Technology Investment Decision-Making under Uncertainty in Mobile Payment Systems

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Introduction

• 2012 is the year in payments
• Mobile payments:
  • Near field communication (NFC)-enabled
  • Cloud-based
  • Third party app

- Google wallet
- Isis Mobile Wallet
- PayPal
- Square
- Intuit
- Apple Passbook
Motivation

• Uncertainties
  • Consumer demand
  • Multi-sided business platform
  • Revenue model and collaboration
  • NFC smartphones and merchant terminals
  • Technology standard and regulation

• Banks are key stakeholders in payments.
• Decision making under uncertainty
• Research Questions:
  • How can a bank maximize the business value of m-payments technology adoption under uncertainty?
  • How long can a bank postpone its investment and commitment to a specific technological solution?
Cost, Benefits and Deferral

- Investment time horizon \([0, T]\)

- Investment cost \(I\) follows geometric Brownian motion:

\[ dI = \alpha_I I dt + \sigma_I I dz, \quad \alpha_I < 0 \]

- Benefit flows \(B\) from time \(t\) to \(T\) follow geometric Brownian motion:

\[ dB = \alpha_B B dt + \sigma_B B dz, \quad \alpha_B > 0 \]
Model Preliminary

- No competitor, no correlation
- The value equals to integration over the interval \((t, T)\) is:
  \[
  V = \frac{B_0(t)}{r_f - (\alpha_B - \eta_B)} \left[1 - e^{-[r_f - (\alpha_B - \eta_B)](T-t)}\right]
  \]
- Expected investment cost \(I\) is:
  \[
  E[I(t)] = I_0 e^{(\alpha_I - \eta_I)t}
  \]
Real Option Value

• Deferral option:

\[ NPV^A = (V - I) + ROV = \max(V - I, 0) \]

\[ ROV = \max[0, I - V] \]

• By Bellman optimality equation, \( r_f ROV dt = E(dROV) \), we obtain:

\[ \frac{1}{2} \sigma_B^2 B^2 ROV_{BB} + \frac{1}{2} \sigma_l^2 l^2 ROV_{ll} + (\alpha_B - \eta_B) BROV_B + (\alpha_l - \eta_l)IROV_l + ROV_t - r_f ROV = 0 \]

Two boundary conditions:

\[ ROV(B, I, T) = 0, \]

\[ ROV(B, I, t) \geq 0 \quad \forall \ 0 \leq t < T \]
### Numerical Analysis

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
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<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$I_0$</td>
<td>Initial investment</td>
<td>$B_0(t)$</td>
<td>Initial benefit flow</td>
</tr>
<tr>
<td>$\alpha_I$</td>
<td>Rate of cost change</td>
<td>-0.1</td>
<td>$\alpha_B$</td>
</tr>
<tr>
<td>$\sigma_I$</td>
<td>Cost uncertainty</td>
<td>0.2</td>
<td>$\sigma_B$</td>
</tr>
<tr>
<td>$T$</td>
<td>Maximal deferral time</td>
<td>5 years</td>
<td>$r_f$</td>
</tr>
<tr>
<td>$N$</td>
<td>No. of simulated paths</td>
<td>100,000</td>
<td>$\Delta t$</td>
</tr>
</tbody>
</table>

**Investment timing benchmark simulation**

Average payoff (million $)

Optimal timing $t^* = 14$ month; Maximal payoff is $4.10$ million

![Graph showing the relationship between time and average payoff](image)
Sensitivity Analysis

Benchmark, $t^* = 14$

When $T = 6$ years, $t^* = 13$

When $T = 4$ years, $t^* = 15$

When $r_f = 0.5$, $t^* = 13$

When $r_f = 0.7$, $t^* = 16$

When $\alpha_B = 0.8$, $t^* = 11$

When $\alpha_B = 0.6$, $t^* = 18$
Google announced all the way back in November of 2011 that it would be shutting down Google Checkout in favor of a transition to Google Wallet.

This week, Google announced that in six months, Google Checkout will officially be dead to merchants. They will no longer be able to accept payments using Google Checkout starting November 20th.

