EXPLAINING THE CONTRACT TERMS OF ENERGY PERFORMANCE CONTRACTING IN CHINA

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Introduction

- Energy Performance Contracting
  - Energy service company ("ESCO") uses EPC to provide energy-saving services to the clients
  - Examples of ESCO's clients: manufacturing plants, construction companies, etc
  - ESCO and the client invest in the energy efficiency project at the client's site according to a negotiated investment share
  - ESCO and the client share the energy savings within the contract period
  - After the contract ends, client claims all the energy savings

Introduction

- EPC industry in China
  - Chinese central government began to implement policies on EPC in 2010.
  - Since then, ESCOs and EPC activities began to increase rapidly in China.
  - From 2006 to 2010, the number of ESCOs grew by almost tenfold, and amount of investment for EPC projects increased nearly by fourteen times .

Introduction

- Types of EPC contracts
  - energy-saving guarantee (ESG)
  - energy-saving benefits sharing (ESBS)
  - energy expense entrusted (EEE)

Introduction

- Types of EPC contracts
  - Energy-saving guarantee (ESG):
    - most common one
    - ESCO set a guaranteed level of energy savings for the client within the contract period.
    - ESCO will pay the client the difference if the utility savings fall short of the guaranteed level.

Introduction

- Types of EPC contracts
  - Energy-saving benefits sharing (ESBS):
    - rare
    - ESCO and the client share the energy savings within the contract period according to some negotiated rate.
    - ESCO does not have to guarantee a level of energy savings for the client.

Introduction

- Types of EPC contracts
  - energy expense entrusted (EEE)
    - rare
    - Client entrusts the ESCO to operate its energy system or implement the energy-saving innovation during the contract term at an agreed energy saving level
    - The client pays the ESCO service fee

Research motivation

- Different EPC projects have different contract terms
  - Contract length
  - Investment share
  - Total investment in energy efficiency project
- Very few studies have used quantities theoretical models to explain the underlying mechanisms of various contract terms at project or contract level.
- This paper tries to fill in the above gap by analysing the contract terms of EPC contract both theoretically and empirically.

Research objective

- To explain the heterogeneity of EPC contract terms: contract length, investment, investment share
  - This paper builds a theoretical optimization model to find out the structural relationship among these contract terms
  - Then, using the information of about 100 EPC contracts in China in 2010 and 2011, we conduct econometric analysis based on the results of theoretical models.

Theoretical model

- Main model assumption
  - The client will agree on a contract proposed by an ESCO as long as the expected net present value for client is equal to or greater than a threshold value.
  - Justification: most of the EPC contract types in China are Energy Saving Guarantee (ESG) type

Theoretical model

- Other assumptions
  - All investment happens upfront. It is an initial investment.
  - The share of benefit is the same as the share of investment.
  - The dollar value of saved energy is proportional to the upfront investment, with a diminishing return.
  - There is no operating and maintenance cost associated with the energy efficiency measures.
  - The interest rates of the ESCOs and clients remain the same over the years.
  - The life time of the invested energy efficiency is proportional to the total investment.

Theoretical model

$$\max_{T,I,I_s} \pi_s = \underbrace{\frac{I_s \alpha \sqrt{I}}{r_s}\left(1 - \frac{1}{(1+r_s)^T}\right)}_{NPV\,(benefit)} - I_s I \qquad (5)$$

