Technology Innovation and Market Turbulence

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Abstract

This paper explains market turbulence, such as the recent dotcom shakeout, as a competitive equilibrium outcome. When a major technology innovation arrives, a wave of new firms enter the market implementing the innovation for profits. However, if the new technology 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. Empirical evidence from retail industry and banking industry supports the theoretical findings.

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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 mania has presented itself as a dramatic example of this process.

Internet technology became commercially available in the middle of 1990s. Soon after that, 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
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\(^1\) new substantial dotcom companies were established, most with a vision of generating huge market values after taking the firm public. The boom fueled tremendous excitement and speculation throughout the business world.

However, the spring of year 2000 was a turning point. From then on, dotcom firms started suffering a severe shakeout. In the following three years, nearly 5,000 dotcom companies exited, of which at least 3892 were sold and 962 closed or declared bankruptcy\(^2\). Meanwhile, from peak to bottom the Dow Jones Internet stock index\(^3\) plummeted by 93\%, and the Nasdaq composite lost 78\% of its value. The plots of Dow Jones Internet stock index and number of dotcom shutdowns are presented in Figure 1.

What could be the underlying mechanism? To answer this question, there have been several theories. Most of them appeal to financial bubble, rational or irrational (Shiller 2000, Abreu and Brunnermeier 2003, Ofek & Richardson 2003, LeRoy 2004). However, as Garber (2000) has persuasively argued, “[bubble] is a fuzzy word filled with import but lacking a solid operational definition. Thus, one can make whatever

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\(^1\)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

More important, even if a bubble did exist, it still remains a puzzle that 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, uncertainty about future profitability (Pastor and Veronesi 2004), length of pre-production (Jovanovic 2004) or the 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-
commerce sales as a percent of total retail sales\textsuperscript{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\textsuperscript{5}, suggests that the driving force is indeed the increasing online presence of traditional brick-and-mortar firms. 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, in particular, online pure plays vs. traditional brick-and-mortar firms.

\textsuperscript{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).

Here comes 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 & McDonald (1994). 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 does help explain the timing and financial loss of the shakeout. Moreover, this paper considers explicitly each individual firm’s uncertainty in learning about new technology, which explains the delayed adoption 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).

The paper is organized as follows. Section 2 presents the model, in which we study competitive industry dynamics reacting to an exogenous technology innovation. De-
pending 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 the 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. In particular, we show that empirical evidence on retail industry and banking industry support the 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, and 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 $\pi^\theta$. A firm’s technology can be in one of four states. The first is a primitive one $\theta$ 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 $\pi^\theta$, 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 $\sigma$. As the result, two new types of firms, in addition to the traditional *brick* one, may present 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 learning the new technology, he then becomes a *hybrid* firm. Therefore, driven by 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 of 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 $\pi^\theta$ 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 $\pi_i^b$, which is a standard profit function that depends on price $P_i$ and technology $b$, i.e.

$$\pi_i^b = \max\{P_iq_i^b - C_b(q_i^b)\}$$

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

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

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

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

where $U_t^\theta$ ($U_t^b$) is the maximum value of a firm with technology $\theta$ ($b$) at time $t$, and $\beta$ is the discount factor.

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, we have

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

which implies that

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

so that

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

(3)
In addition, the demand equals supply at the equilibrium, hence we have

\[ Q = D(P^*) = N^b q^b(P^*) \]  

(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 \( \theta \) 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 about entry and exit. The optimal decision problems for each type of firms at each time \( t \geq T \) are listed as follows:

\[ V^\theta_t = \pi^\theta + \max \{ \beta V^\theta_{t+1}, \beta V^b_{t+1} - S_b, \beta[\sigma V^c_{t+1} + (1 - \sigma)V^\theta_{t+1}] - S_c \} \]

\[ \beta[\sigma V^h_{t+1} + (1 - \sigma)V^b_{t+1}] - S_b - S_c \]  

(5)

\[ V^b_t = \max \{ \pi^\theta, \pi^b_t \} + \max \{ \beta V^b_{t+1}, \beta[\sigma V^h_{t+1} + (1 - \sigma)V^b_{t+1}] - S_c \} \]

(6)

\[ V^c_t = \max \{ \pi^\theta, \pi^c_t \} + \max \{ \beta V^c_{t+1}, \beta V^h_{t+1} - S_b \} \]

(7)

\[ V^h_t = \max \{ \pi^\theta, \pi^b_t, \pi^c_t, \pi^h_t \} + \beta V^h_{t+1} \]

(8)

Equations 5 to 8 say the following.