“If you don’t have your own payment processing, you will need to transition to a different solution within six months,” says Google Wallet senior product manager Justin Lawyer. “To make things easier, we’ve partnered with Braintree, Shopify and Freshbooks to offer you discounted migration options.”

“If you are a U.S. merchant that does have payment processing, you can apply for Google Wallet Instant Buy, which offers a fast buying experience to Google Wallet shoppers,” adds Justin Lawyer.
Samsung Wallet launches in Korea, US beta now out to compete against Apple Passbook and Google Wallet

by J. Angelo Racoma on May 22, 2013 9:27 pm

Do you still bring your wallet everywhere you go? Chances are you still do, but with the rise of wallet and “passbook” apps, we might soon find no need to bring actual cash, tickets or coupons (except for that last one).
Jump Diffusion Process

- When jump events happen:

\[
\text{Benefit flow} = \text{Continuous Benefit Flows} + \text{Jump Value}
\]

\[
dB = (\alpha_B + \lambda k)Bdt + \sigma_B Bdz + (Y - 1)Bdq
\]

where

\[dq = \begin{cases} 
0 & \text{with probability } 1 - \lambda dt \\
1 & \text{with probability } \lambda dt
\end{cases}\]

<table>
<thead>
<tr>
<th>Description</th>
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<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\lambda) Mean jumps number</td>
<td>0.05</td>
<td>(k) % change of benefits</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Average payoff (million $)

- **Upward Jump at** \(t = 20, t^* = 12\)
- **Catastrophic Jump at** \(t = 10, t^* = 14\)

Benchmark, \(t^* = 14\)
Jump Diffusion Simulation

Upward jump at \( t = 10, t^* = 9 \)

Upward jump at \( t = 4, t^* = 14 \)

Catastrophic jump at \( t = 20, t^* = 20 \)

Catastrophic jump at \( t = 40, t^* = 15 \)

Average payoff (million $)

Time (in months)

Jump magnitude \((Y - 1)\)

Timing shift regions

Time (in months)
Requirements for Valuation

• Need to replicate characteristics of non-traded asset with one that is traded

• Financial economics uses the idea of “twin security”

• Two possibilities:
  – Use a single market-traded stock
  – Use a portfolio of traded stocks

• Goal: “Twin security” should have risk and return characteristics that roughly match the m-payment project

• No perfect match is possible, since the risk and reward characteristics of the m-payment project will not be entirely known
# Twin Security: Relevant Parameters

<table>
<thead>
<tr>
<th>Financial asset</th>
<th>Investment Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price</td>
<td>Project value (NPV)</td>
</tr>
<tr>
<td>Exercise price</td>
<td>Amount of investment</td>
</tr>
<tr>
<td>Volatility of the price [%]</td>
<td>Volatility of project value [%]</td>
</tr>
<tr>
<td>Term to maturity</td>
<td>Term period that option will exist</td>
</tr>
<tr>
<td>Risk-free rate [%]</td>
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</tr>
</tbody>
</table>

- The volatility of an investment project’s value cannot be directly observed; it must be estimated
- There is no historical data on the investment project, as there is with stock prices
- So the application of the method is an approximation
Valuing with Simulation: Least Squares Monte Carlo Method

- Longstaff and Schwartz (2001) provides a simulation-based method for valuing American options, which allows state variables to follow a jump diffusion process.
- Use the cross-sectional information in the simulated paths to identify a set of conditional expectation functions.
- Exploit the early exercise boundary with and without jumps.

![Graph showing early exercise boundary with jumps](image-url)
Conclusion

• Managerial implications
  • Investment in multi-sided business platform
  • First mover advantage vs. second mover advantage
  • Rational expectations of senior management

• Contribution
  • A new modeling perspective on how financial economics theory could support m-payments decision-making
  • Help senior manager estimate optimal timing and payoffs from m-payments
  • Use of jump diffusion process to model the dynamically changing of value of IT investment
Model Preliminary

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- Expected investment cost \(I\) is:
  \[
  E[I(t)] = I_0 e^{(\alpha_I - \eta_I) t}
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