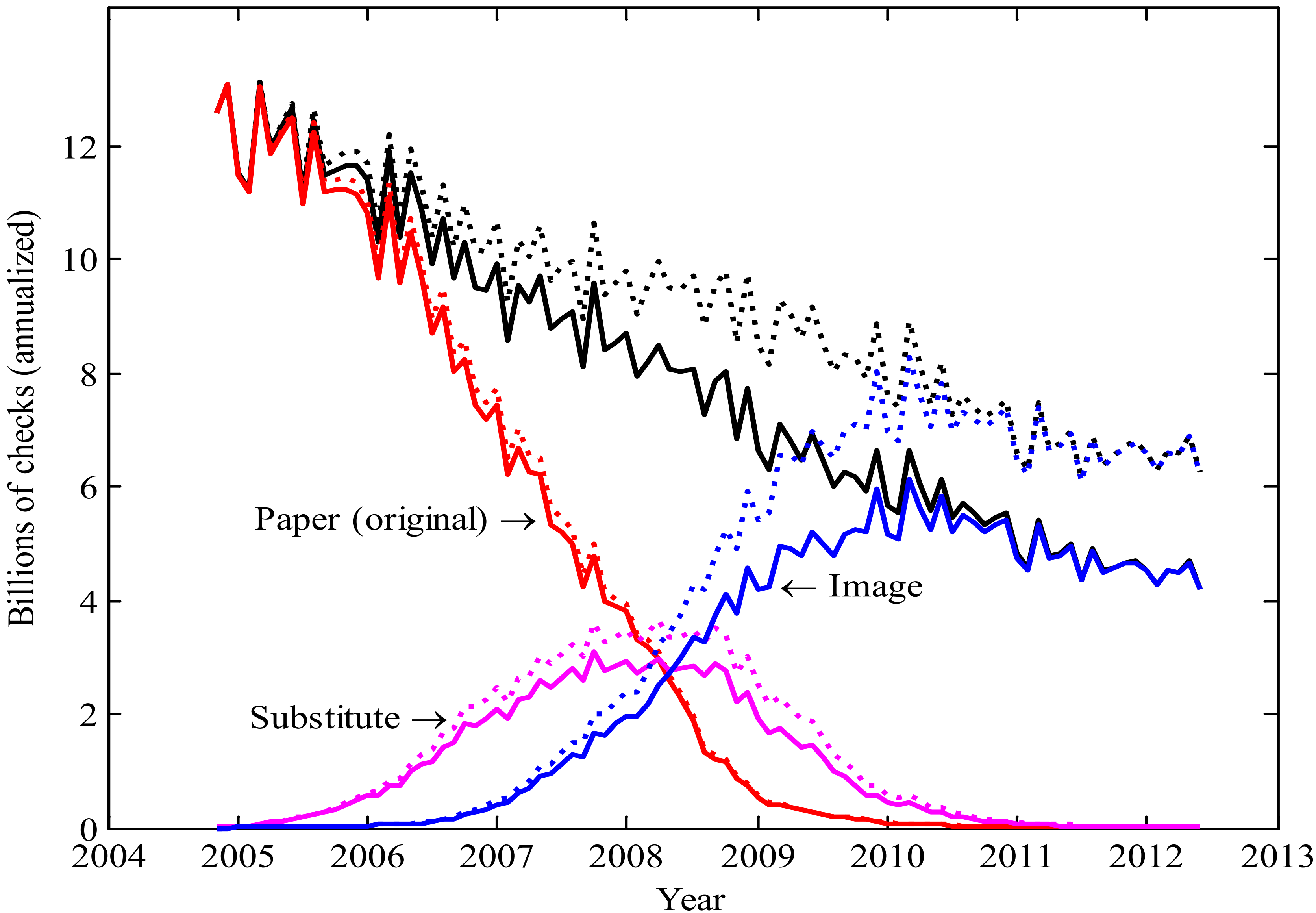
The Model (cont'd)

- If we define the adoption rate as $r = A/N$ then the network externality is $\frac{\mathrm{d}f(r)}{\mathrm{d}r} = v(s-e)$
  - The externality is positive so long as substitute checks cost more than electronic checks
  - Note that intermediaries (e.g. Reserve Banks) can set incentive-based prices to encourage adoption
  - Also, any knowledge spillover externality would also increase with r

