Technology Innovation and Market Turbulence: A Dotcom Example

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Abstract

This paper explains market turbulence, such as the recent dotcom boom/bust cycle, as equilibrium industry dynamics triggered by technology innovation. When a major technology innovation arrives, a wave of new firms implement the innovation and enter the market. However, if the innovation complements existing technology, some new entrants will later be forced out as more and more incumbent firms succeed in adopting the innovation. It is shown that the diffusion of Internet technology among traditional brick-and-mortar firms is indeed the driving force behind the rise and fall of dotcoms as well as the sustained growth of e-commerce. Systematic empirical evidence from retail and banking industries supports the theoretical findings.

Keywords: Technology Diffusion, Industry Dynamics, Shakeout

JEL Classification: E30, L10, O30

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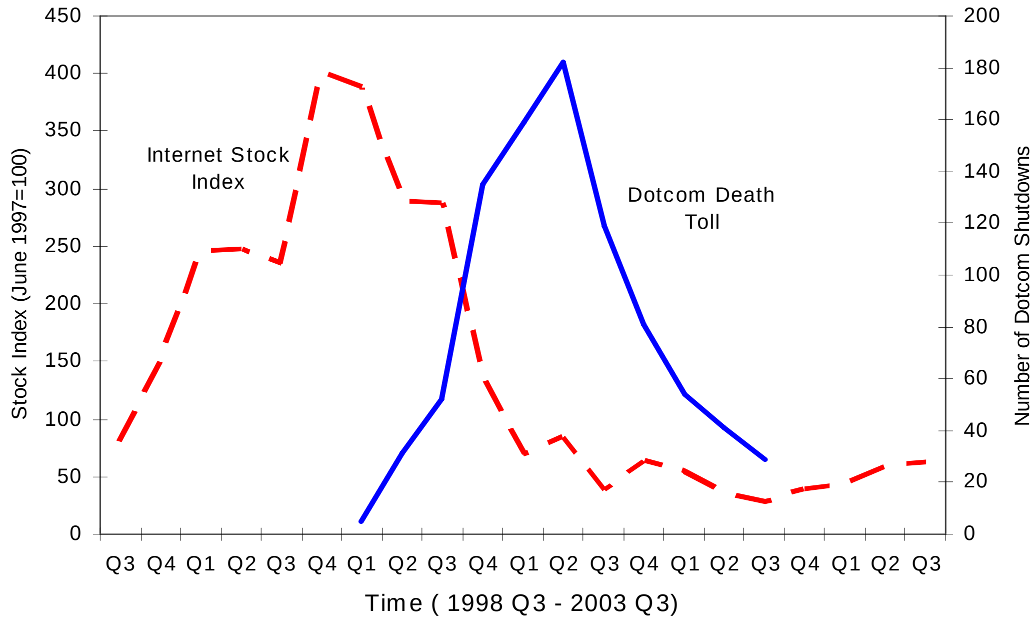

Figure 1: Internet Stock Index and Dotcom Death Toll

1 Motivation

Technology innovation is one of the most fundamental impulses that set and keep the market economy in motion. It incessantly transforms production and consumption as well as organization of firms and industries, destroying old ones and creating new ones – a process that Schumpeter named Creative Destruction. The recent Internet innovation and following dotcom boom/bust cycle has presented itself, although in an unconventional sense, as a dramatic example of this process.

Internet technology became commercially available in the middle of the 1990s. Soon after, the potential of electronic commerce was discovered. A huge wave of companies, so-called "dotcoms", were then formed to conduct business over the Internet. A typical dotcom firm is an Internet pure play that operates only from its online Web site. Its ability to reach customers in vast geographic regions via the Internet, while not having to invest in building physical facilities, has been among its most attractive features for investors and entrepreneurs. During a short period, especially 1998 and 1999, about 7,000-10,000 new substantial dotcom companies were established,[1] most with a vision of generating huge market values after taking the firm public. The boom fueled tremendous excitement throughout the business world.

However, the spring of 2000 was a turning point. The dotcom stock index began to fall and it bottomed out in the middle of 2001, when the dotcom exit rate hit its peak. The stock index stabilized afterwards, while dotcom exits continued, though at a decreasing rate. Up to the first quarter of 2003, nearly 5,000 dotcom companies exited the market, of which at least 3,892 were sold and 962 closed or declared bankruptcy.[2] From peak to bottom, the Dow Jones Internet stock index[3] plummeted by 93%, and the Nasdaq composite lost 78% of its value. The Dow Jones Internet stock index and number of dotcom shutdowns are plotted in Figure 1.

What can explain this striking boom/bust cycle of dotcoms? To answer this question, there are several theories. Most of them appeal to financial bubbles, rational or irrational (Shiller 2000, Abreu and Brunnermeier 2003, Ofek & Richardson 2003, LeRoy 2004). However, as Garber (2000) has persuasively argued, "[bubble] is a

[1] Data Source: Webmergers.com, a San Francisco-based company that monitors the internet mergers and acquisitions. Webmergers.com counts as "substantial" all internet companies that have received some formal outside funding from venture capitalists or other investors.

[2] Data Source: Webmergers.com, which issues monthly reports on dotcom shutdowns and M&As.

[3] Dow Jones defines an Internet stock as the stock of a company that generates more than 50% of its annual revenues directly from the Internet. With 40 components, the Dow Jones Internet stock index represents roughly 80% of the total market cap of the Internet sector.

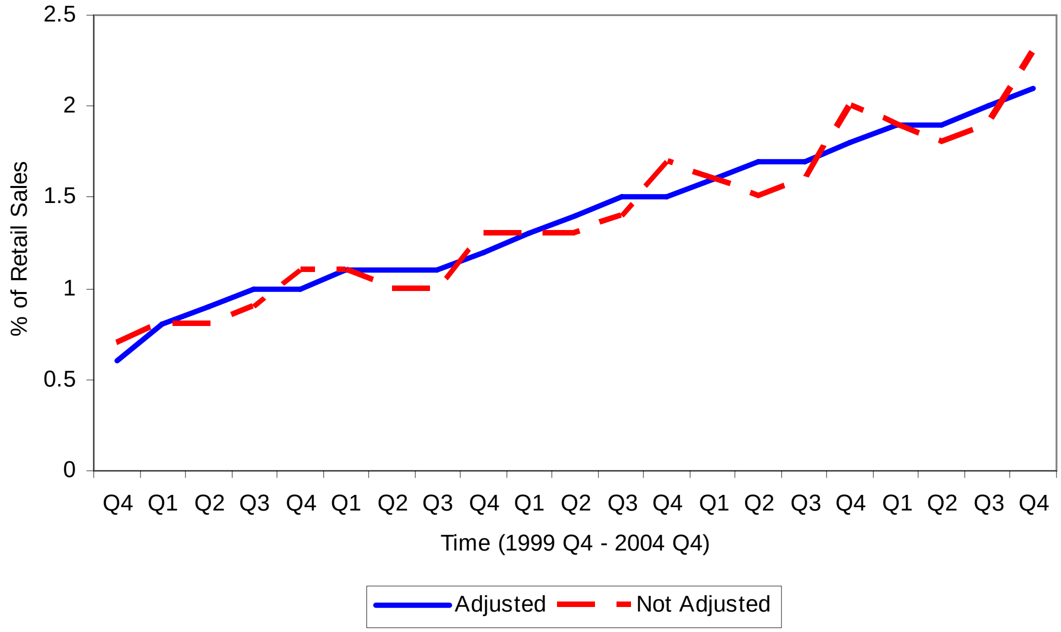

Figure 2: US Retail E-Commerce Sales as a Percent of Total Retail Sales

fuzzy word filled with import but lacking a solid operational definition. Thus, one can make whatever one wants of it." More important, even if a bubble did exist, it still remains a puzzle what changes of real fundamentals, if any, could have induced the bubble to form and burst in the first place. Some other theories try to build more upon economic foundations, especially uncertainties in new markets. For example, uncertainties about profitability (Pastor and Veronesi 2004, Horvath, Schivardi and Woywode 2001), pre-production (Jovanovic 2004) or potential market size (Rob 1996, Zeira 1999). Those factors certainly play important roles in the new economy, but some key issues are still overlooked. In particular, the nature of competition in the Internet-related market has not been fully understood and analyzed.

To illustrate this point, Figure 2 presents the time trend of the US retail e-

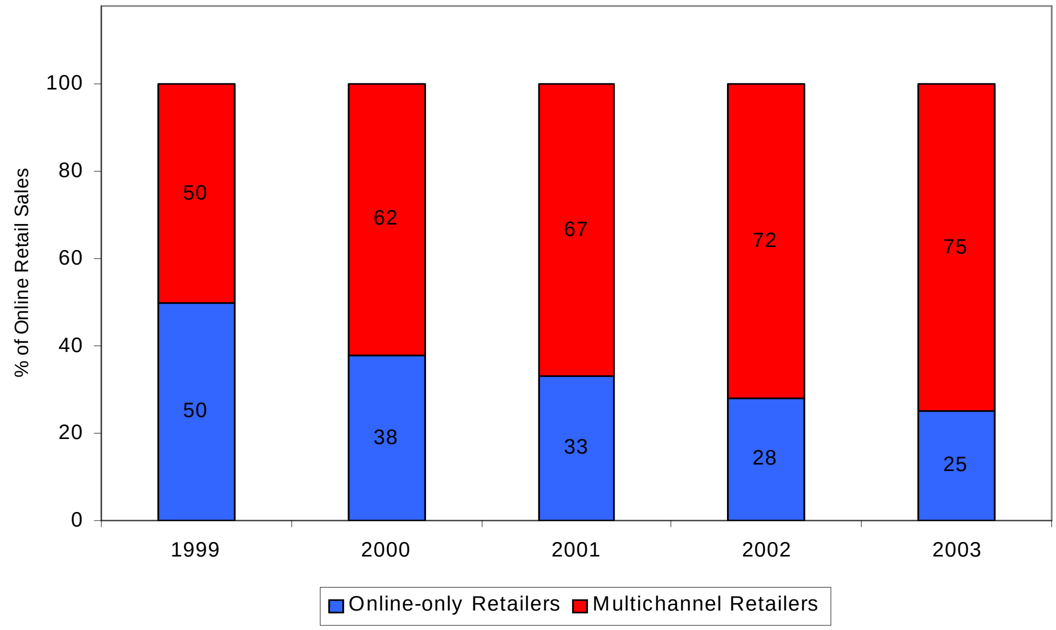

Figure 3: Percentage of Online Retail Sales: Dotcoms vs. Multichannel Retailers

commerce sales as a percent of total retail sales.[4] It shows clearly that e-commerce has kept a strong and stable growth in spite of the dramatic shakeout of dotcom companies. What could have been driving this sustained growth? The evidence in Figure 3, showing the composition of retail e-commerce over time,[5] suggests that a major driving force is the increasing online presence of traditional brick-and-mortar firms.[6] Therefore, in order to better understand the rise and fall of dotcoms, we have to look into the dynamic competition among firms of different types in the market,

[4]Data Source: The Census Bureau of the Department of Commerce (Estimates are adjusted for seasonal variation and holiday and trading-day differences, but not for price changes).

[5]Data Source: *The State of Online Retailing (2001, 2002, 2003)*, an annual survey conducted by Shop.org, Boston Consulting Group and Forrester Research.

[6]Improvement of Internet technology and changes of consumer preference for e-commerce probably also played a role in the process.

in particular, online pure plays vs. traditional brick-and-mortar firms.

Here is the explanation of this paper. When a major technology innovation (e.g. Internet) arrives, a wave of new firms (e.g. dotcoms) enter the market to compete with the incumbents (e.g. brick-and-mortar firms). This entry is especially facilitated by the lower entry cost associated with the new technology (e.g. lower physical investment required for dotcoms). However, if the new technology (e.g. Internet) is complementary to existing technology (e.g. brick-and-mortar), some new entrants (e.g. dotcoms) will later be forced out as more and more incumbent firms succeed in adopting the innovation (e.g. becoming so-called "click-and-mortar" firms). During this process, the contribution of new technology to the total industry output (e.g. share of e-commerce in total commerce) keeps rising, while the share of new-technology-only firms (e.g. dotcoms) keeps falling.