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• A firm with primitive technology $\theta$ 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 $\sigma$). 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 $\sigma$), 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 $\sigma$), 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 $\theta$, $b$, $c$ or $h$ to pursue the highest profit.

Depending on the value of parameters, the resulting equilibrium time paths could be quite many. 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 investment to start an online store which can then serve the national or even international mar-
ket. However, the cost would be prohibitive to reach that extent of a market using the traditional brick-and-mortar technology. Therefore, the equations 5 to 8 can be simplified as follows.

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

Now the equilibrium time paths depend on how the new technology \( c \) is related to the traditional one \( b \). In the following, we discuss two scenarios. First, we 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, we have \( \pi_t^h > \pi_t^c \) and \( \pi_t^h > \pi_t^b \). 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 \( n_t \equiv (n_t^a, n_t^b, n_t^c, n_t^h) \). 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, $N^\theta$ type-$\theta$ firms attempt entering the market with technology $c$. For those firms, the free entry condition requires that

$$\beta V^\theta_{T+1} = \beta[\sigma V^c_{T+1} + (1 - \sigma)V^\theta_{T+1}] - S_c$$

which implies

$$V^c_{T+1} - V^\theta_{T+1} = \frac{S_c}{\beta \sigma} \quad (13)$$

Given that $S_c$ is sufficiently small, the existing $N^b$ brick firms will also find it profitable to upgrade the technology\textsuperscript{6}. 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 $N^\theta$ entry attempts, a fraction of $\sigma$ turns out to succeed. Hence there will be $n^\theta_{T+1} = \sigma N^\theta$ 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 $\sigma$ 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-$\theta$ 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.

\textsuperscript{6}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.
Hence for $T + 1 \leq t < T^c$, the number of each type of participating firms is

$$n^b_t = N^b(1 - \sigma)^{t - T}$$
$$n^c_t = N^c$$
$$n^b_t = N^b - n^b_t = N^b[1 - (1 - \sigma)^{t - T}]$$

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

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

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

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

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

$$x^c_{T^c} = N^c - n^c_{T^c}$$

(14)

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

$$x^c_tq^c(P^c) = (n^h_t - n^h_{t-1})(q^h(P^c) - q^b(P^c))$$
$$= N^b\sigma(1 - \sigma)^{t-(T+1)}[q^b(P^c) - q^b(P^c)]$$

It implies that

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

(16)
In the long run, if we have \( n^c_T \cdot q^c(P^c) \geq n^b_T \cdot [q^b(P^c) - q^b(P^c)] \), 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 \( n^c_T \cdot q^c(P^c) < n^b_T \cdot [q^h(P^c) - q^b(P^c)] \), then the market price will eventually fall again and the shakeout of brick firms may also be possible.

To complete the model, notice that \( N^\theta \) 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 \( T^c - 1 \geq t \geq T + 1 \),

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

and for \( t = T^c \),

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

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

**Proposition 1** The value of a click firm rises from \( V^\theta \) at time \( T \) to \( V^\theta + \frac{S_c}{\beta\sigma} \) at time \( T + 1 \), and then declines back to \( V^\theta \) at time \( T^c \) and afterwards. In the meantime, it enjoys a high market-to-book value\(^7\), i.e. \( V_i^c/V^\theta > 1 \).

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

\(^7\)This high market-to-book value is due to the survivor bias. Using an alternative measure of the book value \( V^\theta + S_c \), it still holds for some time after time \( T + 1 \) (i.e. \( V_i^c/(V^\theta + S_c) > 1 \)).
In the meantime, we have

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

\[
V^c_{T^c>t>T+c} = V^\theta + \sum_{t=T+1}^{T+c-1} \beta^{t-T} [\pi^c(P_t) - \pi^\theta] = \frac{\partial V^c_{T^c>t>T+c}}{\partial t} < 0
\]

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

**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 \(\frac{\partial x^c_t}{\partial t} < 0\) 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 \(\alpha\) of sales is conducted using the online channel and is counted as e-commerce sales.

