Small Firm Innovative Investment, Bank Lending and Uncertainty

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Outline

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- If we add uncertainty this might – under some circumstances – turn around into overinvestment
- How does size of the firm affect this process?
- Empirical illustrations for Japanese data

Asymmetric information and underinvestment

- The firm typically knows more about the riskiness of an investment project than an external financier – for instance a bank
- Increasing the lending rate will attract more risky projects: a profit maximizing bank will be hesitant to increase the lending ate, because expected profits will decrease
- So it is likely that even profitable projects will be declined: underinvestment

Investment under uncertainty

- Investment can be seen as exercising a call option: buy a capital good
- If investment is irreversible, uncertainty will increase the value of waiting and so lead to lower investment
- Combining the result of asymmetric information and option theory though can lead to the opposite result: overinvestment!

A simple base model (1)

- A firm is identical to an investment project
- The size of investment $I = L + W$, where L represents the single external financing form – a loan – and W is internal wealth
- There are two states: good – leading to a return R_i – and bad (return = 0)
- There is an infinite amount of time periods. Investment takes place at $t = 0$. At $t = 1$ the true states of the world will be revealed

A simple base model (2)

- Information problem: the probability of success in only privately – that is by the firm – observed: q_i
- The bank is unable to observe q_i
- The expected return for all firms is equal $q_i R_i$. An increase in q_i implies a safer project (less uncertainty), but the expected returns of all firms are equal
- There is a feasible range for $q : 0 < q_0 \leq q_i \leq q_h < 1$
- There is a safe return μ and this is also the discount factor

A simple base model (3)

- The bank observes firms/projects which all have equal expected returns. If we label the returns in the first period F these total returns are $F + (q_i R_i)/\mu = A$
- So the bank can either store L at a safe rate μ or grant loans to a pool of applicants
- The problem is that the bank cannot observe q_i

Decision by the firm

- The firm invests if the expected risky returns are larger than storing the internal wealth W at the safe rate μ
- The expected returns from the project are:

$$(F - rL) + q_i(R_i - rL)/\mu$$

- One can now derive the marginal project m for which net profits are equal to 0:
- Take the $NPV = (F - rL) + q_i(R_i - rL)/\mu - (1 + \mu)W$. We describe this project by the marginal riskiness parameter q_m

NPV of the firm

- $NPV = (F - rL) + q_i(R_i - rL)/\mu - (1 + \mu)W$
- Using $F + (q_i R_i)/\mu = A$ we can rewrite into:

$$NPV = A - (1 + q_i/\mu)rL - (1 + \mu)W$$

- For a given interest rate r, the NPV is lower, the less risky the project is (the higher q_i is)
- So firms are risk-loving

What happens if the bank increases r?

- The bank might think that it will increase profits: higher returns on the loan
- But it is easy to see that the riskier firms have a stronger incentive to be willing to invest even in the costs increase
- In mathematical terms this is described by:

$$dq_m/dr = -(q_m + \mu)/r < 0$$

- The reservation rate – the cutoff lending rate above which the firm decides not to invest – is higher for high risk firms
- This is what we call adverse selection
- It is easy to show that in general equilibrium this leads to underinvestment (banks have an incentive to be risk adverse)

What about small firms?

- Firms might have a relatively low internal wealth W and so have to rely more on lending L to finance investment
- This might boil down to the assumption that smaller firms do have a higher leverage
- We are interested in the impact of a higher leverage on the underinvestment problem: does it become better or worse?

What happens at the margin?

- Remember that firms are risk loving, because $dNPV/dq_i < 0$ (and a lower q_i represents more risk)
- The cut-off marginal lending rate is

$$q_m = (\mu/rL)(A - (1+\mu)W) - \mu$$

- Which is higher for lower W' s, and

$$dq_m/dr = -(q_m + \mu)/r < 0$$

- So the adverse selection effect becomes stronger

Low-wealth investment

- There are two types of impact
- First, lower wealth reduces opportunity costs, making firms more eager to invest
- But the slope of dq_m/dr becomes larger in absolute terms
- Prediction is that the adverse-selection problem becomes stronger
- Testable hypothesis: information variables become more important in the investment equation

Option to delay investment

- Suppose we would have the time to wait and see how uncertainty about the future state evolves by postponing investment?
- What is the value of waiting? It is the difference between the NPV of investing at $t = 1$ compared to investing at $t = 0$
- If the option value V is positive, investment will be postponed; if $V < 0$, the firm will invest immediately
- Without information asymmetry it is most likely that uncertainty will have a negative impact on investment