To formalize this idea, this paper develops a dynamic equilibrium model based on the original work of Jovanovic & MacDonald (1994).[7] In a competitive market, forward-looking firms make optimal decisions on entry, exit and technology adoption based on sunk cost and learning opportunity. Without assuming aggregate uncertainty, the model generates mass entry and exit of dotcoms as the result of a complementary technology innovation – the Internet. Adding aggregate uncertainty to the model does not change the main analysis, but helps explain the timing and financial loss of the shakeout. Moreover, this paper considers explicitly each individual firm's uncertainty in adopting new technology, which explains the delayed adoption

[7] This paper, taking a step further from Jovanovic & MacDonald (1994), allows new entrants to bypass old technology and emphasizes the roles that sunk cost and technological complementarity play in the industry evolution.

of Internet among incumbent firms as well as the high market-to-book value for those successful adopters (e.g. dotcoms and click-and-mortar firms).

Our theoretical findings are supported by systematic empirical evidence. Exploring an original dataset of top 400 E-retailers across 14 major retail categories, we find that incumbent multichannel retailers enjoy a substantial advantage over the dotcoms in both online sales and total sales. That advantage stems from the great synergy between the online and offline channels as well as many forms of complementary assets that incumbent firms possess. A similar pattern is also found in the banking industry in which incumbent multichannel banks dominate the dotcoms.

The paper is organized as follows. Section 2 presents the model, in which we study competitive industry dynamics reacting to an exogenous technology innovation. Depending on characteristics of the innovation, such as entry cost and complementarity with existing technology, the industry evolution paths are very different. Section 3 applies the model to Internet innovation in commerce, which features low entry cost and strong complementarity with traditional brick-and-mortar technology, to explain the mass entry and exit of dotcom firms. Empirical studies on retail and banking industries confirm our theoretical findings. Section 4 offers final remarks.

2 Model

2.1 Background

The model is cast in discrete time and infinite horizon. The environment is a competitive market for a homogenous good. On the demand side, the behavior of consumers is summarized by a time-invariant market demand curve $D(P)$, which is continuous and strictly declining. On the supply side, there is a continuum of firms with total mass fixed at unity. Each firm maximizes the present discounted value of its profits.

At each time t, a firm decides whether to stay in the industry. If he does, the firm receives a profit flow that depends on the market price and his technology state. Otherwise, he exits and gets an alternative return of π^{θ}. A firm's technology can be in one of four states. The first is a primitive one θ in which the firm cannot produce in the industry and thus earns zero net revenue to participate. All firms are endowed with this technology. The second one b is the traditional technology of production (In the context of Internet economy, it refers to the *brick* – traditional brick-and-mortar firms). The third one c is a technology innovation (In the context of Internet economy, it refers to the *click* – the online pure plays, dotcoms). The last one h is a combination of the traditional technology and the innovation (In the context of Internet economy, it refers to the *hybrid* – the click-and-mortar firms).

Before the innovation c arrives, only technology states θ and b are available. A firm can either choose to stay out and earn π^{θ}, or pay a fixed cost S_b to obtain the technology b to produce in the industry. After the innovation c arrives, firms then have more options. In particular, if a firm pays a fixed cost S_c, he may learn how to implement the new technology c though the success is random with the probability σ. As a result, two new types of firms, in addition to the traditional *brick* one, may appear in the industry. For example, if a new entrant succeeds entering with technology c, he then becomes a *click* firm; if an incumbent *brick* firm succeeds adopting the new technology, he then becomes a *hybrid* firm.[8] Therefore, driven by

[8] It is possible that *brick* firms may have a different success rate σ from pure play entrants, but

the technology innovation and its diffusion, the market equilibrium generates time paths of product price P_t, industry output Q_t and entry and exit of each type of firms. These time paths are thus the foci of our study.

2.2 Pre-Innovation Equilibrium

The market for the homogenous good starts at time 0 when technology states θ and b become available. At time 0, though all firms have the opportunity to earn a profit π^θ from working somewhere else, some of them may choose to enter this market. For those entrants, they pay an once-and-for-all fixed cost S_b to implement the technology b. The corresponding return is a profit flow of π_t^b, which is a standard profit function that depends on price P_t and technology b, i.e.

$$\pi_t^b = \max_{q_t^b}\{P_t q_t^b - C_b(q_t^b)\},$$

where C_b refers to the cost function for technology b, and q_t^b is a *brick* firm's optimal output (notice $q_t^b = \partial\pi_t^b/\partial P_t$ and $\partial q_t^b/\partial P_t > 0$).

For simplicity, we have assumed that the technology b is a standard practice that involves no uncertainty to implement, and any future innovation like technology c may arrive at a probability too small to affect a firm's decision. Therefore, at each time $t \geq 0$, optimal firm behavior implies

$$U_t^\theta = \pi^\theta + \max\{\beta U_{t+1}^\theta, \beta U_{t+1}^b - S_b\}, \tag{1}$$

$$U_t^b = \max\{\pi^\theta, \pi_t^b\} + \beta U_{t+1}^b, \tag{2}$$

where U_t^θ (U_t^b) is the maximum value of a firm with technology θ (b) at time t, and β is the discount factor.

assuming that does not affect our analysis except allowing our model to be more flexible.

The corresponding equilibrium is straightforward. Since the entry is free, there exists a certain price level P^* that firms are indifferent about entry or not. Hence,

$$\beta U_{t+1}^{\theta} = \beta U_{t+1}^{b} - S_b,$$

which implies that

$$\frac{\beta \pi^{\theta}}{1-\beta} = \frac{\beta \pi^{b}(P^*)}{1-\beta} - S_b,$$

so that

$$\pi^{b}(P^*) = \pi^{\theta} + \frac{1-\beta}{\beta} S_b. \tag{3}$$

In addition, the demand equals supply at the equilibrium, hence we have

$$Q = D(P^*) = N^b q^b(P^*), \tag{4}$$

where N^b is the number of *brick* firms in this market.

Using Equations 3 and 4, we can then solve for the equilibrium price P^*, number of firms N^b, an individual firm's output q^b as well as the market total output Q. It implies a simple industry dynamic path – at time 0, firms decide whether to enter the new market. N^b of them then pay a cost S_b to enter and stay there afterwards. Since it takes one period to transform the technology from state θ to b, no firm is able to produce in the new market at time 0. From time 1 on, the industry has a fixed price P^* and output $Q = D(P^*) = N^b q^b(P^*)$, and there will be no further entry and exit.

2.3 Post-Innovation Equilibrium

At time T, the innovation c arrives as an unexpected shock and triggers a market turbulence. Now that firms have more options because of the technology progress, they have to reconsider entry and exit. The optimal decision problems for each type of firms at each time $t \geq T$ are listed as follows:

$$
\begin{aligned}
V_t^\theta \;&=\; \pi^\theta + \max\{\beta V_{t+1}^\theta, \beta V_{t+1}^b - S_b, \beta[\sigma V_{t+1}^c + (1-\sigma)V_{t+1}^\theta] - S_c, \\
&\qquad \beta[\sigma V_{t+1}^h + (1-\sigma)V_{t+1}^b] - S_b - S_c\},
\end{aligned} \tag{5}
$$

$$V_t^b = \max\{\pi^\theta, \pi_t^b\} + \max\{\beta V_{t+1}^b, \beta[\sigma V_{t+1}^h + (1-\sigma)V_{t+1}^b] - S_c\}, \tag{6}$$

$$V_t^c = \max\{\pi^\theta, \pi_t^c\} + \max\{\beta V_{t+1}^c, \beta V_{t+1}^h - S_b\}, \tag{7}$$

$$V_t^h = \max\{\pi^\theta, \pi_t^b, \pi_t^c, \pi_t^h\} + \beta V_{t+1}^h. \tag{8}$$

Equations 5 to 8 say the following.

- A firm with primitive technology θ may choose to keep staying out of this market, or pay a fixed cost S_b to enter with technology b, or pay a fixed cost S_c to hopefully enter with technology c (the probability of success is σ). In addition, it is even possible for him to pay both cost S_b and S_c to implement technology b and c at the same time. By doing that, he may enter as a *hybrid* firm if he succeed in learning about the innovation c (the probability is σ), or he may become a traditional *brick* firm if he fails (the probability is $1-\sigma$).

- A traditional *brick* firm has option to work somewhere else, or stay in the market with technology b, or pay a fixed cost S_c to hopefully implement the technology c. If he succeeds in implementing c (the probability is σ), he then transforms himself into a *hybrid* firm; if he fails, he stays as a *brick* firm (the probability is $1-\sigma$).

- A *click* firm has option to work somewhere else, or stay in the market with technology c, or pay a fixed cost S_b to implement the technology b. If he invests S_b, he can then transform himself into a *hybrid* firm.
- A *hybrid* firm does not have to invest in any new technology, and can implement whatever technology θ, b, c or h to pursue the highest profit.

Depending on the value of parameters, there can be a number of resulting equilibrium time paths. To keep our discussion more focused, we assume here that the investment S_b is too large for any type of firms to find it profitable from time T on. It is indeed true in the dotcom context – it takes a relatively small amount of investment to start an online store which can then serve the national or even international market. However, the cost would be prohibitive to reach that extent of a market using the traditional brick-and-mortar technology.[9] Therefore, Equations 5 to 8 can be simplified as follows:

$$V_t^\theta = \pi^\theta + \max\{\beta V_{t+1}^\theta, \beta[\sigma V_{t+1}^c + (1-\sigma)V_{t+1}^\theta] - S_c\}, \tag{9}$$

$$V_t^b = \max\{\pi^\theta, \pi_t^b\} + \max\{\beta V_{t+1}^b, \beta[\sigma V_{t+1}^h + (1-\sigma)V_{t+1}^b] - S_c\}, \tag{10}$$

$$V_t^c = \max\{\pi^\theta, \pi_t^c\} + \beta V_{t+1}^c, \tag{11}$$

$$V_t^h = \max\{\pi^\theta, \pi_t^b, \pi_t^c, \pi_t^h\} + \beta V_{t+1}^h. \tag{12}$$

Now the equilibrium time paths depend on how the new technology c is related to the traditional technology b. In the following, we discuss two scenarios. First, we

[9]Our empirical studies on retail and banking industries in section 3 confirm that many brick-and-mortar firms have become major online players, while few dotcoms have ever developed substantial offline channels.

assume that the innovation complements the traditional technology in the sense that it is more efficient to combine those two rather than using each of them separately (i.e. $\pi_t^h > \pi_t^c$ and $\pi_t^h > \pi_t^b$). Second, we assume that the new technology dominates the traditional one in the sense that it is absolutely superior and even better than the combination of those two (i.e. $\pi_t^c > \pi_t^h$ and $\pi_t^c > \pi_t^b$).

2.3.1 Complementary Innovation

If the innovation complements the traditional technology (i.e. $\pi_t^h > \pi_t^c$ and $\pi_t^h > \pi_t^b$), the industry tends to experience a shakeout of the new entrants. Still, we have to distinguish the following two cases: $\pi_t^h > \pi_t^b > \pi_t^c$ and $\pi_t^h > \pi_t^c > \pi_t^b$. Let us start with the first one.

Case 1: $\pi_t^h > \pi_t^b > \pi_t^c$ In the first case, we assume $\pi_t^h > \pi_t^b > \pi_t^c$ and $q_t^h > q_t^b > q_t^c$. Denote the mass of participating firms in the four technology states at time t to be $n_t \equiv (n_t^\theta, n_t^b, n_t^c, n_t^h)$. The market equilibrium path can be characterized as follows.

At time T, as long as the entry cost S_c is sufficiently small, some firms will choose to invest in the new technology. As the result, N^θ type-θ firms attempt entering the market with technology c. For those firms, the free entry condition requires that

$$\beta V_{T+1}^\theta = \beta[\sigma V_{T+1}^c + (1-\sigma)V_{T+1}^\theta] - S_c,$$

which implies

$$V_{T+1}^c - V_{T+1}^\theta = \frac{S_c}{\beta\sigma}. \tag{13}$$

Given that S_c is sufficiently small, the existing N^b *brick* firms will also find it profitable to upgrade the technology.[10] Since it takes one period for the technology upgrade to effect, there is no change of price and output at time T.