**Proposition 3** If \(\alpha\) is large enough, 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

\[
s_t = 1 - \frac{N^b(1 - \sigma)^{t-T} q^b(P_t)}{Q(P_t)} + (1 - \alpha)N^b[1 - \sigma)^{t-T}]q^b(P_t)
\]

\[
s_c, t = \frac{s_t q^c(P_t)}{s_t Q(P_t)}
\]

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Hence, if $\alpha > 1 - \left( \frac{q^b}{q^h} \right)$, we have $\partial s_t / \partial t > 0$ and $\partial s_{e,t} / \partial t < 0$ 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 $T^c + 1$;

- The value of a click firm rises from $V^\theta$ at time $T$ to $V^\theta + \frac{S_x}{\mu_0}$ at time $T + 1$, and then declines back to $V^\theta$ at time $T^c$ and afterwards. In the meantime, it enjoys a high market-to-book value, i.e. $V^c_t / V^\theta > 1$;

- 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: $\pi^{h}_t > \pi^{c}_t > \pi^{b}_t$ The above analysis can be similarly applied to the second case, in which we have $\pi^{h}_t > \pi^{c}_t > \pi^{b}_t$ and $q^{h}_t > q^{c}_t > q^{b}_t$. In particular, the equilibrium industry dynamics until time $T + 1$ are exactly the same as last case: At time $T$, $N^\theta$ type-$\theta$ firms as well as $N^b$ existing brick firms attempt adopting the new technology c, but price and output do not change. At time $T + 1$, $\sigma N^\theta$ click firms and $\sigma N^b$ hybrid firms succeed implementing the new technology. As the supply increases, the price declines, and no more type-$\theta$ 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 the brick firms are continuously working on the technology upgrading. As the result, the price will eventually fall to a critical value $P^c$ at time $T^c$ that click firms start to exit.

### 2.3.2 Dominant Innovation

If the innovation dominates the traditional technology, we have $\pi^{c}_t > \pi^{h}_t$ and $\pi^{c}_t > \pi^{b}_t$.

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

\[ V_{T+1}^c - V_{T+1}^\theta = \frac{S_c}{\beta \sigma} \]

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 \( N^\theta \) attempts for technology upgrading at time \( T \) (notice that the \( N^\theta \) attempts may include both type-\( \theta \) and brick firms because they have the same opportunity cost \( \pi^\theta \)), \( \sigma N^\theta \) 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;
- The value of a click firm rises from \( V^\theta \) 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, i.e. \( V_t^c/V^\theta > 1 \);
Figure 5: Dynamics of Stock Value and Firm Exits: Dominant Innovation

- 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 remaining in the market. The corresponding conditions are

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

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

$$Q = D(P^*) = \sigma N^0 q^c(P^*) + N^b q^b(P^*)$$
which implies that $N^\theta$ type-$\theta$ firms attempt to enter with technology $c$ at time $T$ (notice that no brick firm would try learning technology $c$ because of the higher opportunity cost, i.e. $\pi^b(P^*) > \pi^\theta$), and the fraction $\sigma$ of them succeed at time $T + 1$ From then on, $\sigma N^\theta$ click firms and $N^b$ brick firms are in the market, and there will be no more dynamics.

2.4 Aggregate Uncertainty and Financial Loss

The above analysis has suggested that a shakeout would occur to new entrants if the innovation that they rely on is rather a complement than a replacement for the existing technology. It is indeed the key reason for the dotcom shakeout, as we will show with more empirical evidence in the next section. However, before we move on, there is an important question that we have not answered: why has market seen a huge financial loss during the dotcom shakeout?

A simple extension of our model can address this issue. So far, we have assumed no aggregate uncertainty associated with the innovation, hence a shakeout does not incur financial loss$^8$. However, it is very plausible that the aggregate uncertainty exists. In fact, it took quite a time for the market participants to understand the competitive disadvantages of online-only business model. Therefore, a financial loss can easily result from any ex ante overestimation of the dotcoms’ potential.

