The Application of Real Options to ERP Investment Valuation

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Abstract: - This paper discusses the options for adaptability to environmental change inherent in ERP systems, the value of these options, and methods to assess the ERP value.

The first point of discussion is the issue of ascertaining the effectiveness of ERP, an underlying asset. We divide the effectiveness into two types—effectiveness in actually generating cash and effectiveness confined to opportunity cost reduction—and propose a method for calculating the ERP value effective in generating cash.

The second point of discussion is the valuation of information systems in the context of business acquisition and divestiture. Although business acquisition and divestiture is another unavoidable topic for corporate management, information system valuation has not been discussed in that context. We present a valuation method for the purpose of including information systems in divestment value, something not considered heretofore, to reveal the potential value of information systems in corporate management.

Key-Words: - investment valuation, real options, ERP system development, EDI, opportunity cost, M&A

1 Introduction

1.1 Evaluation of Investments

Previously, evaluation of the economic efficiency of information system investments was often performed using the payback period method. In a management environment that requires the effective utilization of capital, however, evaluation using the NPV method is becoming increasingly prevalent. However, in cases of investment in software platforms that become the infrastructure for systems such as ERP, there are times when approval for project commencement cannot be obtained when the evaluation is performed using the NPV method. This is because only effectiveness as a solution to immediate problems is assessed, and adaptability to future changes in the systems environment is excluded from evaluation. We believe that to fairly assess the value of a software platform, evaluation must take into account the value of applications that may be implemented on the platform in the future, the flexibility to cope with application expansion, contraction, and splitting, and the effects on operation.

1.2 Previous Research on Option Valuation

Since the 1990s, a number of studies have been published that consider the adaptability to environmental change inherent in information systems as an option and assess its value.

The first such study was by Dos Santos, who discussed the experimental adoption of an advanced technology. Dos Santos proposed adding the value of subsequent projects that adopt the technology as an option value to the original experimental adoption [1].

Amram and Kulatilaka discussed Internet sales of mortgage-backed securities and analyzed the expansion option value included in the introduction of an image processing system as a first-stage infrastructure [2].

Taudes et al. formulated the value of software platforms such as ERP as follows [3].

\[
\text{Value of a software platform} = \text{NPV of fixed application portfolio} + \text{Option value of implementation opportunities} \quad (1)
\]

In this study, Taudes et al. took the payroll reduction resulting from user productivity enhancement as the principal factor of the first term on the right-hand side of Equation (1), took EDI that have ERP systems as the
second term on the right-hand side of Equation (1), and performed valuation as the option to cope with expansion. They formulated the effect of EDI, the underlying asset of the option, as follows:

\[ P_t = N_t \cdot b \].......................... (2)

where, \( P_t \) is the application effect in period \( t \), \( N_t \) is the number of transactions processed by the application in question during period \( t \), and \( b \) is the cost reduction amount per transaction. That is, in previous research, the underlying asset value of the option to cope with expansion was regarded as simply the accumulation of cost reduction effects resulting from EDI transactions.

2 Introduction in Evaluation

2.1 Avoidance of the Mixture of Two Effects

As shown in the study by Taudes et al. in effects calculation for software platforms such as ERP, ordinarily the cost reduction amount resulting from user productivity improvement is calculated. In the case of Taudes et al., the value for user productivity improvement is estimated at 2%, and the annual effect is calculated at $240,000 on the basis of an average worker salary of $80,000. Also, Taudes et al. describe that empirical support for Equation (2) is provided by Mukhopadhyay et al. [4] who study the benefits obtained by Chrysler through introducing EDI-based purchasing. In each case, the mixing of cash generation effects and opportunity cost reduction effects can be considered a problem. We believe that to solve this problem, it is necessary in information system valuation to eliminate the effects confined to opportunity cost reduction and propose a more objective valuation method.

In this paper, in Case Study 1 we attempt to solve the issue through valuation of ERP introduction and of the EDI function realizable as a result of ERP introduction. This analysis is similar to Taudes et al. [3].