At time $T+1$, among all the N^θ entry attempts, a fraction of σ turns out to succeed. Hence there will be $n^c_{T+1} = \sigma N^\theta$ *click* firms in the market. Also, as long as there are *click* firms in the market, no *brick* firms will choose to exit since $\pi^b_t > \pi^c_t \geq \pi^\theta$. Among all the N^b *brick* firms, a fraction of σ succeeds in adopting technology c, hence the number of *hybrid* firm becomes $n^h_{T+1} = \sigma N^b$. The rest *brick* firms will have to try upgrading for the next period. As the supply increases, the price declines, and no more type-θ firms will find it profitable to enter.

After time $T+1$, as more and more *brick* firms succeed in adopting the innovation, the output keeps increasing and price keeps declining. The price will eventually reach a critical value P^c at time T^c that makes *click* firms indifferent to stay or exit the market.

Hence for $T+1 \leq t < T^c$, the number of each type of participating firms is

$$\begin{aligned} n^b_t &= N^b(1-\sigma)^{t-T}, \\ n^c_t &= N^\theta \sigma, \\ n^h_t &= N^b - n^b_t = N^b[1-(1-\sigma)^{t-T}]. \end{aligned}$$

At time T^c, the price reaches a critical value P^c for which

$$\pi^c(P^c) = \pi^\theta,$$

[10] In another word, the complementarity gain from upgrading technology b to h needs to be large enough. Here, we assume that $V^h_t - V^b_t > S_c/(\beta\sigma)$ holds for all $t \geq T+1$ so that *brick* firms always find it profitable to upgrade.

so some *click* firms start to exit. As the result, we have

$$D(P^c) = n^c_{T^c} q^c(P^c) + n^b_{T^c} q^b(P^c) + n^h_{T^c} q^h(P^c),$$

which implies that

$$n^c_{T^c} = \frac{D(P^c) - N^b(1-\sigma)^{T^c - T} q^b(P^c) - N^b[1-(1-\sigma)^{T^c-T}] q^h(P^c)}{q^c(P^c)}, \tag{14}$$

so that the number of exiting *click* firms $x^c_{T^c}$ is

$$x^c_{T^c} = N^\theta \sigma - n^c_{T^c}. \tag{15}$$

For $t > T^c$, as the rest *brick* firms continuously succeed in adopting the innovation, more *click* firms have to exit to keep the price at the level P^c. At each time, the number of exiting firms $x^c_{T^c}$ is determined by

$$\begin{aligned} x^c_t q^c(P^c) &= (n^h_t - n^h_{t-1})(q^h(P^c) - q^b(P^c)) \\ &= N^b \sigma (1-\sigma)^{t-(T+1)} [q^h(P^c) - q^b(P^c)]. \end{aligned}$$

It implies that

$$x^c_t = \frac{N^b \sigma (1-\sigma)^{t-(T+1)} (q^h(P^c) - q^b(P^c))}{q^c(P^c)}. \tag{16}$$

In the long run, if we have $n^c_{T^c} q^c(P^c) \geq n^b_{T^c}[q^h(P^c) - q^b(P^c)]$, not all *click* firms will exit and the market will keep price at P^c and output at $D(P^c)$. However, if we have $n^c_{T^c} q^c(P^c) < n^b_{T^c}[q^h(P^c) - q^b(P^c)]$, then the market price will eventually fall again and the shakeout of *brick* firms may also be possible.

To complete the model, notice that N^θ and T^c are explicitly determined by the following conditions 17–19:

$$V^c_{T+1} - V^\theta_{T+1} = \sum_{t=T+1}^{T^c-1} \beta^{t-(T+1)} [\pi^c(P_t) - \pi^\theta] = \frac{S_c}{\beta\sigma}, \tag{17}$$

where for $T^c - 1 \geq t \geq T + 1$,

$$P_t = D^{-1}\{N^\theta \sigma q^c(P_t) + N^b(1-\sigma)^{t-T} q^b(P_t) + N^b[1-(1-\sigma)^{t-T}]q^h(P_t)\}, \qquad (18)$$

and for $t = T^c$,

$$D^{-1}\{N^\theta \sigma q^c(P_t) + N^b(1-\sigma)^{t-T} q^b(P_t) + N^b[1-(1-\sigma)^{t-T}]q^h(P_t)\} \leq P^c. \qquad (19)$$

There are several further results that we can learn from the model.

Proposition 1 *The value of a click firm rises from V^θ at time T to $V^\theta + \frac{S_c}{\beta\sigma}$ at time $T+1$, and then declines back to V^θ at time T^c and afterwards. In the meantime, it enjoys a high market-to-book value, i.e. $V_t^c / V^\theta > 1$.*[11]

Proof. At time T, given the free entry condition, a *click* firm must have the same value V^θ as a type-θ firm; at time T^c and afterwards, a *click* firm is indifferent between staying or exiting the industry so that its value equals V^θ. In the meantime, we have

$$\begin{aligned} V^c_{T+1} &= V^\theta + \frac{S_c}{\beta\sigma} = V^\theta + \sum_{t=T+1}^{T^c-1} \beta^{t-(T+1)}[\pi^c(P_t) - \pi^\theta], \\ V^c_{T^c>t>T+1} &= V^\theta + \sum_{\tau=t}^{T^c-1} \beta^{\tau-t}[\pi^c(P_t) - \pi^\theta] => \frac{\partial V^c_{T^c>t>T+1}}{\partial t} < 0. \end{aligned}$$

Hence the value of a *click* firm rises from V^θ at time T to $V^\theta + \frac{S_c}{\beta\sigma}$ at time $T+1$, and then declines back to V^θ at time T^c and afterwards. Meanwhile, $V_t^c / V^\theta > 1$. ■

[11] The high market-to-book value is due to the survivor bias, and consistent with empirical findings. Using Thomson Venture Economics dataset, Hochberg et al. (2004) shows that for VC funds raised in 1998 and 1999, on average only 20% of a fund's portfolio companies (presumably most were dotcoms) have successfully exited via IPO or M&A as of Nov. 2003. Using the same dataset, Gompers et al. (2005) reports that for Internet and Computer companies that did successfully go to public, the average Q value jumped to 6 in 2000, and fell to 2 in 2001 and to 1.5 in 2003.

Proposition 2 *Click firms start exiting at time T^c, but the number of exits keeps falling after time $T^c + 1$.*

Proof. Given Equation 16, we have $\partial x_t^c / \partial t < 0$ for $t \geq T^c + 1$. ■

Furthermore, we tend to observe that out of the total output, the share that uses the innovation keeps rising from time $T + 1$ on, but the contribution of *click* firms keeps falling. In the context of Internet economy, it implies that the e-commerce's share of total output keeps rising but dotcoms' contribution keeps falling (Recall Figure 2 and 3). To see that, let us assume for a *hybrid* firm, the share ω of sales is conducted using the online channel and is counted as e-commerce sales.

Proposition 3 *If ω is large, out of the total output, the share using the innovation keeps rising from time $T + 1$ on, but the contribution of click firms keeps falling.*

Proof. Denote s the share of total output that use the innovation, and s_c the contribution of *click* firms. We have

$$s_t = 1 - \frac{N^b(1-\sigma)^{t-T} q^b(P_t) + (1-\omega) N^b [1 - (1-\sigma)^{t-T}] q^h(P_t)}{Q(P_t)}, \qquad s_{c,t} = \frac{n_t^c q^c(P_t)}{s_t Q(P_t)}.$$

Hence, if $\omega > 1 - (q_t^b / q_t^h)$, we have $\partial s_t / \partial t > 0$ and $\partial s_{c,t} / \partial t < 0$ for $t \geq T + 1$. ■

In summary, Case 1 offers the following findings, as illustrated with Figure 4.

- The number of *click* firms peaks from time $T+1$ to T^c, and declines afterwards;
- *Click* firms start exiting at time T^c, but the number of exits keeps falling after time $T^c + 1$;

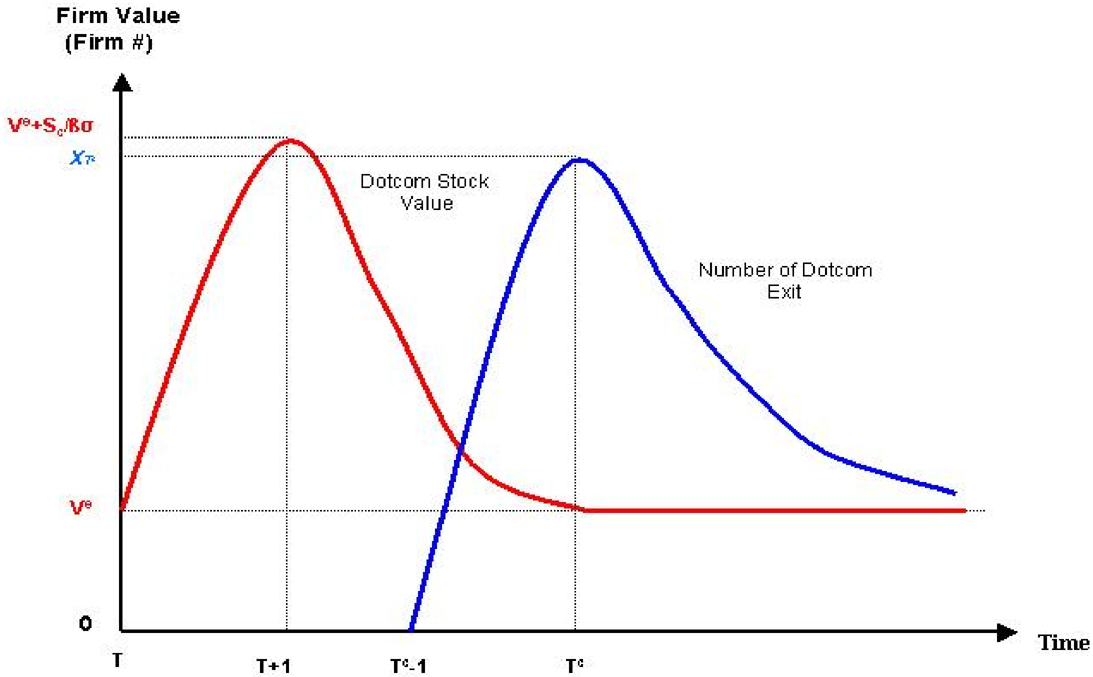

Figure 4: Dynamics of Stock Value and Firm Exits: Complementary Innovation

- The value of a *click* firm rises from V^θ at time T to $V^\theta + \frac{S_c}{\beta\sigma}$ at time $T+1$, and then declines back to V^θ at time T^c and afterwards. In the meantime, it enjoys a high market-to-book value: $V_t^c / V^\theta > 1$;

- As more firms adopt the technology innovation over time, market output Q_t keeps rising and price P_t keeps falling up to time T^c or possibly even afterwards;

- Out of the total output, the share that uses the innovation keeps rising from time $T+1$ on, but the contribution of *click* firms keeps falling.

Case 2: $\pi_t^h > \pi_t^c > \pi_t^b$ The above analysis can be similarly applied to the second case, in which we have $\pi_t^h > \pi_t^c > \pi_t^b$ and $q_t^h > q_t^c > q_t^b$. In particular, the equilibrium industry dynamics until time $T+1$ are the same as last case: At time T, N^θ type-θ

firms as well as N^b existing *brick* firms attempt adopting the new technology c, but price and output do not change. At time $T+1$, σN^θ *click* firms and σN^b *hybrid* firms succeed implementing the new technology. As the supply increases, the price declines, and no more type-θ firms will find it profitable to enter.

After time $T+1$, more and more *brick* firms succeed in upgrading, hence the output keeps increasing and price keeps declining. The price will then reach a critical value P^b at time T^b,

$$\pi^b(P^b) = \pi^\theta,$$

so that some *brick* firms no longer actively supply in the market.

However, all *brick* firms are continuously working on the technology upgrading. As a result, the price will eventually fall to a critical value P^c at time T^c and *click* firms start to exit.

Summary As discussed, dotcom shakeout tends to occur if *hybrid* is the most profitable business model, but the order of exits for *click* firms and *brick* firms may vary due to their relative efficiency to each other. More generally, if individual *click* or *brick* firms are heterogenous in efficiency, it is also possible to observe some *click* firms and *brick* firms exit at the same time.