The option value

- Suppose that the firm can wait and see how uncertainty is resolved at $t = 1$. We can compute the *NPV* of the project at $t = 1$:

$$q_i/\mu(R_i - \mu L) - q_i W$$

- Taking the difference with the NPV at $t = 0$, we get the option value:

$$V_i = -(F - rL) + (q_i L/\mu)(r - \mu) + W(1 - q_i) + \mu W$$

- If $V_i < 0$, the firm will invest immediately

Investment hurdle

- In general the hurdle to invest will be higher with an option to postpone
- We can see that $dV_i/dW > 0$, so lower internal wealth will decrease the option value and lead to higher immediate investment
- The impact of q_i on V_i is ambiguous: it depends on the model parameters whether high or low risk firms will wait to invest

Basic findings

- We are interested again in the sign of dq_m/dr
- If the sign is negative, we do have underinvestment - if it reverses we might have overinvestment
- It can be shown that in case $rL < \mu I$, or relatively low interest payments on the loan, low-risk projects will be carried out immediately and the probability of overinvestment increases
- For $rL > \mu I$, or even with no internal wealth ($W = 0$), we get the basic adverse selection effect, or underinvestment

Small firms: low internal wealth

- The option to wait will be less valuable: lower impact of uncertainty
- The sign of the slope of dq_m/dr is ambiguous, but the lower internal wealth W is, the more likely underinvestment occurs
- Without any internal wealth $W = 0$, we can see that: $dq_m/dr = -(qm + \mu)/(r + \mu) < 0$
- This impact is smaller compared to the case without the option to delay in absolute terms

Testable hypotheses

1. Small firms have lower internal wealth, so a higher leverage
2. Lower internal wealth leads to more asymmetric information problems
3. Lower wealth leads to a lower impact of uncertainty on investment
4. The combination of asymmetric information and uncertainty leads to a relatively smaller impact of asymmetric information for high leverage firms

Data and the econometric model

- Corporate financial data on large firms and SMEs of the Development Bank of Japan
- About 1,000 Manufacturing firms from 1970 to 2014: Unbalanced panel data
- Discussion based on the descriptive statistics
- Discussion based on the econometric model.

$$\frac{I}{K_{-1}} = f\left(M_q, \frac{CF}{k_{-1}}, UC, LV\right)$$

Japanese corporate financial data

Sample mean and median by firm size

	(1)	(2)	(3)	(4)	(5)	(6)
		mean			median	
	large firms	SMEs	Total	large firms	SMEs	Total
Number of employees	2,906	428	2,580	1,199	359	991
Capital*	16,892	631	14,752	5,684	600	4,463
Investment rate	0.113	0.113	0.113	0.089	0.084	0.089
Tobin's marginal q	1.173	1.240	1.181	0.872	0.961	0.882
Cash flow ratio	0.074	0.071	0.073	0.065	0.061	0.065
Uncertainty	0.084	0.103	0.087	0.067	0.085	0.069
Interest rate	0.046	0.066	0.048	0.038	0.071	0.042
Leverage	3.065	4.117	3.203	2.482	3.716	2.602
Number of observations	22,434	3,400	25,834	22,434	3,400	25,834

$*$ unit: million yen

Japanese corporate financial data

Correlation matrix of variables

	(1) I/K	(2) M_q	(3) CF	(4) UC	(5) IR	(6) LV
Large firms						
Investment rate	1					
Tobin's marginal q	0.2005	1				
Cash flow ratio	0.1176	0.3332	1			
Uncertainty	-0.0766	0.0109	-0.0369	1		
Interest rate	0.1354	-0.1676	-0.0713	0.0486	1	
Leverage	-0.0294	-0.2573	-0.1959	0.0925	0.4034	1
SMEs						
Investment rate	1					
Tobin's marginal q	0.1534	1				
Cash flow ratio	0.0998	0.2729	1			
Uncertainty	-0.0309	-0.0305	-0.0492	1		
Interest rate	0.1746	-0.1359	-0.0312	0.1441	1	
Leverage	0.0369	-0.2393	-0.1484	0.0953	0.2305	1