2.2 Valuation of Information Systems in the Buying and Selling of Businesses

While the acquisition and divestiture of businesses is not an everyday occurrence, it is by no means unusual in today’s corporate management environment. Nevertheless, information system valuation has not been discussed in previous research. This is because the value of information systems has not been a subject for discussion in negotiations. To reveal the potential value of information systems in corporate management, it is necessary to propose a valuation method for including information systems in the divestment value.

In Case Study 2, we discuss the divestiture of a certain business site, when one set of information systems covers multiple business sites, tasks associated with systems separation arise at the time of business site divestiture. In contrast, if the business site to be divested has an independent system, it becomes possible to recover the systems construction cost, which increases by alternatives available in negotiations. In addition, calculation of the market price in this type of situation shows the feasibility and effectiveness of applying option valuation to information systems.

3 Case Study 1

We discuss in this paper a method for eliminating the effects confined to opportunity cost reduction and actually ascertaining the cash generation effects in information system valuation. We extract quantifiable factors from the improvement effects on routine work, which include many qualitative factors, and summarize those factors in the inventory reduction amount, and ascertain the cash flow improvement amount. We use ¥1,000,000 as the monetary unit in Sections 3 and 4, including the amounts shown in the tables.

3.1 ERP Introduction

Company X, a manufacturer of machine parts, considered introduction of an ERP system on the occasion of manufacturing line expansion at its A Plant.

<table>
<thead>
<tr>
<th>Items</th>
<th>ERP</th>
<th>Present</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installation expenses</td>
<td>131.2</td>
<td>N/A</td>
</tr>
<tr>
<td>Annual ongoing expenses</td>
<td>9.2</td>
<td>3.5</td>
</tr>
</tbody>
</table>

We verify the value of this project. Increased costs occurring if the company continues use of the existing system are costs associated with a personnel increase related to data handling on the additional line and a decrease in productivity resulting from manual processing. We estimate the decrease in productivity, calculate the resulting increase in work hours, and calculate the increase in payroll by multiplying the work hours by the average salary. We calculate the amount of payroll reduction to be obtained from the avoidance of increased costs to result from ERP introduction and, furthermore, from a productivity increase to be achieved by the application of ERP to
existing manufacturing lines. We consider those figures as the effects of ERP introduction. With this calculation method, opportunity cost reduction factors are included in the effects. These factors include employment costs that cannot be cut, the avoidance of cost increases from factors such as response deterioration attributable to an increase in transactions, and increased productivity due to lower error frequency resulting from the simplification of data processing.

Taking a different approach, we eliminate the effects confined to opportunity cost reduction in the information system valuation and attempt a more objective valuation method (refer to Fig. 1). We first perform a work analysis that includes the additional manufacturing line and then prepare a post-system introduction workflow. We extract the quantitative effects by comparing the two workflows, identifying improvements, and performing a numerical evaluation. At this stage, we calculate personnel cost reduction and logistics cost reduction which will be realized by improving working processes. (Fig. 1(1) and (2)). We also analyze and break down items confined to qualitative effects and identify quantifiable components. In this case, first, manufacturing lead time is reduced due to automation of data receipt and delivery. We further break this result down into lead time reduction in planning, parts procurement, manufacturing, and delivery. We narrow down ascertainment of the resulting effects to the amount of decrease in parts on the shop floor and finished goods and calculate it as the monetary value of improvement in the capital turnover ratio (Fig. 1(3)). We further identify additional logistics cost reductions (Fig. 1(4)) and payroll reductions (Fig. 1(5)) as the results of indirect work improvement.

Through the above analysis, the increase in inventory caused by a manual processing attendant on manufacturing line expansion, due to a decrease in logistics speed, was estimated at 15%. It is assumed that this cost increase can be avoided by ERP introduction, and the effect of this is shown in Equation (3). Table 2 shows the figures for sales and inventory values based on this calculation.