2.3.2 Dominant Innovation

Alternatively, if the innovation dominates the traditional technology (i.e. $\pi_t^c > \pi_t^h$ and $\pi_t^c > \pi_t^b$), no shakeout would occur to the new entrants. The industry dynamics are discussed as follows.

At time T, firms attempt adopting the new technology c. Since $\pi_t^c > \pi_t^h$, *hybrid* is not at all a profitable model. Hence, *brick* and type-θ firms, if they choose to adopt the innovation, would try transforming themselves into *click* firms. The free entry condition requires

$$V^c_{T+1} - V^\theta_{T+1} = \frac{S_c}{\beta\sigma}.$$

Since it takes one period for the technology upgrade to effect, there is no change of price and output at time T. At time $T+1$, some *click* firms appear in the market. As the supply increases, the price declines, and no more firms will find it profitable to try the innovation. Hence, from time $T+1$ on, there is no more entry and exit. Two possible equilibrium outcomes are discussed below.

Case 3. $\pi^b(P^*) \leq \pi^\theta$ The first equilibrium has no *brick* firms remaining in the market for $t \geq T+1$. It satisfies the following conditions:

$$\frac{\pi^c(P^*) - \pi^\theta}{1-\beta} = \frac{S_c}{\beta\sigma},$$

$$\pi^b(P^*) \leq \pi^\theta,$$

$$Q = D(P^*) = \sigma N^\theta q^c(P^*),$$

which implies that among N^θ attempts for technology upgrading at time T (notice that the N^θ attempts may include both type-θ and *brick* firms because they have the same opportunity cost π^θ), σN^θ firms succeed and produce at time $T+1$. From then on, only *click* firms are in the market, and there will be no more dynamics.

In summary, Case 3 offers the following findings, as illustrated with Figure 5.

- The number of *click* firms peaks at time $T+1$ and stays constant afterwards;

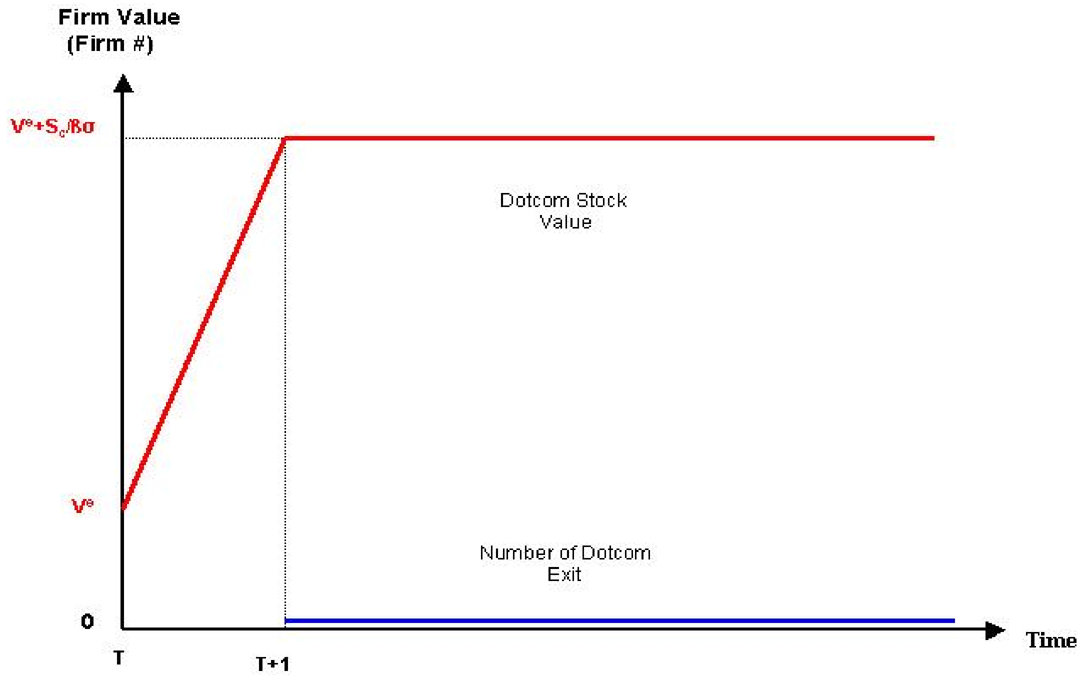

Figure 5: Dynamics of Stock Value and Firm Exits: Dominant Innovation

- The value of a *click* firm rises from V^θ at time T to $V^\theta + \frac{S_c}{\beta\sigma}$ at time $T+1$, and stays constant afterwards. It enjoys a high market to book value: $V_t^c/V^\theta > 1$;
- As firms adopt the innovation, the market output Q_t rises and price P_t falls at time $T+1$, and both stay constant afterwards;
- From time $T+1$ on, the share of total output that uses the innovation rises to 100%, and all come from the contribution of *click* firms.

Case 4. $\pi^b(P^*) > \pi^\theta$ The analysis can be similarly applied to the other case. The second equilibrium allows *brick* firms to remain in the market. The corresponding conditions are

$$\frac{\pi^c(P^*) - \pi^\theta}{1-\beta} = \frac{S_c}{\beta\sigma},$$

$$\pi^b(P^*) > \pi^\theta,$$

$$Q = D(P^*) = \sigma N^\theta q^c(P^*) + N^b q^b(P^*),$$

which implies that N^θ type-θ firms attempt to enter with technology c at time T (notice that no *brick* firm would try adopting technology c because of the higher opportunity cost, i.e. $\pi^b(P^*) > \pi^\theta$), and the fraction σ of them succeed at time $T+1$. From then on, σN^θ *click* firms and N^b *brick* firms are in the market, and there will be no more dynamics.

Summary As discussed, dotcom shakeout would not occur if the Internet innovation dominates old technology, but whether *brick* firms exit or not depends on their relative profitability to the outside opportunity. In any case, the *hybrid* would not be a profitable business model.

2.4 Aggregate Uncertainty and Financial Loss

The above analysis suggests that a shakeout tends to occur to new entrants if the innovation that they rely on is a complement rather than a replacement for the existing technology. It is indeed the key reason for the dotcom shakeout, as we will show in our empirical studies in section 3. However, before we move on, there is still an unanswered question: what can explain the financial losses incurred during the dotcom shakeout?

A simple extension of our model can address this issue. So far, we have assumed there is no aggregate uncertainty associated with the innovation, hence a shakeout does not incur financial losses.[12] However, it is very plausible that aggregate uncer-

[12]Notice that some new entrants, who fail adopting the innovation and exit, do have financial

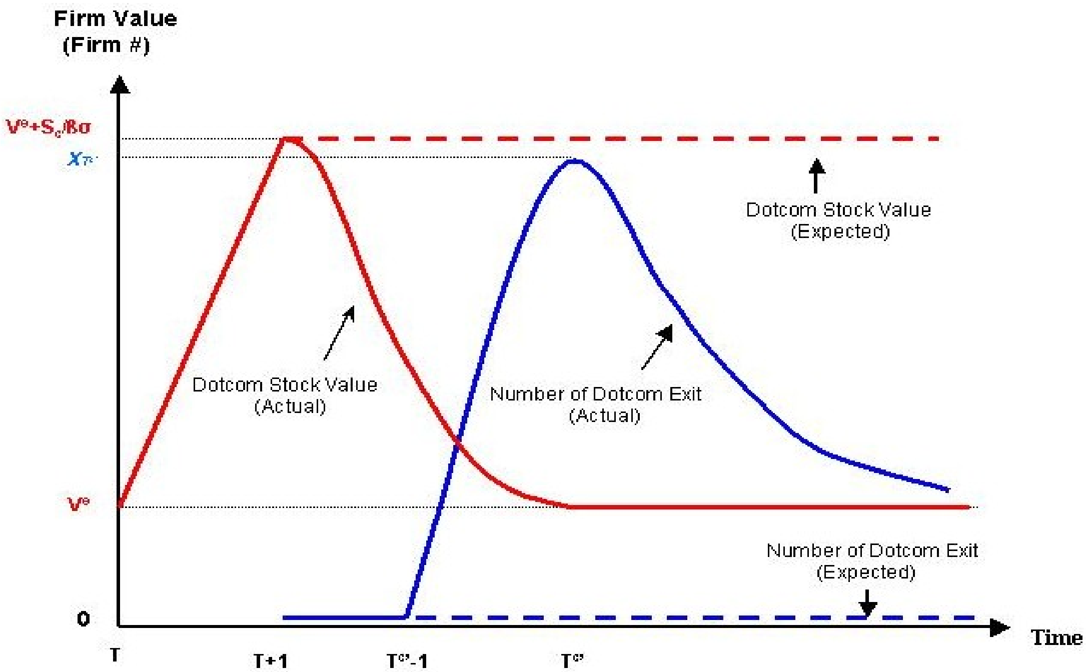

Figure 6: Industry Dynamics: Actual vs. Expected

tainty exists. In fact, it took time for market participants to understand there were competitive disadvantages in the online-only business model. Therefore, financial losses are likely the result of *ex ante* overestimation of the dotcoms' potential.

To see this, assume that at time T firms have to make their decisions to adopt the Internet innovation based on their expected profits: $E(\pi^c)$ and $E(\pi^h)$. If *ex ante* the market expects the innovation to dominate the old technology, this may result in over entry of dotcom firms, (i.e. $N^{\theta\prime} > N^{\theta}$). When the truth is revealed *ex post* (at time $T+1$), we will then observe that all entrants suffer financial losses.[13] The

losses. However, that risk is idiosyncratic and can be insured, e.g. a venture capitalist typically diversify his investment portfolio over many entry attempts.

[13]Some other factors may also induce over entry, e.g. overestimating market demand, underestimating the learning rate of incumbent firms and etc. However, the analyses would be similar.

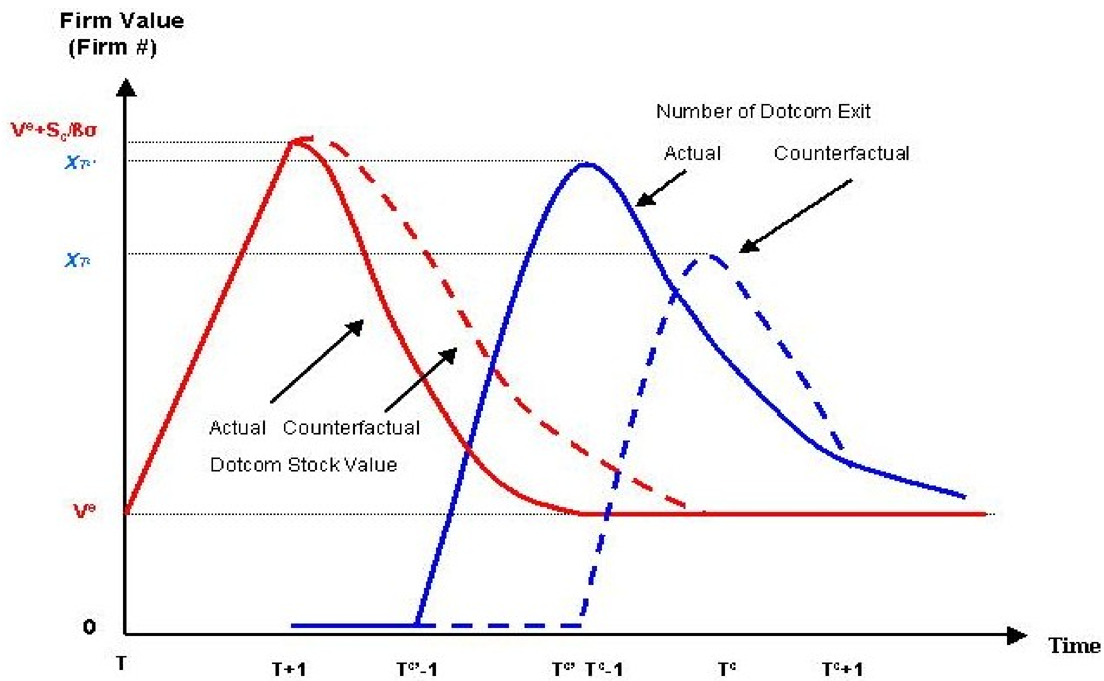

Figure 7: Industry Dynamics: Actual vs. Counterfactual

comparison of industry dynamics is illustrated with Figure 6.