To see that, let us assume that at time $T$, firms have to make their decisions on adopting the Internet innovation based on their expected profits: $E(\pi^c)$ and $E(\pi^h)$.

---

$^8$Notice that some new entrants, who fail learning the innovation and exit, do have financial losses. However, that risk is idiosyncratic and can be insured, e.g. a venture capitalist typically diversify his investment portfolio over many entry attempts.
If \textit{ex ante} the market expects the innovation dominates the old technology and that results in an over entry of dotcom firms, i.e. $N_{\theta_i} > N_{\theta}$, then when the truth is revealed \textit{ex post} at time $T + 1$ we will observe that all entrants suffer financial loss. The 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 are going to observe that with over entry the shakeout arrives earlier and is severer than the counterfactual case. To elaborate on that, let us use $N_{\theta_i}, P'_t, T', x'_t, V'_{T+1}$ for corresponding notations under imperfect information. Recall conditions 17–19. Notice that $N_{\theta_i}(> N_{\theta})$ is now exogenously given at time $T + 1$, so that for $T' - 1 \geq t \geq T + 1$, Equation 18 has to be rewritten as

\[
V^i + S_i > 0
\]

\[
\text{Dotcom Stock Value (Actual)}
\]

\[
\text{Number of Dotcom Exit (Actual)}
\]

\[
\text{Number of Dotcom Exit (Expected)}
\]

\[
\text{Time}
\]
\[ P'_t = D^{-1}\{N^\theta\sigma q^c(P'_t) + N^b(1-\sigma)^{t-T}q^b(P'_t) + N^b[1-(1-\sigma)^{t-T}]q^h(P'_t)\} \]

which implies a lower price path: \( P'_t < P_t \). Because the timing of exit \( T^{c'} \) is the first time period that the following condition holds,

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

it is straightforward to see that the shakeout arrives earlier \( T^{c'} < T^c \). Furthermore, the condition 17 no longer holds, so all dotcoms suffer loss of value:

\[ V^c_{T+1} - V^\theta_{T+1} = \sum_{t=T+1}^{T^{c'}-1} \beta^{t-(T+1)}[\pi^c(P'_t) - \pi^\theta] < \sum_{t=T+1}^{T^c-1} \beta^{t-(T+1)}[\pi^c(P_t) - \pi^\theta] = \frac{S_c}{\beta \sigma} \]

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:

\[
\sum_{t=T^c}^{T^e} x_t^c - x_{T^c}^c = N^0\sigma - N^0\sigma > 0
\]

For any periods after time \(T^c\), Equation 16 suggest the number of exits is the same as the counterfactual case:

\[
x_t^c = \frac{N^h\sigma(1 - \sigma)^t - (T^c)(q^h(P^c) - q^b(P^c))}{q^c(P^c)} = x_t^c
\]

The comparison of industry dynamics is illustrated with Figure 7.

### 3 Empirical Evidence

From the discussion above, 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 all 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 ones. The central advantage stems from the reduced overhead investment. By eliminating its physical operations, the pure plays can substantially lower the entry cost into the market. Moreover, the
Internet firms enjoy many further advantages including access to wider markets, lower inventory costs, flexibility in sourcing inputs, improved transaction automation and data mining capabilities, ability to bypass intermediaries, lower menu costs enabling more rapid response to market changes, ease of bundling complementary products, ease of offering 24-by-7 access, and no limitation on depth of information provided to potential customers (Afuah and Tucci 2001).

However, it was soon found out that eschewing physical space for cyberspace does not come without costs. Above all, different distribution channels are not perfect substitutes. Internet shopping fits better with standardized goods and services, which do not require personal contact or a large physical shopping space. However, it fits less for so called “experience” goods and services, for which consumers have to get first-hand experience. Also Internet firms incur extra costs by running a high-tech system that requires a more expensive labor force and by offering additional physical delivery channels.

Most important, as more and more brick-and-mortar firms start promoting their online presence to become click-and-mortar ones, the dotcoms are put into a serious disadvantage. Click-and-mortar firms create a multichannel enterprise that is greater than the sum of the individual channels given a great source of synergy across the online and offline channels. Among them are common infrastructures, common operations, common marketing, and common customers as listed in Steinfield (2002)\(^9\).