<table>
<thead>
<tr>
<th>Table 2. Items for the Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Item</strong></td>
</tr>
<tr>
<td>I Annual sales</td>
</tr>
<tr>
<td>II Cost of sales</td>
</tr>
<tr>
<td>III Inventory</td>
</tr>
<tr>
<td>IV Finished goods</td>
</tr>
<tr>
<td>V Component parts</td>
</tr>
<tr>
<td>VI Work in process</td>
</tr>
<tr>
<td>VII Sales from the additional line</td>
</tr>
<tr>
<td>VIII Inventory from the additional line</td>
</tr>
<tr>
<td>IX employment cost</td>
</tr>
</tbody>
</table>

Annual Effect

\[ \text{Annual Effect} = \text{Inventory amount} \times \text{Rate of decrease} \times \text{Interest rate} + \text{Employment cost} \times \text{Number of redundancies} \]

\[ \text{Substitution into this Equation of the figures for VIII and IX in Table 4, a 15% rate of increase, and an interest rate of 4% results in:} \]

\[ 1377 \times 0.15 \times 0.04 + 7.5 \times 1 = 15.8 \]

Furthermore, since the ERP system will also cover all indirect work on the current lines, effects on those lines can also be expected. Reductions of two employees and 5% of the total finished goods inventory resulting from streamlining of production control and shipping processing were estimated. These effects, too, were calculated using Equation (3). Substitution into Equation (3) with the figures in IV and IX in Table 2, a 5% rate of decrease, a reduction of two employees, and an interest rate of 4% results in:
The value of this ERP introduction project calculated according to the NPV method is shown using

\[ \text{NPV} = \sum_{i=1}^{n} \left( \frac{\text{annual effect} - \text{increase of annual operation}}{(1 + \text{interest rate})^i} \right) - \text{Initial investment} \] ............... (6)

Insertion into Equation (6) of the values from Equations (4) and (5) (annual effect), the difference in the total amount in Table 1 (annual operational cost increase), the total initial investment amount in Table 1, \( n = 5 \), and an interest rate of 0.04 results in an NPV for the ERP introduction of

\[ \sum_{i=1}^{5} \left( \frac{(15.8 + 17.5) - (9.2 - 3.5)}{(1 + 0.04)^i} \right) - 131.2 = -8.3 \] ............... (7)

When the target investment recovery according to Company X internal regulations is \( n = 5 \), the initial investment and increased costs cannot be recovered. This result is attributable to the fact that “Option value of implementation opportunities,” the second term on the right-hand side of Formula (1), is not assessed. We next verify how valuation of this project changes if a corporate strategy involving utilization of the EDI function of ERP is adopted.

### 3.2 Effects of EDI

We calculate the effects of EDI. Here we once again use the process applied to calculate the value of ERP introduction. Through this calculation, the following effects were confirmed.

- (a) Reduction in payroll due to a decrease in labor hours for data input, etc.
- (b) Reduction in logistics costs, including warehouse costs and emergency transportation costs, due to shortening of manufacturing lead time
- (c) Reduction in inventory (finished goods, component parts, and work in process) of related products due to factors including shortening of lead time from data input to product shipment.

Table 3 shows the amounts of effects of the system.

<table>
<thead>
<tr>
<th>Item</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Payroll</td>
<td>11.2</td>
</tr>
<tr>
<td>(b) Logistics</td>
<td>3.0</td>
</tr>
<tr>
<td>(c) Finished Goods</td>
<td>126.7</td>
</tr>
<tr>
<td></td>
<td>Component Parts</td>
</tr>
<tr>
<td></td>
<td>Work in Process</td>
</tr>
</tbody>
</table>

The five-year cumulative effect on cash flow, \( V_e \), is calculated using the formula:

\[ V_e = \sum_{i=1}^{5+\tau} \left( \frac{(I \times \alpha r + P + L)}{(1 + r)^i} \right) \] ............... (8)

where \( \tau \) is the period from ERP operation to the start of EDI, \( \alpha \) is the ratio of products covered by EDI, \( r \) is the interest rate (0.04), \( I \) is the inventory reduction amount, \( P \) is the payroll reduction amount, and \( L \) is the logistics cost reduction amount.