Using this example, we can further compare the industry dynamics under imperfect information (actual paths) with that under perfect information (counterfactual paths). We should observe that with over entry the shakeout arrives earlier and is more severe than the counterfactual case.

To elaborate on that, let us use $N^{\theta\prime}, P_t^{\prime}, T^{c\prime}$, $x_t^{c\prime}, V_{T+1}^{c\prime}$ for corresponding notations under imperfect information. Recall conditions 17–19. Notice that $N^{\theta\prime}(> N^{\theta})$ is now exogenously given at time $T+1$, so that for $T^{c\prime}-1 \geq t \geq T+1$, Equation 18 has to be rewritten as

$$P_t^{\prime} = D^{-1}\{N^{\theta\prime}\sigma q^c(P_t^{\prime}) + N^b(1-\sigma)^{t-T}q^b(P_t^{\prime}) + N^b[1-(1-\sigma)^{t-T}]q^h(P_t^{\prime})\},$$

which implies a lower price path: $P_t^{\prime} < P_t$. Because the timing of exit $T^{c\prime}$ is the first time period that the following condition holds,

$$D^{-1}\{N^{\theta\prime}\sigma q^c(P_t') + N^b(1-\sigma)^{t-T}q^b(P_t') + N^b[1-(1-\sigma)^{t-T}]q^h(P_t')\} \leq P^c,$$

it is straightforward to see that the shakeout arrives earlier, i.e. $T^{c\prime} < T^c$. Furthermore, condition 17 no longer holds, so all dotcoms suffer a loss of value:

$$V_{T+1}^{c\prime} - V_{T+1}^{\theta} = \sum_{t=T+1}^{T^{c\prime}-1} \beta^{t-(T+1)}[\pi^c(P_t') - \pi^\theta] < \sum_{t=T+1}^{T^c-1} \beta^{t-(T+1)}[\pi^c(P_t) - \pi^\theta] = \frac{S_c}{\beta\sigma}.$$

In addition, the number of dotcom exits will also be larger. Rewriting Equations 14 and 15, we have that up to time T^c, the actual cumulative number of exits is greater than the counterfactual case:

$$\sum_{t=T^{c\prime}}^{T^c} x_t^{c\prime} - x_{T^c}^c = N^{\theta\prime}\sigma - N^\theta\sigma > 0.$$

For the periods after time T^c, Equation 16 suggests the number of actual exits is the same as the counterfactual case:

$$x_t^{c\prime} = \frac{N^b\sigma(1-\sigma)^{t-(T+1)}(q^h(P^c) - q^b(P^c))}{q^c(P^c)} = x_t^c.$$

The comparison of industry dynamics is illustrated with Figure 7.

3 Empirical Studies

From the above discussion, we have seen that the initial mass entry and later exit of innovation-based pure plays are plausible given the following conditions: (1) the innovation creates some advantages for pure-play entrants (e.g. low entry cost and/or low operation cost); (2) the innovation is complementary to the existing technology; (3) it takes time for the innovation to diffuse among incumbents using traditional technology. The evolving history of e-commerce suggests to us that those are indeed the features of doing business over the Internet.

3.1 E-commerce Overview

In the early days of e-commerce, the market was excited about the potential competitive advantages that Internet firms had over traditional firms. By eliminating its physical operations, the pure plays could lower substantially the cost of entry into the market. Internet firms also enjoyed further advantages, including access to wider markets, lower inventory costs, ability to bypass intermediaries, lower menu costs enabling more rapid response to market changes, ease of bundling complementary products, ease of offering 24/7 access, and so on.

However, the market experienced that eschewing physical space for cyberspace did not come without consequences. Above all, online and offline channels were not perfect substitutes. Internet shopping fits better with standardized goods and services, for instance, buying books, which do not require personal contact with the item or a large physical shopping space. Conversely, it fits less well for the "experience" goods and services, such as clothing, for which customers need first-hand experience with the item. Also, Internet firms incur extra costs by running high-tech systems that require a more expensive labor force and by offering additional physical delivery channels.

Most important, traditional firms that succeeded getting into the online business enjoyed great sources of synergy between their online and offline channels. The sources include common infrastructures, common operations, common marketing, and common customers as listed in Steinfield (2002).[14] They are also represented in the many forms of complementary assets that incumbent firms possess, such as existing supplier and distributor relationships, experience in the market, a customer base, and others that can enable them to take better advantage of an innovation like e-commerce. Eventually, traditional firms were able to capitalize on these synergies between their existing and new online service channels to beat the dotcoms at their own game.

3.2 The Retail Industry

To test our theory, we need to empirically identify the competitive advantage of multichannel firms over dotcoms, which is not obvious from anecdote evidence on the retail industry. On one hand, we do observe dotcom retailers losing ground to multichannel retailers. According to *Retail Forward*'s annual study, dotcoms comprised 23

[14] An example of the use of a common infrastructure is when a firm relies on the same logistics system or share the same IT infrastructure for both online and offline sales. An order processing system shared between e-commerce and physical channels is a good example of a common operation as a source of synergy. This can enable, for example, improved tracking of customers' movements between channels, in addition to potential cost savings. E-commerce and physical channels may also share common marketing and sales assets, such as a common product catalogue, a sales force that understands the products and customer needs and directs potential buyers to each channel, or advertisements and promotions that draw attention to both channels. Moreover, e-commerce and physical outlets in click-and-mortar firms often target the same potential buyers. This enables a click-and-mortar firm to better meet customers' needs for both convenience and immediacy, for example, to allow consumers to buy a product online and return it offline, or try a product in the store before purchasing it online.

of the Top 50 E-retailers in 1999, but the number dropped to 11 in 2004 as reported by *Internet Retailer*. However, on the other hand, the dotcom giant, Amazon, has continued as the largest online retailer with $6.9 billion Web sales in 2004, far larger than the top multichannel rivals, e.g. Office Depot ($3.1 Billion), Sears ($1.7 Billion) or Walmart ($0.78 billion). Therefore, we need a systematic empirical analysis to fully address this issue.

3.2.1 Data

Our analysis uses an original dataset from two primary sources: the *Internet Retailer* and *Compustat*. Let us briefly describe here the dataset and our market definition.

The first data source, the *Internet Retailer,* identifies the 400 largest online retailers by their 2004 Internet sales.[15] It provides a comprehensive coverage of the online retail universe: the top 400 E-retailers generated combined Web sales of more than $51 billion and account for more than 90% of the total U.S. Internet retail sales (excluding motor vehicle sales, travel, financial and ticket-related services) in 2004.[16] Also, with additional help from the *Internet Retailer,* we are able to identify the type of each retailer, i.e. dotcoms vs. multichannels, and even divide multichannel retailers further into traditional store retailers and traditional direct retailers (e.g. catalog

[15] Whenever possible, *Internet Retailer* obtained the data from the company. If the company would not provide the data, *Internet Retailer* formed estimates based on other sources. Companies were then given the opportunity to respond to the estimates.

[16] According to the U.S. Census Bureau, the U.S. Internet retail sales totaled $69 billion in 2004, of which about 20% were automobile sales occurred over auto dealers' Websites. Online travel services, financial brokers and dealers, and ticket sales agencies are not classified as retail and are not included.

and mail order retailers).

The second data source, the *Compustat,* reports annual total sales of publicly traded firms. Merged with the data from the *Internet Retailer*, it adds information of total sales (online plus offline sales) for 275 firms in our top 400 E-retailer list.

Following *Internet Retailer*'s definition, we divide the 400 retailers into 14 merchandising categories based on their primary business: Beaut (Health/Beauty), Book (Books/CD/DVDs), Cloth (Apparel/Accessories), Dept (Department Store/Mass Merchant), Drug (Drug/Food), Elect (Computer/Electronics), Flow (Flowers/Gifts), Hard (Hardware/Home Improvement), House (Housewares/Home Furnishings), Jewel (Jewelry), Offi (Office Supplies), Spec (Specialty/Non-Apparel), Sport (Sporting Goods), Toys (Toys/Hobbies). We then try to identify if multichannel retailers have competitive advantage over dotcoms in each market category.

Detailed data summary statistics are provided in Appendix Table A1 and A2. Both data, online sales and total sales, are based on 2004 information. Ten years after the birth of Internet retail and five years after the start of dotcom shakeout, it is reasonable to assume that the retail industry has well absorbed the Internet technology shock and evolved into a new steady state. Hence, this allows for a meaningful comparison of market performance between firm types across retail categories.

3.2.2 Multichannel Retailers vs. Dotcoms

To identify the advantage of multichannel retailers over dotcoms, we first treat the Internet as a separate marketplace from offline. We then test if multichannel retailers enjoy larger online sales than dotcoms.[17]

[17] Based on our model, larger sales also imply larger profits.

The regression is set up as follows:

$$\begin{aligned}\ln(WEBSALE) &= CONSTANT + \sum_{i=1}^{13} \lambda_i * CATEGORY_i \\ &+ \sum_{i=1}^{14} \gamma_i * CATEGORY_i * MULTI + \mu, \qquad \text{(R1)}\end{aligned}$$

where $\ln(WEBSALE)$ is the logarithm of online sales, $CATEGORY_i$ is the category dummies (=1 if in category i; =0 otherwise), $MULTI$ is the firm type dummy (=1 if multichannel; =0 if dotcom), and μ is the random error (likely being heteroskedastic). The coefficient estimates and robust standard errors are reported in the Appendix Table A3.[18]

The γ_i, by definition, is the average additional online sales of a multichannel retailer over a dotcom in category i. The estimation results confirm multichannel firms' advantage, and also show that the advantage varies across retail categories. Among the total 14 categories, we find that a multichannel firm tends to sell more online than a dotcom ($\gamma_i > 0$) in 10 categories, of which in 6 categories the advantage is statistically significant (i.e. the null hypothesis $\gamma_i \leq 0$ is rejected based on a one-sided t test). In the remaining 4 categories, a multichannel firm is found to sell less than a dotcom on average ($\gamma_i < 0$) but only in one category (drug/food), the difference is statistically significant (i.e. the null hypothesis $\gamma_i \geq 0$ is rejected based on a one-sided t test).

For the 10 retail categories in which multichannel firms are found to perform better, the average difference of online sales between a multichannel firm and a dotcom ranges from 7% (Housewares/Home Furnishings) to 263%(Office Supplies). We also notice that the 4 categories in which dotcoms are likely to do better are drug/food,

[18] We also run separate regressions for each individual retail category and get consistent results.

department store/mass merchant, jewelry and book/CD/DVDs. One potential explanation is that products in those categories tend to be standard goods and easy to transport. Therefore, the spillovers from offline channels to the online channel (e.g. product display, customer consultation, transportation and distribution networks and etc.) are less important than other categories.

However, treating the online as a separate marketplace is an extreme assumption that may underestimate the performance of multichannel retailers by ignoring the spillovers from the online channel to the offline channels. Therefore, we also run the above regression R1 using total sales (online plus offline) as the dependent variable, assuming that the online and offline sales compete in the same marketplace. This may be another extreme assumption, but at least we know the truth should lie somewhere in between. The regression results are also presented in the Appendix Table A3, which clearly shows that the multichannel firms dominate dotcoms in every retail category, and the advantage is so economically and statistically significant that there is no comparison. This result is consistent with our general intuition. Consider Amazon and Walmart for example, the largest dotcom retailer versus the largest multichannel retailer[19] – Amazon has 6.9 billion online and total sales in 2004, while Walmart has 0.78 billion online sales but 285 billion total sales.

The above findings are summarized in Figure 8, which clearly shows multichannel firms' dominance over dotcoms in most online retail categories, and also their dominance in total retail sales. Using market share instead of average sales per firm,

[19]Amazon and Walmart are both in the Department Store/Mass Merchant category. Notice Amazon is also the largest online book store. However, no matter which category Amazon is counted in, Dept or Book, it does not change our empirical findings throughout the paper.