\(^9\)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.
These various sources of synergy is represented in the many forms of complementary assets that click-and-mortar firms possess such as existing supplier and distributor relationships, experience in the market, a customer base, and other complementary assets that can enable them to take better advantage of an innovation like e-commerce (Otto and Chung 2000; Steinfield, Adelaar and Lai 2002). Therefore, it is not a surprise to see that dotcoms did not fare well in the market, which is clearly shown in the following empirical evidence.

3.2 Dotcoms in Retail Industry

For the retail industry, Rasheed & Geiger (2004) analyzed a data set of 240 firms engaged in Internet-based consumer marketing, with 58% are click-and-mortar while 42% are pure plays. They show that click-and-mortar firms enjoy advantage over pure plays in advertising, promotion and brand recognition, and also have higher profit expectations than pure plays.

This result is confirmed by The State of Retailing Online 6.0 (2003), an annual survey conducted by Shop.org, Boston Consulting Group and Forrester Research based on 130 retailers. It shows online pure plays have consistently higher marketing 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 be able to meet customers' needs for both convenience and immediacy, for example, to allow consumers to buy online and return offline, or to try a product in the store and then buy it online.
cost, consumer acquisition cost, but lower profit margin than multichannels in their online operations. In addition, more and more offline retailers are getting online to explore the synergy across channels. Up to year 2003, of the top 100 retailers, 66% currently sell online, with average sales hitting the $100 to $250 million range. As the result, online sales now closely mirror offline sales: with the exception of Amazon.com and eBay, the majority of online sales are closed by the same retailers that dominate offline sales.

Table 1. Top 10 E-Retailers in 2002

<table>
<thead>
<tr>
<th>Rank</th>
<th>E-Retailers¹⁰</th>
<th>Online Revenue ($ millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>* Amazon.com</td>
<td>3,687</td>
</tr>
<tr>
<td>2</td>
<td>Office Depot</td>
<td>2,100</td>
</tr>
<tr>
<td>3</td>
<td>Staples</td>
<td>1,600</td>
</tr>
<tr>
<td>4</td>
<td>Gateway</td>
<td>650</td>
</tr>
<tr>
<td>5</td>
<td>Sears</td>
<td>600</td>
</tr>
<tr>
<td>6</td>
<td>Barnes &amp; Noble</td>
<td>423</td>
</tr>
<tr>
<td>7</td>
<td>* Buy.com</td>
<td>419</td>
</tr>
<tr>
<td>8</td>
<td>QVC</td>
<td>401</td>
</tr>
<tr>
<td>9</td>
<td>JC Penny</td>
<td>381</td>
</tr>
<tr>
<td>10</td>
<td>Spiegel Group</td>
<td>355</td>
</tr>
</tbody>
</table>

* Online-only retailers

¹⁰The Top 10 E-retailers include only two pure plays - Amazon.com and Buy.com, and even Amazon is leaning more and more toward multichannel status. Notice that the online auction house eBay is not included in the list since the goods sold over eBay are used.
According to Retail Forward’s annual study of the Top 50 E-Retailers\(^ {11}\) in year 2002, eight of the top ten E-retailers are multichannel players (see Table 1) which is an increase from only five in 2000 and three in 1999. Additionally, multichannel players comprise 43 of the Top 50 E-retailers on the list compared to only 27 in 1999.

### 3.3 Dotcoms in Banking Industry

The history of online banking provides another good testimony. The beginning of "Internet era" in banking service can be traced back to year 1995, when Wells Fargo became the first bank to offer its customer online-access to account statement, and Security First Network Bank became the first online-only bank. The next a few years was more or less an experiment stage, at which the industry witnessed a relatively slow adoption of the Internet technology – up to year 1998, 6% national banks had offered transactional Internet services, and 7 banks offered online-only services. Then the diffusion of online banking took off in year 1999 and 2000. By the end of year 2000, 37% national banks offered transactional Internet banking, and about 40 new dotcom banks entered the market. However, a shakeout started striking the dotcom banks in year 2001. As shown in Figure 8, the stock index\(^ {12}\) for dotcom banks dropped by 80%, and 20 dotcoms\(^ {13}\) exited the banking industry by year 2003.