Subject to

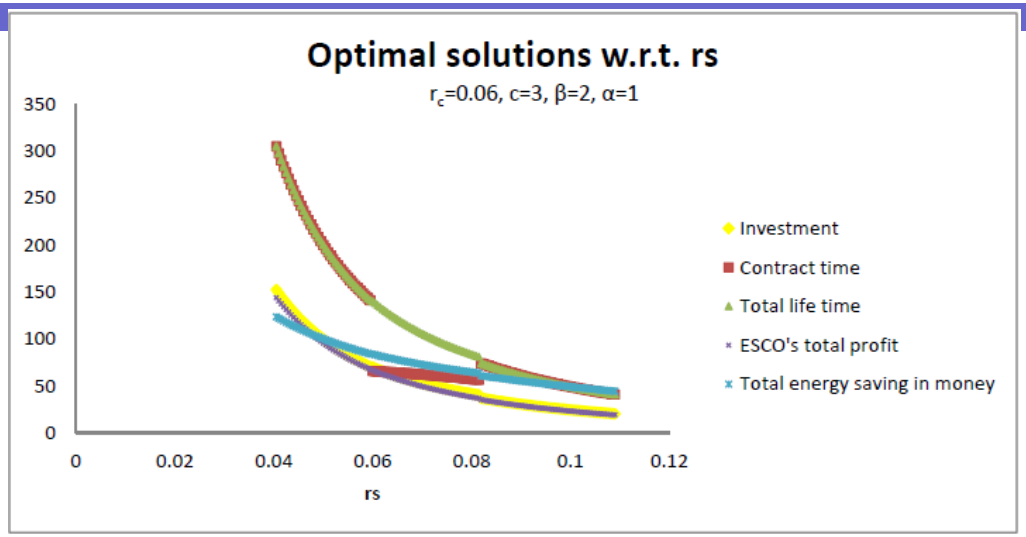
$$\pi_c = \underbrace{\frac{(1-I_s)\alpha\sqrt{I}}{r_c}\left(1 - \frac{1}{(1+r_c)^T}\right)}_{NPV\,(benefit)\quad within\quad the\quad contract} + \underbrace{\frac{\alpha\sqrt{I}}{r_c}\left(\frac{1}{(1+r_c)^T} - \frac{1}{(1+r_c)^{\beta I}}\right)}_{NPV\,(benefit)\quad beyond\quad the\quad contract} - (1-I_s)I \geq c$$