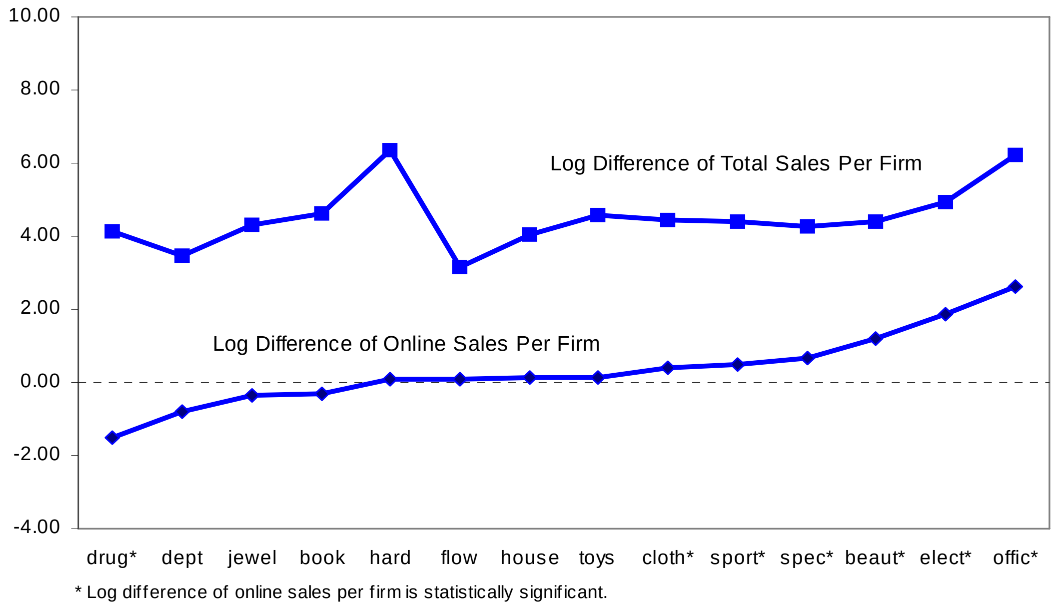

Figure 8: Log Difference of Sales Per Firm: Multichannel Retailers minus Dotcoms

Figure 13 in the Appendix shows the exactly same pattern. In the 4 categories where dotcoms have larger average online sales per firm than multichannel firms, dotcoms also have larger online market shares (i.e. >50%). However, in the other categories, dotcoms' online market shares are dominated by multichannel firms. In terms of total sales (online plus offline), multichannel firms dominate dotcoms in every retail category (see Figure 14 in the Appendix).[20]

3.2.3 Store Retailers, Direct Retailers vs. Dotcoms

So far, we have treated multichannel retailers as a single group. However, the data suggests that there is some important differentiation within the multichannel group.

[20]In fact, dotcoms' market share of total sales are even overestimated in Figure 14 because many multichannel retailers' total sales are not available to be included in the calculation.

In particular, some multichannel retailers specialize on store retailing, e.g. Walmart, while others focus on direct retailing (catalog/mail order, sales representative, or telemarketing), e.g. L.L. Bean. Based on each company's historical mechandising channels and primary business, we identify 53 direct retailers out of 282 multichannel retailers.[21] It would be interesting to see if there are differences in the online-offline synergy between traditional store retailers and direct retailers. Therefore, we run the following regression:

$$\begin{aligned}\ln(WEBSALE) &= CONSTANT + \sum_{i=1}^{13} \lambda_i * CATEGORY_i \\ &+ \sum_{i=1}^{14} \alpha_i * CATEGORY_i * STORE \\ &+ \sum_{i=1}^{14} \beta_i * CATEGORY_i * DIRECT + \mu, \qquad \text{(R2)}\end{aligned}$$

where $\ln(WEBSALE)$ and $CATEGORY$ are defined as before, and $STORE$ and $DIRECT$ are dummies for firm type ($STORE$=1 if multichannel store retailer, =0 otherwise; $DIRECT$=1 if multichannel direct retailer, =0 otherwise). The regression results are shown in the Appendix Table A4.[22]

The α_i (β_i), by definition, is the average additional online sales of a multichannel store (direct) retailer over a dotcom in category i. With some refinement, the estimation results confirm the previous findings of multichannel retailers' advantage. A store retailer sells more online on average than a dotcom ($\alpha_i > 0$) in 8 categories, of which in 3 categories the advantage is statistically significant. A dotcom tends to sell more online than a store retailer ($\alpha_i < 0$) in 6 categories, but only the difference

[21] Sometimes, the distinction between store retailers and direct retailers may not be very clear since many store retailers also run catalogs and some direct retailers have stores.

[22] We also run separate regressions for each individual retail category and get consistent results.

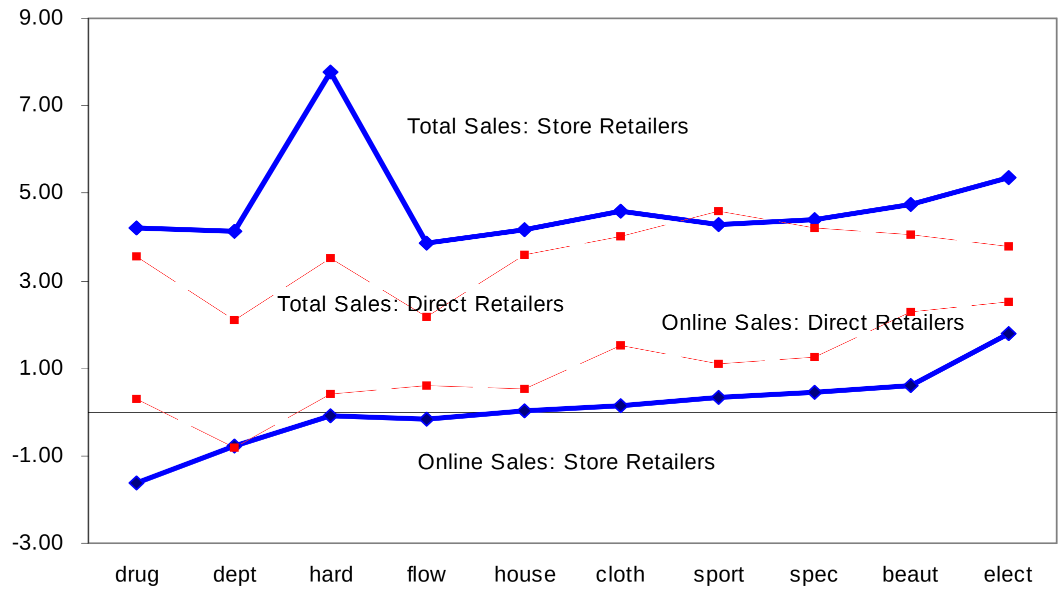

Figure 9: Log Difference of Sales Per Firm: Store (Direct) Retailers minus Dotcoms

in the Drug/Food category is statistically significant. A multichannel direct retailer sells more online on average than a dotcom ($\beta_i > 0$) in 9 categories, of which in 5 categories the advantage is statistically significant. Moreover, we find that direct retailers do not have disadvantage in online sales in the Drug/Food category, but have a disadvantage in the Office Supplies category. On average, a direct retailer seems to enjoy larger advantage in online sales than store retailers as they generate more online sales per firm ($\beta_i > \alpha_i$) in 9 categories.

Running the regression R2 using total sales (online plus offline) as the dependent variable, we find that both traditional store and direct retailers dominate dotcoms in every retail category, and store retailers are typically larger than direct retailers ($\alpha_i > \beta_i$) in all categories except Sporting Goods. The regression results are also shown in the Appendix Table A4.

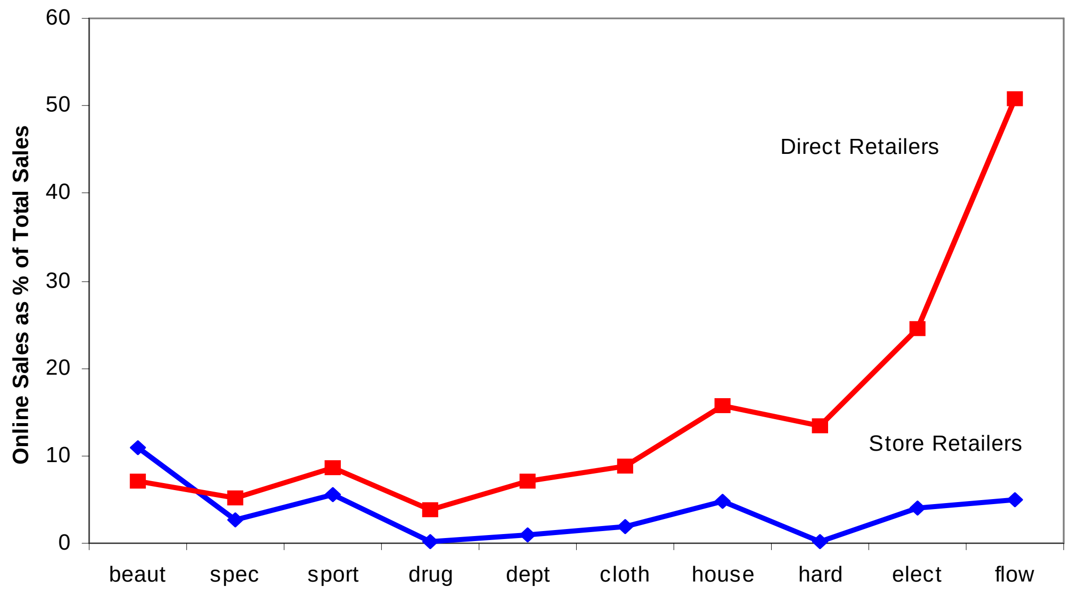

Figure 10: Online Sales as % of Total Sales: Store Retailers vs. Direct Retailers

The above findings are summarized in Figure 9.[23] Comparing Figure 8 and Figure 9, several further findings are noticeable. First, the cross-category pattern of multi-channel retailers' advantage that we previously found, in both online and total sales, is mainly driven by the store-retailers. Second, individual direct retailers tend to sell more online than individual store retailers. It is reasonable to think that direct retailers may be able to better adapt to the online technology, or their product lines are simply more suitable for the online market. In fact, as shown in Figure 10, direct retailers in general do rely more on their online channels than the store retailers. However, higher online sales per firm does not necessarily mean that direct retailers have contributed more to the dotcom shakeout than store retailers. Since the number of direct retailers are small, less than 1/5 of the multichannel group, their effects

[23] Due to no observation of direct retailers, Figure 9 and 10 cover 10 categories instead of 14.

were rather limited. Figure 13 and 14 in the Appendix present the market share of online and total sales by each firm type, which clearly show the dominance of store retailers. Even so, our study of direct retailers does remind us that the sources of multichannel synergies should include not only physical stores, but also other offline channels as well as broader assets that incumbents possess like brand, customer base and business relations.

3.3 The Banking Industry

In addition to the retail industry, the history of online banking provides further support for our theory.

The beginning of "Internet era" in banking service can be traced back to 1995, when Wells Fargo became the first bank to offer its customers online-access to account statement, and Security First Network Bank became the first online-only bank. The next a few years were more or less an experimental stage, during which the industry witnessed relatively slow adoption of Internet technology – up to 1998, 6% of national banks offered transactional Internet services, and 7 banks offered online-only services. Then the diffusion of online banking took off in 1999 and 2000. By the end of 2000, 37% of national banks offered transactional Internet banking, and about 40 new dotcom banks had entered the market.[24] However, a shakeout started striking the dotcom banks in 2001. As shown in Figure 11 (notice its similarity to Figure 1), the stock index[25] for dotcom banks dropped by 80%, and nearly half of dotcom banks

[24] Data source: OCC and *Online Banking Report.*

[25] The stock index is calculated as value weighted sum of stock prices for six publicly owned dotcom banks, which include Security First Network Bank (SFNB), Next Bank (NXCD), Net Bank

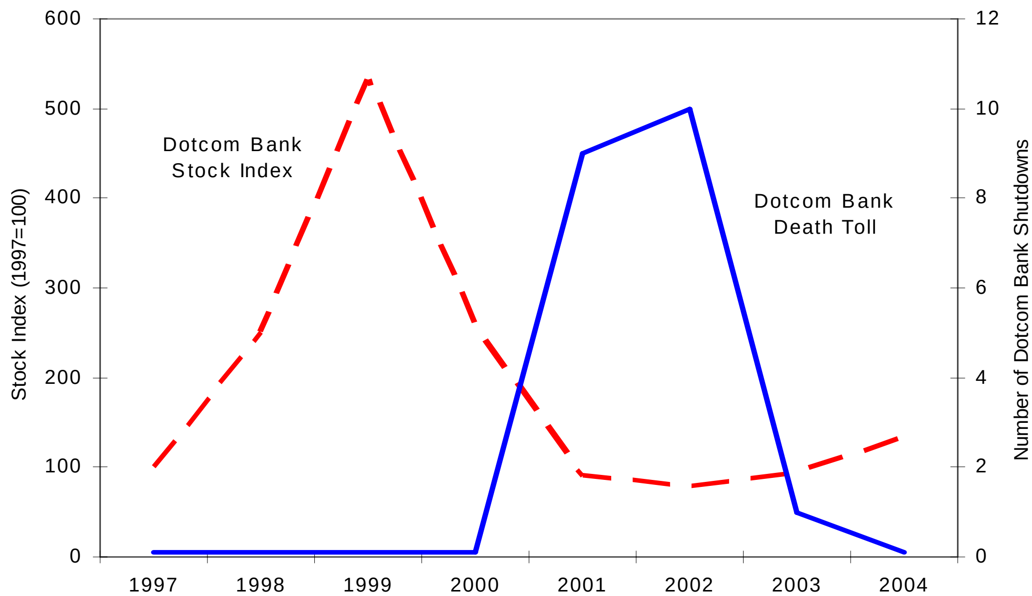

Figure 11: Dotcom Banks: Stock Index and Death Toll

exited the industry by 2003.[26]

As suggested, the key to explaining the dotcom shakeout in the banking industry is to compare the competitive positions of pure Internet banks against their competitors with brick-and-mortar branches. Similar to other e-commerce industries, the core strategy of an Internet-only banking model is to reduce overhead expenses by eliminating the physical branch channel. However, it turns out that the online channel is not a perfect substitute for the branch channel, but rather, a good complement. Figure 12 shows that the number of ATMs or brick-and-mortar offices per bank actually has been increasing since the mid-1990s, together with the increasing adoption of online banking.[27]

(NTBK), E*trade Bank (ET), USA Bancshares (USAB) and American Bank (AMBK).

[26]Data Source: *Online Banking Report*, various issues, (1999-2003).

[27]Note: Institution includes all FDIC-Insured depository financial institutions. Data of of-

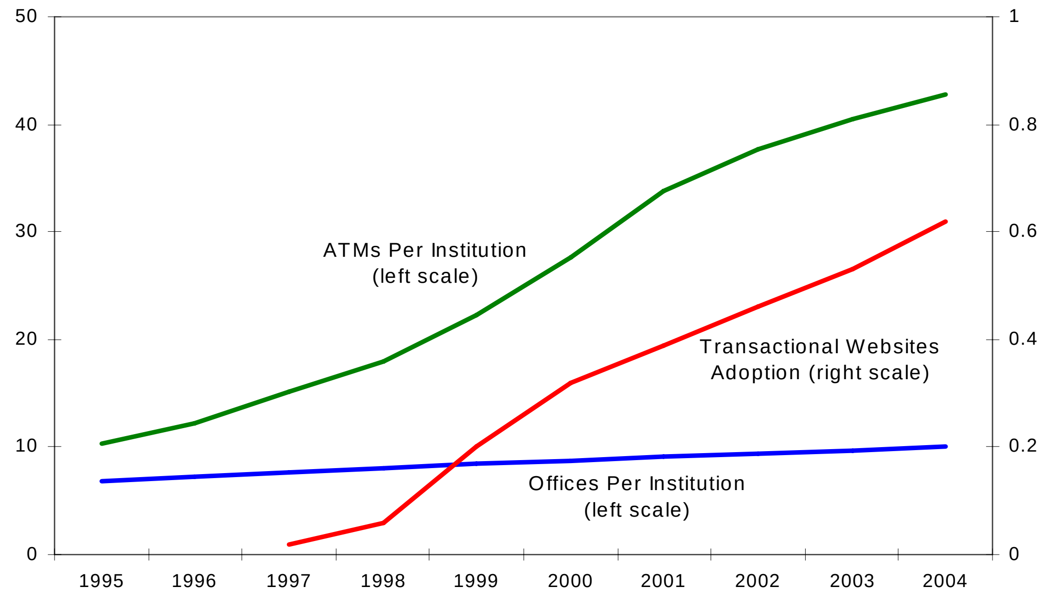

Figure 12: Evolution of Banking Service Delivery Channels

Exploring the synergy between online and offline channels reveals that a click-and-mortar bank typically delivers standardized, low-value-added transactions such as bill payments, balance inquiries, account transfers and credit card lending through the inexpensive Internet channel, while delivering specialized, high-value-added transactions such as small business lending, personal trust services and investment banking through the more expensive branch channel. By providing more service options to its customers, a click-and-mortar bank is able to retain its most profitable customers and generate more revenue from cross-selling.

DeYoung (2005) compares the performance between Internet-only full-service banks

fices (headquarters and branches) is from *Summary of Deposits,* FDIC/OTS (2004), ATMs from *ATM&Debit News*, Transactional Websites from OCC and Call Report.

and their branching counterparts from 1997 to 2001.[28] The empirical results show that Internet-only banks on average have lower asset returns than incumbent branching banks as well as new branching entrants. This is primarily due to Internet-only banks' lower interest margins and fee income, lower levels of loan and deposit generation, fewer business loans, and higher noninterest expense for equipment and skilled labor. These results are robust after controlling effects of age and survivorship.

As more and more brick-and-mortar banks get online, the competitive pressure in the online banking market has surely increased. According to the Call Report, 75% of depository institutions had adopted a Website by 2004 compared to 35% in 1999, and 60% reported Websites with transactional capability in 2004 compared to under 37% in 2000.[29] Even more important, the online technology gap between dotcom banks and traditional banks has been closing. Based on the research conducted by GomexPro on online banking service,[30] six pure-play banks ranked among the top ten for the "Best Online Banking Service" in 1999, but the number dropped to two in 2001, then to one in 2003 (see Table 1).

Consequently, the online-only banks have steadily lost ground to their multichan-

[28] Besides dotcom banks, two comparison groups of banks are investigated. One is incumbent branching banks, including 3,777 small, established banks and thrifts (assets less than $1 billion and at least 10 years old) in urban U.S. markets between 1997 and 2000. The other is new branching entrants, including 644 branching banks and thrifts newly chartered during the same sample period.

[29] The Call Report started collecting Website information for all FDIC-insured depository institutions in 1999, but the information of Transactional Websites was not available until 2003. An independent survey by OCC reported that 37% national banks adopted transactional Websites in 2000, which suggests the adoption rate for the overall banking population should be even lower.

[30] The total score of online service is evaluated as a weighted sum of scores in categories of functionality, ease of use, privacy & security, quality & availability based on 150 to 300 criteria.

nel competitors. As the Media Metrix traffic data reveal, the number of unique visitors to multichannel banks' Websites climbed from 6.4 million in July 2000 to 13.4 million in July 2001, while traffic to online-only banks fell from 1.2 million to 1.1 million over the same period (see Table 2). Meanwhile, the shakeout of online-only banks started in 2000, with the number declining from around 50 in 2000 to less than 30 in 2003.

Table 1. GomexPro Ranking of Online Banking Service

Rank	Oct. 1999[31]	Sept. 2001	Nov. 2003
1	* SFNB	Citibank	Citibank
2	Wells Fargo	* FIBI	Bank of America
3	* NetBank	* NetBank	Wells Fargo
4	* FIBI	Bank of America	Charter One
5	* Wingspan	Bank One	Huntington
6	* CompuBank	Wells Fargo	Chase
7	Bank One	Key Bank	* E*trade Bank
8	Citibank	First Tennessee	National City Bank
9	* USAccess	Fleet	Key Bank
10	Huntington	Charter One	HSBC

* Online-only Bank

Security First Network Bank, the first dotcom bank, was one of the casualties. Acquired by Royal Bank of Canada in 1998, its Internet operations were discontinued in 2001, and Internet transaction accounts were sold to RBC Centura Bank. Other

[31] SFNB: Security First Network Bank; FIBI: First Internet Bank of Indiana.

dotcom survivors have generally adjusted their strategies, trying to avoid head-on competition with big click-and-mortars. For example, ING Direct, the largest dotcom bank today, offers services on saving accounts but not checking, and encourages their customers to keep their old bank accounts.

Table 2. Traffic to Banking Sites

Home & Work Users (1,000)

	July 2000	July 2001	Annual Change
Total Websites	76,910	92,175	19.8%
Banking Sites	10,411	18,489	77.6%
Multichannel Banking	6,367	13,405	110.5%
Online-Only Banking	1,194	1,097	-8.1%
		Multichannel Banks	
Chase	957	3,647	281.1%
Wells Fargo	2,007	3,492	74.0%
Citibank	1,718	3,469	101.9%
Bank of America	1,502	3,296	119.4%
Bank One	536	1,139	112.5%
Fleet	501	900	79.6%
		Online-only Banks	
Netbank	688	461	-33.0%
Juniper	N/A	382	N/A
E*Trade Bank	359	238	-33.7%
Wingspan Bank	282	closed	N/A

4 Final Remarks

This paper explains market turbulence, such as the recent dotcom boom/bust cycle, as equilibrium industry dynamics resulting from a complementary technology innovation. The shakeout of new entrants tends to occur if the existing technology and assets allow incumbent firms to take better advantage of the innovation. Our empirical studies on retail and banking industries reveal that it is indeed the feature of e-commerce. Therefore, the dotcom shakeout would occur even without aggregate uncertainty in the market. In addition, we show that *ex ante* overestimation on dotcoms' potential may help explain the timing and financial loss of the shakeout.

With no externality involved, we can also show the competitive equilibrium that we derive from the model is socially optimal. It implies that as long as the social planner does not have better information about the innovation than market participants, there is no need for government intervention. That explains why the US government authorities chose not to intervene the dotcom market during the boom period.

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Table A1. **Summary Statistics: Online Retail Sales ($ million)**

Category	Firm Type	Firm #	Mean Sales	Std. Dev.	Min Sales	Max Sales	% of Sales
Overall	Dotcom	118	112.99	643.57	3.30	6921.12	26.06
	Multi	282	134.11	407.61	3.81	3257.42	73.94
	Total	400	127.88	488.42	3.30	6921.12	100.00
Beaut	Dotcom	6	25.03	13.86	8.90	48.08	9.91
	Multi	6	227.68	306.42	9.26	748.00	90.09
	Total	12	126.36	232.30	8.90	748.00	100.00
Book	Dotcom	11	79.01	146.14	4.65	506.23	51.12
	Multi	14	59.36	115.03	4.60	419.80	48.88
	Total	25	68.01	127.14	4.60	506.23	100.00
Cloth	Dotcom	17	31.07	44.53	3.58	184.00	11.26
	Multi	82	50.75	80.14	3.81	438.96	88.74
	Total	99	47.37	75.42	3.58	438.96	100.00
Dept	Dotcom	5	1568.95	2997.24	46.00	6921.12	55.41
	Multi	16	394.61	468.62	7.63	1740.00	44.59
	Total	21	674.22	1491.33	7.63	6921.12	100.00
Drug	Dotcom	5	152.27	129.22	36.25	360.10	53.58
	Multi	15	43.97	45.09	4.84	150.00	46.42
	Total	20	71.04	85.60	4.84	360.10	100.00
Elect	Dotcom	12	129.85	287.53	5.70	1000.00	10.93
	Multi	20	635.03	934.65	11.40	3257.42	89.07
	Total	32	445.59	791.51	5.70	3257.42	100.00
Flow	Dotcom	7	42.33	46.55	4.00	128.80	31.87
	Multi	9	70.36	106.71	4.56	307.47	68.13
	Total	16	58.10	84.53	4.00	307.47	100.00
Hard	Dotcom	3	26.29	18.60	11.00	47.00	16.36
	Multi	7	57.60	65.77	4.40	163.68	83.64
	Total	10	48.21	56.47	4.40	163.68	100.00
House	Dotcom	15	24.47	19.45	4.22	68.70	20.36
	Multi	33	43.51	88.81	4.80	477.50	79.64
	Total	48	37.56	74.58	4.22	477.50	100.00
Jewel	Dotcom	5	53.91	66.73	7.47	169.24	62.59
	Multi	6	26.86	18.13	5.36	52.40	37.41
	Total	11	39.15	46.31	5.36	169.24	100.00
Offi	Dotcom	3	10.98	4.56	6.80	15.85	0.51
	Multi	6	1061.84	1542.04	5.80	3100.00	99.49
	Total	9	711.55	1327.50	5.80	3100.00	100.00
Spec	Dotcom	19	21.64	19.12	3.30	69.70	23.96
	Multi	28	46.59	48.04	5.47	172.81	76.04
	Total	47	36.51	40.63	3.30	172.81	100.00
Sport	Dotcom	7	15.42	13.54	3.91	39.60	10.81
	Multi	27	32.98	45.46	4.02	200.18	89.19
	Total	34	29.36	41.40	3.91	200.18	100.00
Toys	Dotcom	3	19.08	16.57	8.00	38.13	8.87
	Multi	13	45.26	103.12	5.06	386.00	91.13
	Total	16	40.35	93.03	5.06	386.00	100.00

* Dotcom refers to online-only retailers; Multi refers to multichannel retailers who sell through both online and offline channels.