Japanese corporate financial data

Sample mean and median by leverage ratio: SMEs

	(1)	(2)	(3)	(4)	(5)	(6)
		mean			median	
	lower 33%	upper 33%	Total	lower 33%	upper 33%	Total
Number of employees	379	443	428	313	380	359
Capital*	646	613	631	604	600	600
Investment rate	0.111	0.117	0.113	0.082	0.085	0.084
Tobin's marginal q	1.565	0.953	1.240	1.212	0.769	0.961
Cash flow ratio	0.091	0.058	0.071	0.077	0.053	0.061
Uncertainty	0.095	0.109	0.103	0.077	0.091	0.085
Interest rate	0.057	0.073	0.066	0.060	0.078	0.071
Leverage	2.187	6.429	4.117	2.211	6.055	3.716
Number of observations	1,134	1,134	3,400	1,134	1,134	3,400

$*$ unit: million yen

Impact of leverage and uncertainty

Estimation result of the investment function by firm size

	(1) large firms	(2) SMEs	(3) large firms	(4) SMEs	(5) large firms	(6) SMEs
Tobin's marginal q	0.0287	0.0284	0.0286	0.0289	0.0285	0.0285
	(38.69)	(12.23)	(38.52)	(12.46)	(38.32)	(12.25)
Cash-flow ratio	0.0224	0.0644	0.0206	0.0655	0.0204	0.0654
	(3.13)	(3.34)	(2.87)	(3.39)	(2.84)	(3.39)
Uncertainty	-0.0472	-0.0469			-0.0464	-0.0473
	(4.48)	(1.61)			(4.41)	(1.62)
Leverage			-0.0021	0.0011	-0.0021	0.0011
			(4.13)	(0.74)	(4.05)	(0.77)
Constant term	0.1557	0.1925	0.1603	0.1809	0.1655	0.1872
	(37.63)	(22.91)	(34.47)	(17.83)	(34.51)	(17.25)
Overall R^2	0.1350	0.1018	0.1339	0.1002	0.1356	0.1030
N of observations	22,434	3,400	22,434	3,400	22,434	3,400
Hausman test	*F*	*F*	*F*	*F*	*F*	*F*

F and *R* stand for fixed and random effect model respectively.
Values in parenthesis are t-values for fixed effect model and z-values for random effect model.

Impact of leverage and uncertainty

Estimation result of the investment function for SMEs by leverage ratio

	(1) lower 33%	(2) upper 33%	(3) lower 33%	(4) upper 33%	(5) lower 33%	(6) upper 33%
Tobin's marginal q	0.0122	0.0267	0.0127	0.0279	0.0125	0.0273
	(4.84)	(4.58)	(5.09)	(4.74)	(4.98)	(4.64)
Cash-flow ratio	0.1042	0.0544	0.1226	0.0512	0.1211	0.0548
	(3.13)	(1.47)	(3.64)	(1.38)	(3.59)	(1.48)
Uncertainty	-0.0536	-0.0970			-0.0464	-0.0994
	(1.14)	(1.71)			(0.99)	(1.75)
Leverage			0.0227	0.0021	0.0222	0.0023
			(2.89)	(0.75)	(2.84)	(0.84)
Constant term	0.2322	0.2270	0.1657	0.2012	0.1743	0.2123
	(11.84)	(15.61)	(6.13)	(9.23)	(6.16)	(9.36)
Overall R^2	0.1349	0.1465	0.1421	0.1415	0.1441	0.1475
N of observations	1,134	1,134	1,134	1,134	1,134	1,134
Hausman test	*R*	*F*	*R*	*F*	*R*	*F*

F and *R* stand for fixed and random effect model respectively.
Values in parenthesis are t-values for fixed effect model and z-values for random effect model.

Concluding remarks: theory

- We extend a theoretical model of investment, bank lending and uncertainty and focus on the case of low internal wealth.
- The model can be divided into two parts: one allowing for asymmetric information that leads to underinvestment, and one providing an extension with the option to wait to invest.
- The model predicts that low-internal wealth firms will face more intense asymmetric information issues, but are less prone to the temptation to wait to invest. These two notions are taken to an empirical exploration using Japanese data.

Concluding remarks: empirical evidence

- Empirical analysis provides support for both notions. SMEs are more prone to asymmetric information than large firms in Japan.
- We assume that both cash flow and leverage can indicate asymmetric information issues. If we zoom in on SMEs by leverage, we continue to find the smaller impact of uncertainty for low-internal wealth firms.
- Underinvestment issues play an important role in the Japanese economy. It is well-known that SMEs are responsible for the growth of employment, so a more in-deep understanding of SME investment behavior is key.
- Future work needs more insights into how to model asymmetric information.