We insert the figures from Table 4 into Equation (8) and calculate \( V_e \). Taking \( \tau = 1 \) and \( \alpha = 0.7 \), the result is

\[ V_e = \sum_{i=1}^{5+1} \left( \frac{(550.8 \times 0.7 \times 0.04 + 11.2 + 3)}{(1+0.04)^i} \right) = 126.8 \] ............... (9)

The introduction cost is estimated 13.8, and the NPV of EDI introduction is as follows:

\[ \text{NPV of EDI} = V_e - 13.8 = 113.0 \] ............... (10)

### 3.3 Valuation of the EDI Option

It is important that management establish a corporate strategy that enables the exercise of the EDI option and that involved departments act accordingly.

#### 4 Case Study 2

In this section we propose a valuation method to include information systems in the divestment value, something not considered previously.

#### 4.1 System Construction Options

Company X, discussed in the previous section, has acquired Company Y. It’s information system uses independently developed software run on a mainframe and covers the headquarters plant (B Plant) and one other plant (C Plant).
The following three options for the design of an information system to serve as an implementation tool in a project to incorporate Company Y into Company X’s global structure can be considered.

Plan A: Make improvements based on Company Y’s existing system.

Plan B: Scrap Company Y’s existing system and develop a new system to cover the both B and C Plant.

Plan C: Scrap Company Y’s system as well, but introduce separate systems at the two plants.

4.2 Valuation of the Contraction Option

Equation (11) shows the value of Plans B and C.

\[ V = E + \sum_{i=1}^{T} \frac{(A-O)}{(1+r)^i} - I \] .................................(11)

Here, \( E \) is the cumulative effects amount, \( A \) is the annual operational cost of Plan A, \( O \) is the annual operational cost of the plan under evaluation, \( r \) is the interest rate, and \( I \) is the initial investment for the plan under evaluation.

Substitution figures of Plan B in Table 6 into Equation (11) results in

\[ 277.2 + \sum_{i=1}^{5} \frac{(161.1-10.5)}{(1+0.04)^i} - 121.2 = 180.8 \] .............................(12)

Substitution figures of Plan C in Table 4 into Equation (11) results in

\[ 277.2 + \sum_{i=1}^{5} \frac{(161.1-16.2)}{(1+0.04)^i} - 149.6 = 127.1 \] .............................(13)

The value is only approximately 70% of that of Plan B in Equation (12). However, Plan C entails the benefit that the development cost of the C Plant information system could be recovered in the event the plant is divested. The development cost of the C Plant system was estimated at 49.6.

We perform valuation of the options inherent in Plan C. If a bond for Plan C were issued, it would be a bond with a principal of 149.6, maturity of five years, and the possibility of a return of 49.6 at a certain period in time. We use the Black-Scholes method in Formula (14) in the calculation of financial options to calculate the valuation of such a bond if it were traded on the market.

\[ P = S N(-d_1) + Xe^{-rT} N(-d_2) \]
\[ d_1 = \left( \frac{\ln\frac{S}{X} + (r + \frac{\sigma^2}{2})T}{\sigma\sqrt{T}} \right) \]
\[ d_2 = d_1 - \sigma\sqrt{T} \] .............................(14)

where \( P \) is the option premium, \( S \) is the underlying asset (system development cost), \( X \) is the recovery amount, \( T \) is the option period, \( r \) is the safe interest rate, \( \sigma \) is volatility, and \( N(-d_1) \) and \( N(-d_2) \) are the cumulative probability.

Volatility (\( \sigma \)) in this case is the uncertainty with respect to the conclusion of negotiations to divest the plant. Calculation taking \( \sigma \) as 50%, 70%, and 90%, \( T \) as 3, 4, and 5 years, and \( r \) as 4% results in the premium values shown in Table 9.