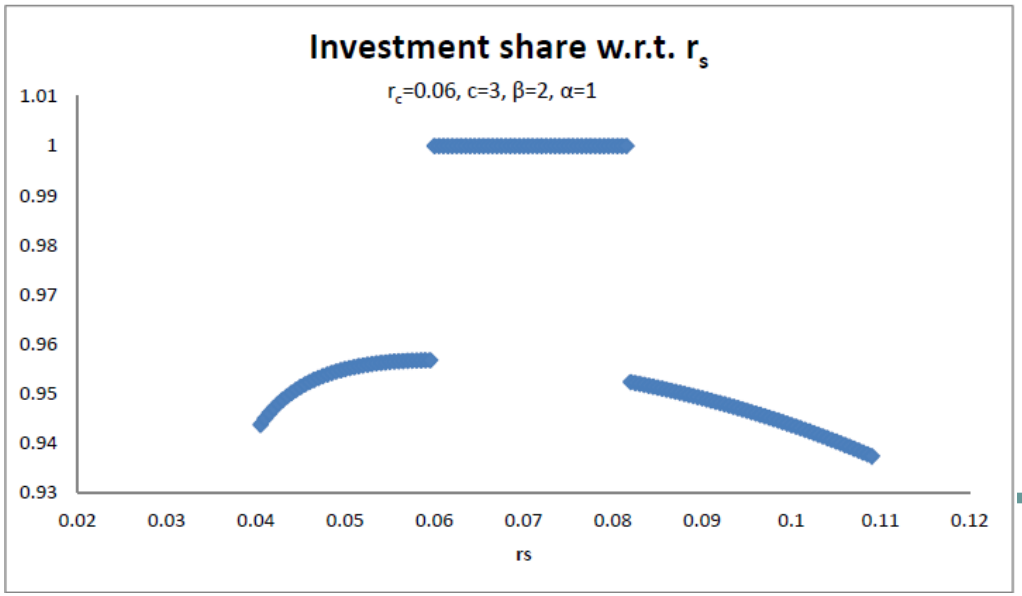
$$T \geq 0 \qquad (7)$$

$$0 \leq I_s \leq 1 \qquad (8)$$

$$I \geq 0 \qquad (9)$$

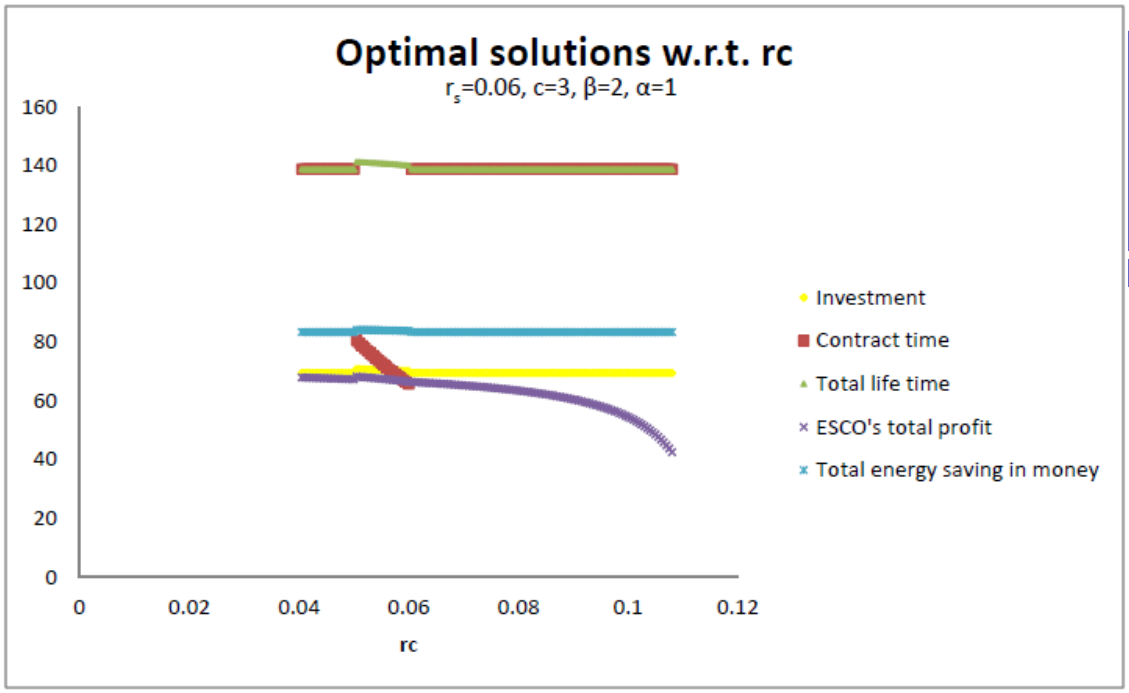
Numerical Results of Theoretical model

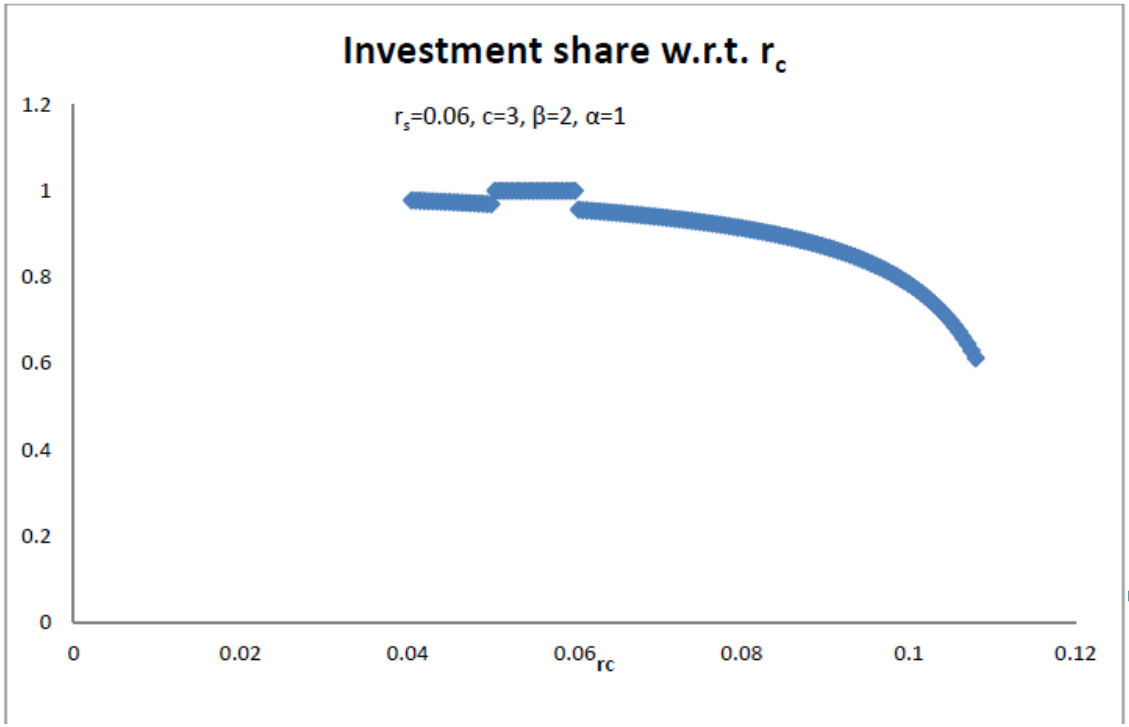




Higher ESCO's discount rate leads to lower investment and saved energy

ESCO tends to invest in more than 90% of the project





Client's discount rate does not have much influence on investment and saved energy

Theoretical model

- Implications
  - **ESCOs tend to assume the majority of the upfront investment**
  - **As ESCO's discount rate increases, investment and the resulted total energy savings decline. Client's discount rate does not have much impact on investment and total energy savings.**
  - **Thus it is important to provide low cost of capital for ESCOs so that greater potential of energy efficiency can be reached through EPC activities.**

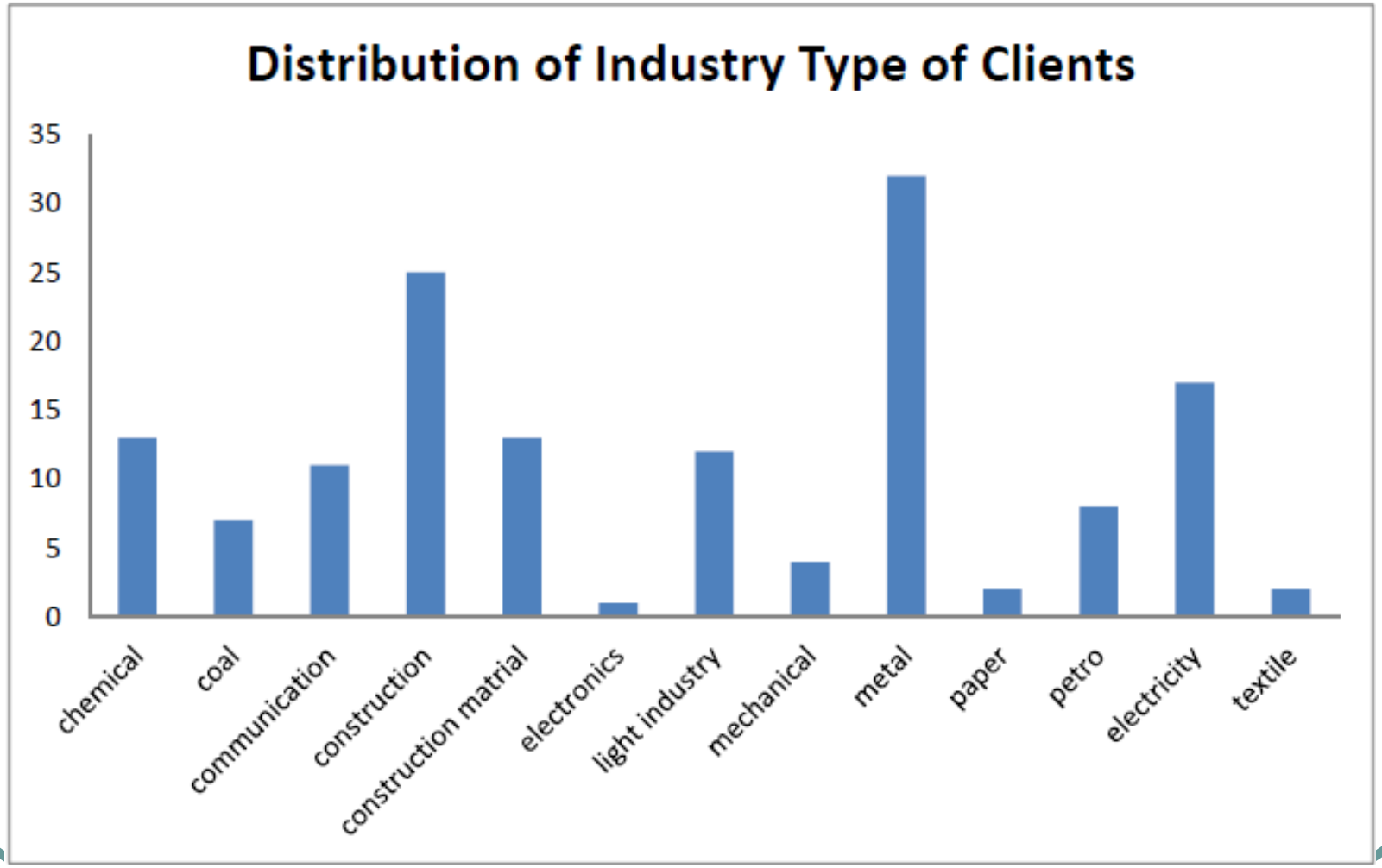
Empirical analysis

- Data

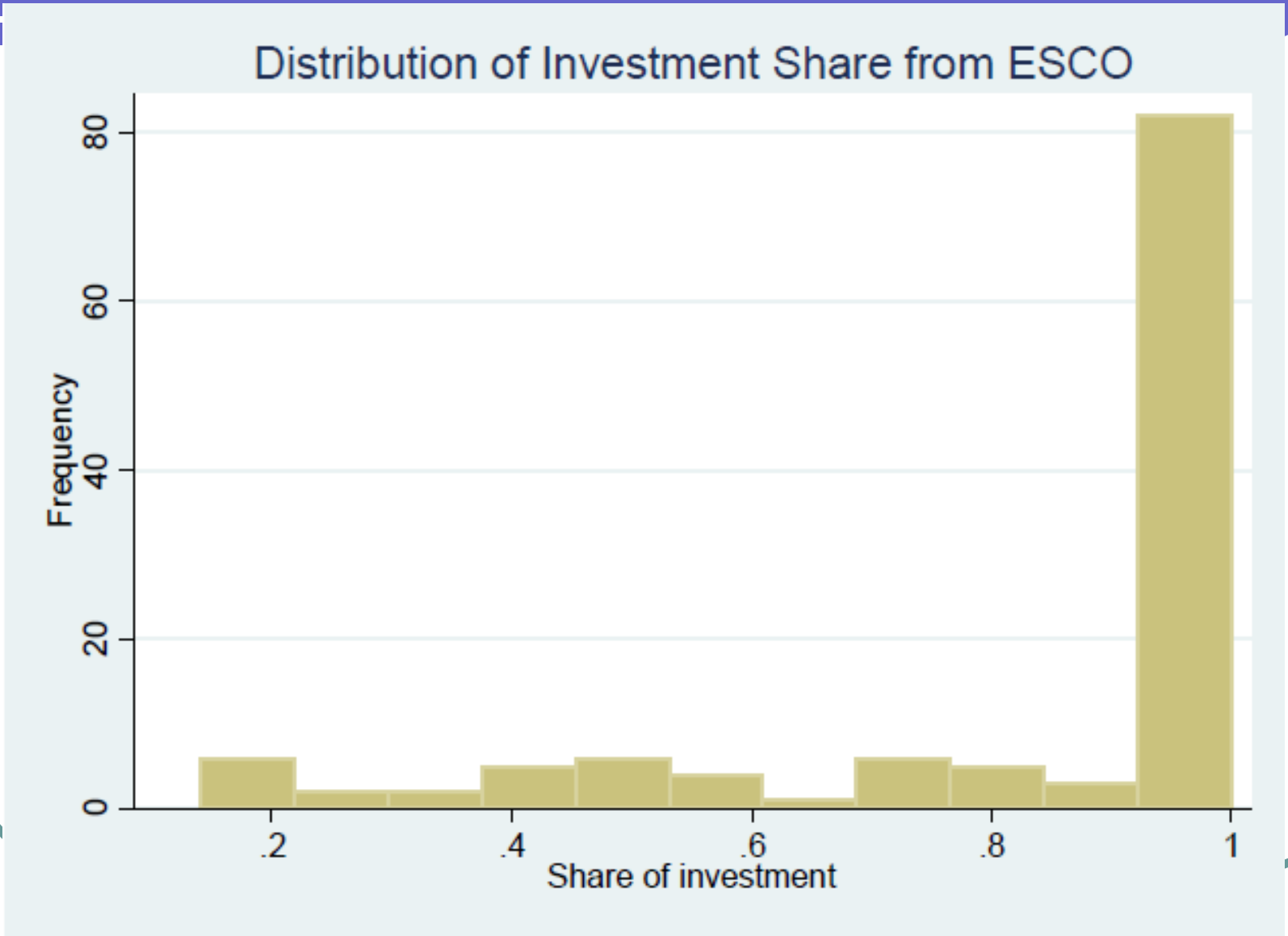
Table 1 Descriptive statistics

Variable Name	# of Obs.	Mean	Std. Dev.	Min	Max
Client's registered capital (100 million yuan RMB)	18	14.672	44.076	0.025	190
ESCO's registered capital (100 million yuan RMB)	75	0.756	0.887	0.01	3.6
Annual energy saving (TCE/year)	141	9661.5	28938.5	50	235000
Annual energy saved in money value (10,000 yuan/year);	124	1299.4	4215.4	5.176	40000
Investment (10,000 yuan RMB);	130	2571.9	8236.6	8	70000
Contract time (year)	123	7.505	8.095	0.5	50
ESCO's share of investment	120	0.84	0.26	0.14	1

Empirical analysis



Empirical analysis



Empirical analysis

- Econometric specification

$$\ln(I_i) = \beta_1 CAP\_esco_i + \sum_j \beta_2^j Industry\_j_i + v_i \qquad (7)$$

$$\ln(E_i) = \beta_1 CAP\_esco_i + \sum_j \beta_2^j Industry\_j_i + v_i \qquad (8)$$

$$\ln(EM_i) = \beta_1 CAP\_esco_i + \sum_j \beta_2^j Industry\_j_i + v_i \qquad (9)$$

$$\ln(T_i) = \beta_1 CAP\_esco_i + \sum_j \beta_2^j Industry\_j_i + v_i \qquad (10)$$

Model Number Dependent Variable		1 ln(annual energy saving)	2 ln(annual energy saving in RMB)	3 ln (investment)	4 ln (contract length)	5 ln(investment share of ESCO)
ESCO's registered capital		0.451 **(0.204)	0.341 *(0.187)	0.120 **(0.055)	-0.151 (0.097)	-0.095 0.071
Base case industry type: chemical [2]	Coal	-1.538 (1.802)	-1.490 (1.502)	3.141 **(1.365)	-0.508 (0.844)	-0.015 (0.619)