5. Estimate the size of the network economies

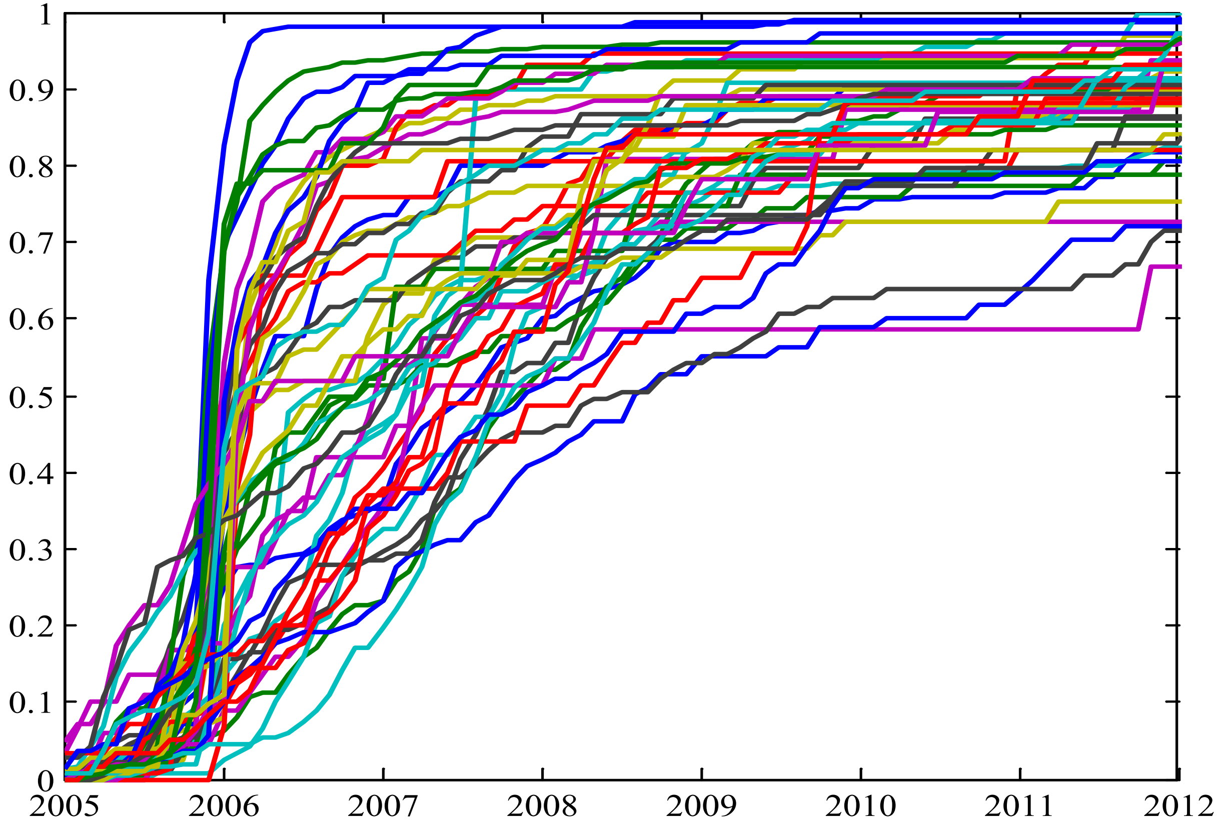
- Use Federal Reserve Billing Data
  - 7,500+ depository institutions
- 47 Fed regions (about 85% of checks drawn and paid with the same region)
- 92 monthly observations from Nov 2004 to June 2012
- Volumes and prices for
  - Paper deposit (p)
  - Electronic deposits presented as substitutes (s)
  - Electronic deposits presented as images (e)

Fed check clearing volumes



Adoption by Fed Region

Widely different adoption rates



Why Survival Analysis and not just OLS?

- The disturbance is not likely to be normally distributed
- If the disturbance is otherwise well behaved and the sample size is large, we can invoke the Central Limit Theorem
- However with survival time data, the disturbance is likely to be nonsymmetrical or bimodal and OLS is not robust to these violations

Survival Analysis: Basics of Cox Model

- Strips out baseline hazard
- extremely flexible—potentially each month has a separate risk of adoption

Empirical estimation

- Systematic factors X and idiosyncratic factors
- Assume corresponding proportional adoption risk

$$a(t) = a_0(t)\exp(\beta X)$$

- The partial likelihood function takes the form

$$PL = \prod_{k=1}^{K} L_k = \prod_{k=1}^{K} \frac{a_k(t_k)}{\sum_{j \in R(t_k)} a_j(t_k)} = \prod_{K=1}^{K} \frac{a_0(t_k)\exp(\beta X_{(k)})}{\sum_{j \in R(t_k)} a_0(t_k)\exp(\beta X_{(j)})},$$

Where $R(t_k)$ is the risk set. It's the product of K events

Estimating the externality

- First define the regional adoption rate as

$$\mathrm{RAR}_{kt-1} = \frac{\sum_{j \in k} a_{jt}}{N_k}.$$

- But inclusion of this variable would confound the network effect with time, technological change, prices, and any other effects correlated with time

Estimating the externality (cont.)

- The “relative regional adoption rate” separates the regional network effect from changes over time

$$\mathrm{RRAR}_{kt-1} = \mathrm{RAR}_{kt-1} - \frac{\sum_{j=1,\ldots,M} \mathrm{RAR}_{jt-1}}{M},$$

Estimated Model 1

- Proportional shift in risk

$$a_i^{\,1}(t) = a_0^{\,1}(t)\exp(\beta \mathrm{RRAR}_{it}).$$

- The relative size of the regional network is the spillover

Empirical estimation (cont'd)

MODEL 1

Number of subjects	7,670	Number of observations	7,670
Number of adoptions	5,902	LR chi2 (1)	287.02
Log likelihood	-48,106		

Coeff.	Hazard Ratio	Standard Error	P > |z|
β	3.91	(0.309)	0.000

Hazard ratio interpretation

- A one unit increase in RRAR raises the hazard by $100(\beta_{RRAR}-1)$ percent
- Consequently, here a 1% increase in the relative regional adoption rate is expected to increase the risk of adoption by 2.91%

6. General Lessons

- Check 21 is certainly not the most straightforward approach to get banks to switch technologies, but we argue that it is the one a social planner with incomplete information would choose
  - Transition was voluntary, banks with the largest benefits adopted early incurring more of the start up costs than they otherwise would have
  - Late adopters come along as network economies and any scale economies and learning-by-doing begin to build

6. General Lessons (cont.)

- Note voluntary adoption distributes transition costs differently than a mandate would
  - Arguably more efficient (more costs born by those garnering more of the benefits)
  - Transition might even work out to be faster than a political compromise would have allowed
- Benefits and costs *ex ante* are not always clear
  - This approach leaves a safety value that a mandate would not
  - If new technology delivers small benefits, few adopt

Future Work

- Impose parametric functional form for baseline risk
- This would allow us to explicitly include the price of substitute checks