Table A2. **Summary Statistics: Total Retail Sales ($ million)**

Category	Firm Type	Firm #	Mean Sales	Std. Dev.	Min Sales	Max Sales	% of Sales
Overall	Dotcom	118	112.99	643.57	3.30	6921.12	0.95
	Multi	157	8881.93	26157.75	55.83	285200.00	99.05
	Total	275	5119.26	20214.92	3.30	285200.00	100.00
Beaut	Dotcom	6	25.03	13.86	8.90	48.08	1.00
	Multi	4	3713.02	3637.76	211.68	7750.00	99.00
	Total	10	1500.23	2835.17	8.90	7750.00	100.00
Book	Dotcom	11	79.01	146.14	4.65	506.23	1.76
	Multi	7	6938.58	8001.81	266.72	22525.90	98.24
	Total	18	2746.62	5869.53	4.65	22525.90	100.00
Cloth	Dotcom	17	31.07	44.53	3.58	184.00	0.42
	Multi	51	2437.35	3657.40	200.00	19566.00	99.58
	Total	68	1835.78	3329.40	3.58	19566.00	100.00
Dept	Dotcom	5	1568.95	2997.24	46.00	6921.12	1.52
	Multi	15	33951.70	71268.26	649.00	285200.00	98.48
	Total	20	25856.01	62860.18	46.00	285200.00	100.00
Drug	Dotcom	5	152.27	129.22	36.25	360.10	0.41
	Multi	10	18696.05	17625.36	360.00	39897.00	99.59
	Total	15	12514.79	16780.48	36.25	39897.00	100.00
Elect	Dotcom	12	129.85	287.53	5.70	1000.00	0.57
	Multi	15	18012.44	26927.59	100.00	79905.00	99.43
	Total	27	10064.62	21736.32	5.70	79905.00	100.00
Flow	Dotcom	7	42.33	46.55	4.00	128.80	4.65
	Multi	5	1215.42	1829.73	55.83	4466.00	95.35
	Total	12	531.11	1258.37	4.00	4466.00	100.00
Hard	Dotcom	3	26.29	18.60	11.00	47.00	0.07
	Multi	3	36768.00	36172.98	750.00	73094.00	99.93
	Total	6	18397.14	30469.33	11.00	73094.00	100.00
House	Dotcom	15	24.47	19.45	4.22	68.70	1.86
	Multi	13	1491.03	1429.58	187.44	5150.00	98.14
	Total	28	705.37	1209.66	4.22	5150.00	100.00
Jewel	Dotcom	5	53.91	66.73	7.47	169.24	5.64
	Multi	2	2254.64	70.43	2204.83	2304.44	94.36
	Total	7	682.69	1075.61	7.47	2304.44	100.00
Offi	Dotcom	3	10.98	4.56	6.80	15.85	0.08
	Multi	4	10398.50	6766.94	275.43	14448.38	99.92
	Total	7	5946.71	7329.70	6.80	14448.38	100.00
Spec	Dotcom	19	21.64	19.12	3.30	69.70	1.48
	Multi	12	2274.48	2649.48	186.35	8666.00	98.52
	Total	31	893.71	1954.07	3.30	8666.00	100.00
Sport	Dotcom	7	15.42	13.54	3.91	39.60	1.11
	Multi	8	1205.63	840.97	233.00	2435.86	98.89
	Total	15	650.20	855.25	3.91	2435.86	100.00
Toys	Dotcom	3	19.08	16.57	8.00	38.13	0.27
	Multi	8	2688.31	3550.24	301.66	11100.00	99.73
	Total	11	1960.34	3221.41	8.00	11100.00	100.00

* Dotcom refers to online-only retailers; Multi refers to multichannel retailers who sell through both online and offline channels.

Table A3. **Multichannel Effects: γ**

Category	Online Sales	Total Sales
Beaut	1.18*	4.41***
	[0.76]	[0.80]
Book	-0.32	4.61***
	[0.54]	[0.74]
Cloth	0.41*	4.46***
	[0.32]	[0.33]
Dept	-0.78	3.46***
	[0.91]	[0.92]
Drug	-1.49***	4.14***
	[0.48]	[0.70]
Elect	1.89***	5.04***
	[0.60]	[0.70]
Flow	0.09	3.17***
	[0.72]	[0.83]
Hard	0.07	6.35***
	[0.67]	[1.28]
House	0.12	4.05***
	[0.31]	[0.37]
Jewel	-0.36	4.32***
	[0.60]	[0.51]
Offi	2.63***	6.21***
	[1.04]	[0.92]
Spec	0.65**	4.32***
	[0.29]	[0.44]
Sport	0.48*	4.40***
	[0.38]	[0.45]
Toys	0.13	4.58***
	[0.52]	[0.58]
Observations	400	275
Adjusted R^2	0.23	0.76

Robust Standard Errors in the brackets;

One-sided *t* test significance level: *** 1%, ** 5%, *10%.

Table A4. Multichannel Effects: α (Store Retailer) and β (Direct Retailer)

Category	Online Sales		Total Sales	
	α (store retailer)	β (direct retailer)	α (store retailer)	β (direct retailer)
Beaut	0.62	2.31***	4.75***	4.07***
	[0.96]	[0.59]	[0.68]	[1.39]
Book	-0.32	N/A	4.61***	N/A
	[0.55]		[0.75]	
Cloth	0.14	1.54***	4.60***	4.00***
	[0.32]	[0.41]	[0.34]	[0.44]
Dept	-0.76	-0.82	4.14***	2.10**
	[1.00]	[0.99]	[0.94]	[0.93]
Drug	-1.62***	0.29	4.20***	3.57***
	[0.48]	[0.38]	[0.77]	[0.39]
Elect	1.78***	2.50***	5.35***	3.78***
	[0.64]	[0.81]	[0.77]	[0.98]
Flow	-0.18	0.61	3.85***	2.16**
	[0.79]	[1.08]	[0.85]	[1.05]
Hard	-0.07	0.42	7.76***	3.53***
	[0.81]	[0.89]	[0.45]	[0.37]
House	0.01	0.54	4.19***	3.60***
	[0.32]	[0.52]	[0.41]	[0.45]
Jewel	-0.37	N/A	4.32***	N/A
	[0.61]		[0.52]	
Offi	3.27***	-0.58***	6.21***	N/A
	[1.02]	[0.21]	[0.94]	
Spec	0.44*	1.27***	4.39***	4.20***
	[0.29]	[0.53]	[0.49]	[0.82]
Sport	0.34	1.11*	4.28***	4.60***
	[0.38]	[0.69]	[0.57]	[0.47]
Toys	0.13	N/A	4.58***	N/A
	[0.52]		[0.59]	
Observations	400		275	
Adjusted R^2	0.28		0.78	

Robust Standard Errors in the brackets;

One-sided *t* test significance level: *** 1%, ** 5%, *10%.

N/A: not available because of no observation.

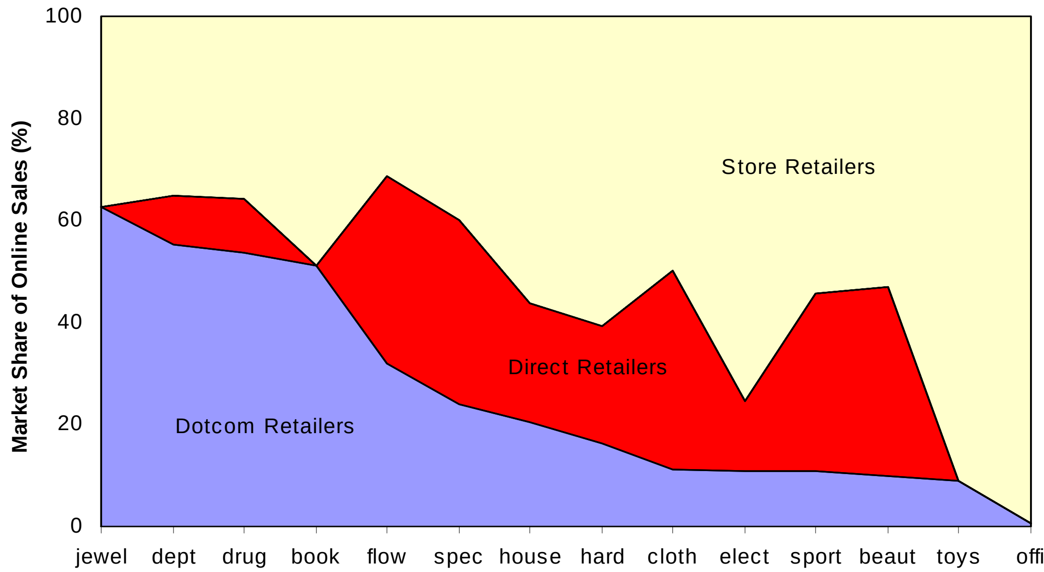

Figure 13: Market Share of Online Sales

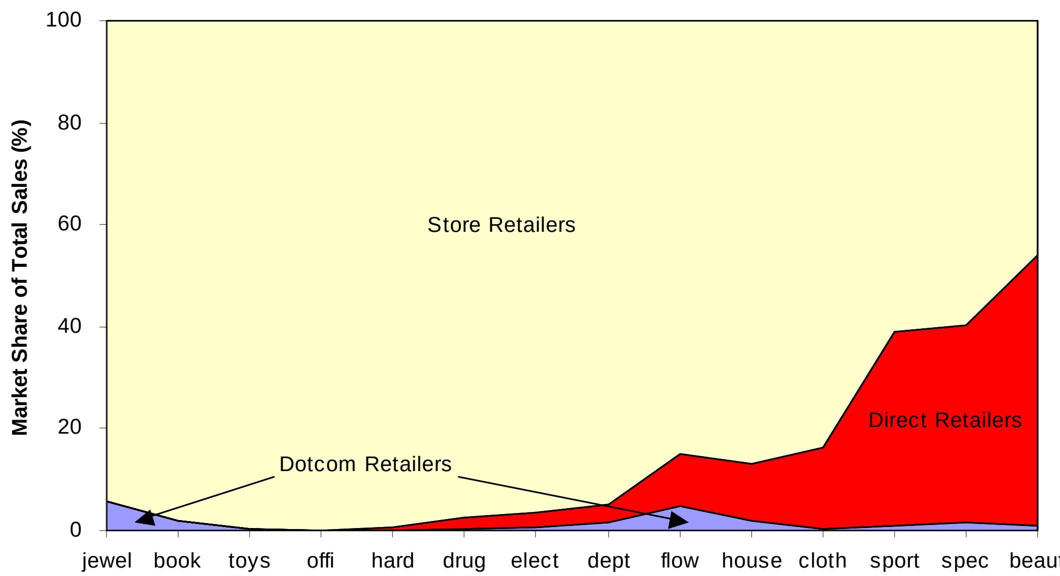

Figure 14: Market Share of Total Sales (Online and Offline)