	Communication	-0.572 (1.266)	-0.288 (1.054)	1.498 (1.244)	-0.546 (0.689)	-0.225 (0.462)
	Construction	-0.595 (1.101)	-0.766 (0.916)	2.079 **(1.029)	1.504 **(0.618)	-0.015 (0.388)
	Construction material	1.708 (1.157)	1.788 *(0.963)	4.049 ***(1.079)	0.111 (0.638)	-0.212 (0.414)
	Light industry	0.880 (1.224)	0.948 (1.019)	3.145 ***(1.141)	-0.082 (0.655)	-0.489 (0.424)
	Mechanical	0.484 (1.274)	0.738 (1.490)	4.050 ***(1.257)	0.013 (0.689)	-0.163 (0.441)
	Metal	2.406 **(1.115)	2.331 **(0.930)	4.055 ***(1.039)	-0.208 (0.632)	-0.404 (0.388)
	Petro	1.293 (1.223)	1.172 (1.054)	2.259 **(1.140)	-0.235 (0.654)	-0.138 (0.423)
	Electricity	0.774 (1.152)	0.834 (1.045)	2.898 ***(1.074)	-0.242 (0.647)	-0.278 (0.399)
	Constant	6.421 ***(1.034)	4.602 ***(0.861)	3.140 ***(0.964)	1.612 ***(0.597)	0.019 (0.358)
	# of obs	70	63	68	64	61
	Adj R-square	0.3573	0.4886	0.3006	0.6125	0

Conclusions

- This paper analyses the contract terms, including total investment, share of investment and contract length, of EPC contracts both theoretically and empirically.
- Both the theoretical and the empirical results find that:
  - 1) if ESCOs have a lower cost of capital and discount rate, the total investment, and energy saving will increase;
  - 2) ESCOs tend to assume the majority of the total investment in energy efficiency technologies.
  - Thus providing low cost of capital to ESCO is essential to facilitate the effectiveness of EPC activities in terms of saving energy.