\(^{11}\)To be considered for inclusion on Retail Forward’s Top 50 E-Retailers list, the company must generate at least 50 percent of its sales from direct-to-consumer retail operations, including stores, catalogs, and other direct marketing vehicles (i.e., be a retailer).

\(^{12}\)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 (NTBK), E*trade Bank (ET), USA Bancshares (USAB) and American Bank (AMBK).

As our model has suggested, the key to explaining the dotcom shakeout in the banking industry is to compare the competitive positions of pure Internet banks against their branching competitors. Similar to the retail industry, the core strategy of 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 9 shows clearly that the number of brick-and-mortar bank offices\textsuperscript{14} has actually been increasing since mid 1990s together with the increasing adoption of online banking\textsuperscript{15}.

To explore the synergy between online and offline channels, a click-and-mortar

\textsuperscript{14}Data Source: Summary of Deposits, FDIC/OTS (2004).
\textsuperscript{15}Data Source: adoption rates before year 2001 are from the OCC which covers all national banks; adoption rates after 2003 are from the Call Report which covers all commercial banks.
bank typically routes standardized, low-value-added transactions (e.g. bill payments, balance inquiries, account transfer, credit card lending) through the inexpensive Internet channel, while routing specialized, high-value-added transactions (e.g. small business lending, personal trust services, investment banking) through the more expensive branch channel. By providing more service options to its customer, 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 and their branching counterparts during 1997-2001. The results show that Internet-only banks on average have lower asset return. That is due to their lower interest margins and fee income, lower levels of loan and deposit generation, lower business loans, and higher noninterest expense on equipment and skilled labor.
These results are robust after controlling age and survivorship (see Table 2 in the Appendix).

### Table 3. GomexPro Ranking of Online Banking Service

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>* SFNB</td>
<td>Citibank</td>
<td>Citibank</td>
</tr>
<tr>
<td>2</td>
<td>Wells Fargo</td>
<td>* FIBI</td>
<td>Bank of America</td>
</tr>
<tr>
<td>3</td>
<td>* NetBank</td>
<td>* NetBank</td>
<td>Wells Fargo</td>
</tr>
<tr>
<td>4</td>
<td>* FIBI</td>
<td>Bank of America</td>
<td>Charter One</td>
</tr>
<tr>
<td>5</td>
<td>* Wingspan</td>
<td>Bank One</td>
<td>Huntington</td>
</tr>
<tr>
<td>6</td>
<td>* CompuBank</td>
<td>Wells Fargo</td>
<td>Chase</td>
</tr>
<tr>
<td>7</td>
<td>Bank One</td>
<td>Key Bank</td>
<td>* E*trade Bank</td>
</tr>
<tr>
<td>8</td>
<td>Citibank</td>
<td>First Tennessee</td>
<td>National City Bank</td>
</tr>
<tr>
<td>9</td>
<td>* USAccess</td>
<td>Fleet</td>
<td>Key Bank</td>
</tr>
<tr>
<td>10</td>
<td>Huntington</td>
<td>Charter One</td>
<td>HSBC</td>
</tr>
</tbody>
</table>

\(^*\) Online-only Bank

As more and more banks get online, the competitive pressure in the online banking market has surely increased. According to the Call Report, 75% depository institutions have adopted Web site in year 2004 compared to 35% in 1999, and 60% reported Web sites with transaction capability in 2004 compared to 37% in 2000. Even more important, the online technology gap between pure-play banks and traditional banks has also been closing. Based on the research conducted by GomexPro on bank online

\(^{16}\)SFNB: Security First Network Bank; FIBI: First Internet Bank of Indiana.
The pure-play banks dominated online service in year 1999 with six of them leading the Top 10 list, but the number dropped to two in 2001, and to one in 2003 (see Table 3).