<table>
<thead>
<tr>
<th>7</th>
<th>50%</th>
<th>70%</th>
<th>90%</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>2.35</td>
<td>7.16</td>
<td>13.10</td>
</tr>
<tr>
<td>4</td>
<td>3.58</td>
<td>9.58</td>
<td>16.28</td>
</tr>
<tr>
<td>5</td>
<td>4.72</td>
<td>11.54</td>
<td>18.65</td>
</tr>
</tbody>
</table>

At the same time, in the event of development of a system according to Plan B and the divestiture of C Plant, the task of extracting data for the C Plant from the system and transferring it to the acquiring party would occur. We estimate the cost of this as 5 and compare the change in the values of the two plans. The value of Plan B, \( V_B \), and the value of Plan C, \( V_C \), are shown in the following equations:

\[ V_B = V_{BG} - \frac{D}{(1+r)^T} \] .............................(15)
\[ V_C = V_{CG} + P + \frac{X}{(1+r)^T} + \sum_{i=T+1}^{5} \frac{161.1-10.5}{(1+0.04)^i} \] .............................(16)

where \( V_{BG} \) is the value in Equation (12), \( D \) is the data transfer cost, \( V_{CG} \) is the value in Equation (13), \( P \) is the
option premium, $X$ is the recovery amount, $T$ is the period from system development to divestiture, and $r$ is the safe interest rate. Also, the fourth term on the right-hand side of Equation (16) is a term that factors in the post-transfer operating cost reduction.

Table 6 shows a comparison of the two plans when the volatility is set at 0.7 in view of the prospects for the successful conclusion of negotiations.

In the event that C Plant is transferred, it is confirmed that Plan C is more advantageous when $\sigma = 0.7$.

<table>
<thead>
<tr>
<th>$t$</th>
<th>$V_B$</th>
<th>$V_C$</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>176.4</td>
<td>187.7</td>
</tr>
<tr>
<td>4</td>
<td>176.5</td>
<td>183.7</td>
</tr>
<tr>
<td>5</td>
<td>176.7</td>
<td>179.4</td>
</tr>
</tbody>
</table>

In this case study, we performed valuation of the options inherent in an information system in the circumstances of divestiture of a business. Previously, in negotiations for the buying and selling of businesses in the manufacturing industry, the major subjects of discussion have been people (the number and quality of employees), assets (buildings and facilities), money (financial circumstances), and technological capabilities. The subject of information systems has not been addressed.

Issues raised in negotiations heretofore are human assets, fixed assets, financial assets, and technological assets. The inclusion of information systems among the matters for consideration will contribute to informing managers of the impact on the corporate value of the value of information systems and changes in that value over time. Furthermore, information systems have the potential of becoming a new source of information for use in reaching acquisition and investment decisions. The inclusion of information systems among matters for consideration will also contribute to recognition of the value of information systems among managers and users in ordinary circumstances.

5 Conclusions
We discussed the need to ascertain the adaptability to environmental change inherent in information systems as investment options in order to fairly value information system investments.

In Case 1, it is difficult to verify the validity of ERP system introduction because of the broad scope of application of the ERP system introduction discussed. However, we think that if all effects are concentrated into inventory reduction and limited to the cash flow improvement effect, the direction for system development becomes clear. With regard to option valuation of the EDI function inherent in the ERP system, the mixing of actual cost reduction and opportunity cost reduction can be avoided using a similar approach.

In Case 2, we calculated the value of an information system as a disposal option, taking into account the uncertainty surrounding the business divestiture. In information system option valuation, ordinarily securitization of the investment option and trading on the market is assumed and valuation is performed using a binominal model or the Black-Scholes method. In situations such as this, including information systems among the assets for divestment in the securitization assumption is realistic and indicative of the effectiveness of option valuation.

References: