EXPLAINING THE CONTRACT TERMS OF ENERGY PERFORMANCE CONTRACTING IN CHINA

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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.
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
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.
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.
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
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

\[
\max_{T,I,I_s} \pi_s = \frac{I_s \alpha \sqrt{I}}{r_s} \left(1 - \frac{1}{(1 + r_s)^T}\right) - I_s I
\]

Subject to

\[
\pi_c = \frac{(1 - I_s) \alpha \sqrt{I}}{r_c} \left(1 - \frac{1}{(1 + r_c)^T}\right) + \frac{\alpha \sqrt{I}}{r_c} \left(\frac{1}{(1 + r_c)^T} - \frac{1}{(1 + r_c)^{\beta T}}\right) - (1 - I_s) I \geq c
\]

\[
T \geq 0
\]

\[
0 \leq I_s \leq 1
\]

\[
I \geq 0
\]
Numerical Results of Theoretical model

**Optimal solutions w.r.t. \( rs \)**

- **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

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## Data

Table 1 Descriptive statistics

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

Distribution of Industry Type of Clients

- chemical
- coal
- communication
- construction
- construction material
- electronics
- light industry
- mechanical
- metal
- paper
- petro
- electricity
- textile
Empirical analysis

Distribution of Investment Share from ESCO

Frequency

Share of investment
Empirical analysis

- Econometric specification

\[ \ln(I_i) = \beta_1 \text{CAP}_{\text{esco}} + \sum_j \beta_2^j \text{Industry}_{-j} + v_i \]  
\[ \ln(E_i) = \beta_1 \text{CAP}_{\text{esco}} + \sum_j \beta_2^j \text{Industry}_{-j} + v_i \]  
\[ \ln(EM_i) = \beta_1 \text{CAP}_{\text{esco}} + \sum_j \beta_2^j \text{Industry}_{-j} + v_i \]  
\[ \ln(T_i) = \beta_1 \text{CAP}_{\text{esco}} + \sum_j \beta_2^j \text{Industry}_{-j} + v_i \]
<table>
<thead>
<tr>
<th>Model Number</th>
<th>1 ln(annual energy saving)</th>
<th>2 ln(annual energy saving in RMB)</th>
<th>ln(investment)</th>
<th>4 ln(contract length)</th>
<th>5 ln(investment share of ESCO)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent Variable</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ESCO’s registered capital</td>
<td>0.451</td>
<td>0.341</td>
<td>0.120</td>
<td>-0.151</td>
<td>-0.095</td>
</tr>
<tr>
<td>**(0.204)</td>
<td>*(0.187)</td>
<td>***(0.055)</td>
<td>*(0.097)</td>
<td>0.071</td>
<td></td>
</tr>
<tr>
<td>Coal</td>
<td>-1.538</td>
<td>-1.490</td>
<td>3.141</td>
<td>-0.508</td>
<td>-0.015</td>
</tr>
<tr>
<td>(1.802)</td>
<td>(1.502)</td>
<td>***(1.365)</td>
<td>(0.844)</td>
<td>(0.619)</td>
<td></td>
</tr>
<tr>
<td>Communication</td>
<td>-0.572</td>
<td>-0.288</td>
<td>1.498</td>
<td>-0.546</td>
<td>-0.225</td>
</tr>
<tr>
<td>(1.266)</td>
<td>(1.054)</td>
<td>(1.244)</td>
<td>(0.689)</td>
<td>(0.462)</td>
<td></td>
</tr>
<tr>
<td>Construction</td>
<td>-0.595</td>
<td>-0.766</td>
<td>2.079</td>
<td>1.504</td>
<td>-0.015</td>
</tr>
<tr>
<td>(1.101)</td>
<td>(0.916)</td>
<td>***(1.029)</td>
<td>***(0.618)</td>
<td>(0.388)</td>
<td></td>
</tr>
<tr>
<td>Construction material</td>
<td>1.708</td>
<td>1.788</td>
<td>4.049</td>
<td>0.111</td>
<td>-0.212</td>
</tr>
<tr>
<td>(1.157)</td>
<td>*(0.963)</td>
<td>***(1.079)</td>
<td>(0.638)</td>
<td>(0.414)</td>
<td></td>
</tr>
<tr>
<td>Light industry</td>
<td>0.880</td>
<td>0.948</td>
<td>3.145</td>
<td>-0.082</td>
<td>-0.489</td>
</tr>
<tr>
<td>(1.224)</td>
<td>(1.019)</td>
<td>***(1.141)</td>
<td>(0.655)</td>
<td>(0.424)</td>
<td></td>
</tr>
<tr>
<td>Mechanical</td>
<td>0.484</td>
<td>0.738</td>
<td>4.050</td>
<td>0.013</td>
<td>-0.163</td>
</tr>
<tr>
<td>(1.274)</td>
<td>(1.490)</td>
<td>***(1.257)</td>
<td>(0.689)</td>
<td>(0.441)</td>
<td></td>
</tr>
<tr>
<td>Metal</td>
<td>2.406</td>
<td>2.331</td>
<td>4.055</td>
<td>-0.208</td>
<td>-0.404</td>
</tr>
<tr>
<td>***(1.115)</td>
<td>***(0.930)</td>
<td>***(1.039)</td>
<td>(0.632)</td>
<td>(0.388)</td>
<td></td>
</tr>
<tr>
<td>Petro</td>
<td>1.293</td>
<td>1.172</td>
<td>2.259</td>
<td>-0.235</td>
<td>-0.138</td>
</tr>
<tr>
<td>(1.223)</td>
<td>(1.054)</td>
<td>***(1.140)</td>
<td>(0.654)</td>
<td>(0.423)</td>
<td></td>
</tr>
<tr>
<td>Electricity</td>
<td>0.774</td>
<td>0.834</td>
<td>2.898</td>
<td>-0.242</td>
<td>-0.278</td>
</tr>
<tr>
<td>(1.152)</td>
<td>(1.045)</td>
<td>***(1.074)</td>
<td>(0.647)</td>
<td>(0.399)</td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>6.421</td>
<td>4.602</td>
<td>3.140</td>
<td>1.612</td>
<td>0.019</td>
</tr>
<tr>
<td>***(1.034)</td>
<td>***(0.861)</td>
<td>***(0.964)</td>
<td>***(0.597)</td>
<td>(0.358)</td>
<td></td>
</tr>
<tr>
<td># of obs</td>
<td>70</td>
<td>63</td>
<td>68</td>
<td>64</td>
<td>61</td>
</tr>
<tr>
<td>Adj R-square</td>
<td>0.3573</td>
<td>0.4886</td>
<td>0.3006</td>
<td>0.6125</td>
<td>0</td>
</tr>
</tbody>
</table>
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.