Table 4. Traffic to Banking Sites: Home & Work Users (1,000)

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

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.
As the result, the online-only banks have steadily lost market shares to their multichannel competitors. As the Media Metrix traffic data revealed, the number of unique visitors to multichannel banks climbed from 6.4 million in July 2000 to 13.4 million in July 2001, while the traffic to online-only banks fell from 1.2 million to 1.1 million (see Table 4). In the meantime, the shakeout of online-only bank started in year 2000, with the number declining from around 50 in 2000 to about 30 in 2003.

4 Final Remarks

This paper explains market turbulence, such as the recent dotcom shakeout, as competitive equilibrium dynamics resulting from a complementary technology innovation. The shakeout of new entrants tend to occur if the following conditions are met: (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 existing technology; (3) it takes time for the innovation to diffuse among incumbents using traditional technology. Empirical evidence reveals that those are indeed the features 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 does 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.
Appendix:

Table 2. Performance Comparison 1997 Q2 – 2001 Q2

<table>
<thead>
<tr>
<th>Variables</th>
<th>Branch BK (Established)</th>
<th>Branch BK (New)</th>
<th>Dotcom BK (Full Sample)</th>
<th>Dotcom BK (Survivors)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Size</td>
<td>48,146</td>
<td>4,667</td>
<td>75</td>
<td>49</td>
</tr>
<tr>
<td>Sample Mean</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (quarters)</td>
<td>244.24</td>
<td>4.81</td>
<td>4.29</td>
<td>4.37</td>
</tr>
<tr>
<td>Asset ($1000)</td>
<td>192,039</td>
<td>48,668</td>
<td>221,661</td>
<td>251,724</td>
</tr>
<tr>
<td>ROA</td>
<td>0.0109</td>
<td>-0.0134</td>
<td>-0.0431</td>
<td>-0.0240</td>
</tr>
<tr>
<td>ROE</td>
<td>0.1187</td>
<td>-0.0467</td>
<td>-0.1842</td>
<td>-0.1111</td>
</tr>
<tr>
<td>Loan-rate</td>
<td>0.0906</td>
<td>0.0807</td>
<td>0.0629</td>
<td>0.0586</td>
</tr>
<tr>
<td>Dep-rate</td>
<td>0.0358</td>
<td>0.0383</td>
<td>0.0451</td>
<td>0.0461</td>
</tr>
<tr>
<td>Loans</td>
<td>0.6141</td>
<td>0.5740</td>
<td>0.4718</td>
<td>0.5594</td>
</tr>
<tr>
<td>Deposits</td>
<td>0.8450</td>
<td>0.7750</td>
<td>0.6958</td>
<td>0.7124</td>
</tr>
<tr>
<td>Fees</td>
<td>0.0108</td>
<td>0.0071</td>
<td>0.0035</td>
<td>0.0031</td>
</tr>
<tr>
<td>Wage ($1000)</td>
<td>43.54</td>
<td>54.87</td>
<td>73.05</td>
<td>70.90</td>
</tr>
<tr>
<td>Prem-exp</td>
<td>0.0053</td>
<td>0.0085</td>
<td>0.0134</td>
<td>0.0089</td>
</tr>
<tr>
<td>Overhead</td>
<td>0.0198</td>
<td>0.0356</td>
<td>0.0213</td>
<td>0.0143</td>
</tr>
<tr>
<td>% Business</td>
<td>0.1994</td>
<td>0.2744</td>
<td>0.0654</td>
<td>0.0415</td>
</tr>
</tbody>
</table>

The above table is adapted from Table 2 in DeYoung (2005). It compares mean performance of four groups of banks. Column [1] covers 3,777 small, established banks and thrifts (assets less than $1 billion and at least 10 years old) in urban U.S. markets.

Variables are defined as follows. Age = number of quarters since the bank started; Assets = total assets; ROA = return on assets; ROE = return on equity; Loan-rate = interest and fees received on loans divided by loans; Dep-rate = interest paid on deposits divided by deposits; Loans = loans divided by assets; Deposits = deposits divided by assets; Fees = noninterest income divided by assets; Wage = salary and benefits expense divided by number of full-time employees; Prem-exp = expense on premises and equipment divided by assets; Overhead = book value of physical assets divided by assets; % Business = commercial and industrial loans divided by loans.

References


of the Currency.


