Quality and Pricing for Outsourcing Service: Optimal Contract Design

Samar K. Mukhopadhyay
University of Wisconsin-Milwaukee

Co-author:
Xiaowei Zhu, West Chester University of PA

Third annual conference, POMS College of Service Operations
London Business School  July 12 & 13, 2007
Introduction

Why outsource?
- Reduce operational costs
- Use other firm’s competency

Outsourcing manufacturing: for decades

Service outsourcing:
- Business process outsourcing (BPO),
- Information technology outsourcing (ITO)
- Call center outsourcing
Introduction

- Call center "onshore outsourcing"
  - Willow CSN (Miramar, FL) handles calls for Office Depot.
  - Alpine Access (Golden, CO) handles calls for 1-800-Flowers.com.

- Call center "offshore outsourcing"
  - Others, like American Express, Citibank, Sprint, Hewlett Packard, Dell, and IBM.
Introduction

- **Business process outsourcing (BPO)**
  - A.T. Kearney Inc. predicts that 500,000 financial-services jobs will go offshore by 2008.
  - Forrester Research predicts that some 79,000 legal jobs, totaling $5.8 billion in wages, would be sent offshore by 2015.

- **Information technology outsourcing (ITO)**
  - McKinsey forecasts IT services and back-office work in India will swell to a $57 billion annual export industry employing 4 million people by 2008.
Introduction

- Outsourcing is not a trouble free solution.

- A major concern is the quality of outsourcing. *Dell stopped outsourcing the technical support call center, because of severe quality problem*

- Outsourcing decision is a composite of price, quality and other related factors.

- We address the issue of service outsourcing using call-center as an example.
Literature Survey

- Many of the papers in the call center model the call center as a queue, as reviewed by Gan et.al. (2002).

- Aksin, Vericourt and Karaesmen (2004) study two types of call center outsourcing contracts: a volume-based (a per-call pricing) and a capacity-based (a per-agent-per-hour) contract.

- Extensive research have been carried out in the area of quality, like Kouvelis and Mukhopadhyay (1999). Most researches discuss the quality under full information.
Model Scenario

Profit functions

For the supplier: \( \pi_s = (p - c)q - \frac{\eta}{2}Q^2 \) or \( \pi^s \)

For the buyer: \( \pi_B = (B - p)q \) or \( \pi^B \)

Call volume function

\[ p = a - bq + eQ \]

Decision variables

- For the buyer: \( q \) (quantity of the call) and \( N \) (cut-off point)
- For the supplier: \( Q \) (quality of the calls)
The contracts

Two scenarios studied

Contract - under full information (F)
the buyer knows $\eta$.

Contract - under asymmetric information (A)
the buyer does not know $\eta$, knows a prior cumulative distribution $F(\eta)$ with density function $f(\eta)$, defined on $[\underline{\eta}, \overline{\eta}]$. 
The contracts – under full information (F)

Full information- buyer knows $\eta$

Following Stackelberg move:

- Buyer - leader, announcing $q$ first;
- Supplier - follower, announcing $Q$ after that.
The contracts
– under full information (F)

Result 1:

The equilibrium quantity, quality, and price under (F):

\[ Q^F = \frac{(B-a)e}{2(e^2 - \eta b)} \]
\[ q^F = \frac{(B-a)}{2\left(\frac{e^2}{\eta} - b\right)} \]
\[ p^F = \frac{a+B}{2} \]

\[ N^F = \frac{4e^2 \pi_B^-}{(a-B)^2 + 4b \pi_B^-} \]

where \( \pi_B = \pi_B^- \) binding

The corresponding profits at equilibrium are given as:

\[ \pi_B^F = \frac{(B-a)^2}{2\left(\frac{e^2}{\eta} - b\right)} \]
\[ \pi_S^F = \frac{(a+B)}{2} - c q^F - \frac{(eq^F)^2}{2\eta} \]

where \( B \geq a \) and \( e^2 \geq b \eta \)
The contracts
– under full information (F)

Result 2:

\( q^F \) is increasing in \( B, b \) and \( \eta \) and decreasing in \( a \) and \( e \);
\( Q^F \) is increasing in \( B, b \) and \( \eta \) and decreasing in \( a \);
\( p^F \) is increasing in \( a \) and \( B \);
\( \pi^F_B \) is the increasing convex function in \( \eta \).

Result 3:

The optimal level of \( \eta \) for the supplier

\[ \eta^* = \frac{e^2 (3a + B - 4c)}{b(a + 3B - 4c)} \]
Asymmetric information- buyer doesn’t knows $\eta$

Following Stackelberg move:
- Buyer - leader, announcing $q$ first;
- Supplier - follower, announcing $Q$ after that.
The contracts
– under asymmetric information (A)

Result 4:
The buyer’s optimal contract under (A). All pairs of \((q^A, N^A)\) satisfy the following equations:

\[
\frac{(B - a + 2bq)F(\eta)\bigg|_N^\eta - 2e^2 q \int_N^\eta \frac{f(\eta)}{\eta} d\eta}{(a - c) + 2(e^2 q - b)q} = \frac{\pi_B^- f(N) - (B - a + bq - \frac{e^2}{N} q)f(\eta)}{-\frac{e^2 q^2}{2N^2}}
\]

\[
(a - bq + \frac{q^2}{N} - c)q - \frac{q^2}{2N} - \pi_s^- = 0
\]
Result 4 (continued)

If \( N^A = \eta \), the equilibrium quantity, quality, and price under (A):

\[
q^A = \frac{(B-a)}{2\int_0^\eta \frac{f(\eta)}{F(\eta)} d\eta - b}
\]

\[
p^A = a + \left( \frac{e^2}{\int_0^\eta \eta f(\eta)} - b \right) q^A
\]

\[
Q^A = \frac{e}{\eta} q^A
\]
The contracts
- Analysis of (F) and (A)

Result 5:

(a) $q^A < q^F$ if and only if
\[
\frac{F(\eta) \bigg|_{\eta}^{\bar{\eta}}}{\int_N^{\bar{\eta}} f(\eta) \, d\eta} < \eta
\]

(b) $Q^F > Q^A$ if and only if
\[
\frac{(b - e^2 \frac{1}{\eta})E(\eta)}{\left( b - e^2 \frac{\int_N^{\bar{\eta}} f(\eta) \, d\eta}{\eta} \right) \eta < 1}
\]

Third annual conference,  POMS College of Service Operations
London Business School  July 12 & 13, 2007 15
Numerical Experiments

The numerical values used in the experiment are given in the next table 1.

<table>
<thead>
<tr>
<th>a</th>
<th>b</th>
<th>ε</th>
<th>B</th>
<th>η</th>
<th>c</th>
<th>π_B⁻</th>
<th>π_S⁻</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>0.1</td>
<td>1.1</td>
<td>20</td>
<td>5.0</td>
<td>5</td>
<td>20</td>
<td>80</td>
</tr>
</tbody>
</table>

We assume a Uniform distribution for \( \eta \) with:

\[
f(\eta) = \frac{1}{\eta - \eta'}
\]

\[
F(\eta) = \frac{\eta - \eta}{\eta - \eta'}
\]
Numerical Experiments

Figure 2. $\eta$ versus the buyer’s profit

Figure 3. $\eta$ versus the supplier’s profit
Numerical Experiments

Figure 7. The cut-off point versus wideness range of $\eta$
Numerical Experiments

Figure 8. Profit versus the base demand $a$

Third annual conference, POMS College of Service Operations
London Business School  July 12 & 13, 2007
Conclusion

• Our model uses call center as an example to study outsourcing price and quality issues.
• The model can be applied to other outsourcing scenario.
• The model can be extended to many different directions. We could include bonus and penalty for the high and low quality in the contract, using non-linear pricing scheme.