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Full Length Research Paper

Establishment of a temporary workforce transaction mechanism using a real option approach

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To reduce labor costs and enhance profitability, many modern businesses have begun to employ temporary labor. Temporary labor not only helps businesses by providing necessary manpower during the busy season, it can also help businesses reduce labor costs during declining economic conditions by outsourcing labor. To address the need for flexibility in labor supply and extend the time needed to make labor decisions, this study presents the innovative concept of real options on temporary workers. The purpose of such options is to hedge the demand-supply uncertainty in future labor and wages. This study not only introduces the concept and method of real options on temporary workers but also provides real-life empirical samples to verify the reasonableness, applicability and practicability for issuing real options on temporary workers.

Key words: Temporary workforce, Stackelberg model, real option.

TEMPORARY WORKERS AND TEMPORARY EMPLOYMENT INDUSTRY

Although business outsourcing of product manufacturing, parts or sales are well established practices, human resource outsourcing is still a developing concept in Taiwan and currently focuses only on unskilled temporary labor. Minimizing labor costs to improve business competitiveness by achieving a lean, efficient and highly flexible human resource structure is without a doubt the key element to business success. In the present business environment of falling profit margins, increased labor costs, rapidly changing economic conditions, unstable investment environments and aggressive competition, businesses around the globe are attempting to lower costs and increase profits by gradually replacing permanent employees with temporary workers hired from outside sources. Using temporary labor enables organizations to increase competitiveness by adjusting their human resource structures. Lenz (1996) classified the main advantages of using temporary workers as enabling flexibility and rapid response to a changing business environment without sustaining the costs of recruitment, welfare or retirement. Wessel (2001) suggested that the main advantage of temporary workers is when an investment project is expanding but the attractiveness is gone, the business is able to employ temporary workers to lower costs, which allows delay of policy decisions regarding permanent workers. Dixit and Pindyck (1994) also agreed that when engaging in labor-related investment decisions, businesses can utilize temporary workers to increase the flexibility of their human resource policies. Thus, flexibility is one of the main advantages of employing temporary workers. Hence, the temporary worker employment rate has tended to increase in recent years. Currently, the trend towards employing contract workers is expanding from non-technical to technical and skilled labor (Brenčič, 2009; MacPhail and Bowles, 2008).

THE PROFILE OF REAL OPTIONS ON TEMPORARY WORKERS

Past studies on transaction mechanisms using the concept of options all employ real options as a means of evaluating investment policy. For example, Campbell (2002) uses options pricing theory to determine the optimal timing of information systems investments and to explore the effect of different investment review cycles, while Kim et al. (2002) and Pinches (1998) include real options theory to assess investment policies for IT companies and Fauffman and Li (2005) analyzes the investment timing strategy for a firm that is deciding about whether to adopt one or the other of two incompatible and competing technologies. Bhattacharya and Wright (2005) developed an options model for managing different types of uncertainties. Trigeorgis (1993) leans toward the flexible interactive relationship between real options and financial options. Foote and Folta (2002) and Pinker and Larson (2003) used "real option" analyses to determine the value of flexibility gained by using a temporary employee workforce. They found that businesses can expand investment or reduce risk by using temporary workers when facing demand and supply uncertainties in the labor market. Bellalah (2002) applies real options to assess lease contracts while Insley (2002) uses real options to assess investments in the forestry industry. In a practical model research, Nembhard et al. (2003) applies real options to product outsourcing. However, real options are rarely applied to problems involving manpower outsourcing. In fact, supply and demand for high tech technical manpower are uncertain and market price fluctuation is significant (Bhatnagar, et al., 2007; Stratman, et al., 2004). It is advisable to use a transaction style of options to conclude business contracts. Therefore, applying options can resolve problems of uncertain human resource demand in a rapidly changing business environment (Jacobs, 2007).

DESCRIPTION OF THE MODEL

The underlying asset for real options on temporary workers is the option on temporary workers. That is, after buyers (user enterprise) of real options on temporary workers pay the premium to the sellers (temporary workers agency), they are entitled to lay claim to the seller to contract for another option on temporary workers at the appointed exercise price (the premium of options on temporary workers) at the expiration date. The exercise price for options on temporary workers is the outsourcing expense that the buyer agrees to pay the seller for a unit of labor provided, and it is determined as soon as the real option is issued. The price can usually be based on the human resource market price during the time of issue; therefore, real options on temporary workers can simultaneously hedge the risk of both uncertain human resource demand and uncertain wages. Also, the expiration date of options on temporary workers can be set to approximate the date when the workers would be needed.

Notations

C: The per-unit premium provided to the seller in the outsourcing option contract.

K : The per-unit exercise price provided by the seller in the outsourcing option contract.

Q : The total manpower quantity determined in the outsourcing option contract.

S : Technical manpower outsourcing market price per unit upon contract expiration.

t: The contract period between the options contract signing and exercise dates.

r : The risk-free short-term interest rate during the contract period.

m: The probability of the seller successfully deploying manpower, $0 < m < 1$.

Z : Unit cost for surplus manpower.

T : Unit training cost for manpower.

HC : Fixed processing costs borne by the seller when deploying manpower, whether successful or not.

D: Fixed demand volume of the buyer on the contract expiration date.

S_M : Unit market price of manpower at the beginning of the contract.

$f(S_M)$: Probability density function for the unit market price of manpower, with mean value μ and standard deviation σ.

$F(S_M)$: Cumulative probability function for the unit market price of manpower.

E(PS): Expected producer surplus function of the seller.

E(Cost): Expected per unit outsourcing cost of the buyer.

Formulation

The model used here is based on the Stackelberg game model. It assumes that the buyer is the leader and the seller is the follower, with the follower reacting to the actions of the leader. To solve the model, the reaction function of the seller, *K=f(Q)*, is found by maximizing the producer surplus of the seller, which then is plugged into the buyer's model. Finally, by solving for the profit maximization of the buyer, the optimal exercise price and premium of the seller are found, along with the optimal outsourcing quantity of the buyer.

Expected producer surplus for seller

The expected producer surplus function for seller is given as follows:

E(PS)=

$$C\times Q+e^{-rt}\left[(1-F(K))\times K\times Q+m\times Q\int_0^K S_M\cdot f(S_M)\cdot dS_M\right]-e^{-rt}\left[\begin{array}{l}-Q\cdot\int_K^\infty (K-S_M)\cdot f(S_M)\cdot dS_M\\ +F(K)\times(1-m)\times Q\times Z+\\ F(K)\times HC+(1-F(K))\times Q\times T\end{array}\right] \quad (1)$$

The first three terms are: a) the initial premium received for the outsourcing option contract, b) the returns receivable by the seller when the contract expires during an economic upturn, in which case, the seller anticipates that the buyer will fully exercise the option, c) when the economy is performing poorly, causing the market price for manpower to fall below the exercise price, in which case, the seller anticipates that the buyer will not exercise the option and will instead dispatch manpower to other companies.

The last three terms are: a) the lost profit opportunity of the seller when the contract expires in an economic upturn, leading to the market price for manpower to exceed the exercise price, b) surplus costs and c) expected processing costs incurred when the contract expires in an economy downturn, in which case, the buyer will not exercise the option, and the seller does not dispatch manpower to other companies. Due to the professional nature of semiconductor equipment manufacturers, temporary help companies can not provide professional training programs for the engineers, and still must defray the buyer's employee training costs after the completion of the contract transaction.

Expected outsourcing costs for buyer

The expected outsourcing cost function for buyer is given as follows:

$$\text{E(Cost)}= C\times Q + e^{-rt}\left[\begin{array}{l}(1-F(K))\times K\times Q+(D-Q)\times \\ \int_K^{\infty} S_M\cdot f(S_M)\cdot dS_M + D\times\int_0^K S_M\cdot f(S_M)\cdot dS_M - (1-F(K))\times Q\times T\end{array}\right] \quad (2)$$

The costs are described as follows: the premium costs that need to be paid by the buyer when the buyer signs the option outsourcing contract; the expected exercise costs that need to be paid for outsourcing manpower when the contract expires when the economy is good; the expected hiring costs that need to be paid when the contract expires, due to an increase in demand for manpower on contract expiry; when the buyer experiences a manpower shortage; the need to hire more manpower from other temporary help companies to make up for shortfalls; and the manpower training costs that are paid by the seller to the buyer after the completion of the contract transaction.

Setting the premium model for option outsourcing

According to the option pricing model proposed by Black and Scholes, the formula for evaluating call options is as follows:

$$C = SN(d_1) - Ke^{-rt}N(d_2),$$
$$d_1 = \frac{\ln(S/K)+(r+\sigma^2/2)t}{\sigma\sqrt{t}},\ d_2 = d_1 - \sigma\sqrt{t} \quad (3)$$

In the situation of technical manpower outsourcing, S = outsourcing manpower market price per unit at contract expiration, σ^2 = the variances of price, t = the contract period between the option contract signing date and the exercise date, r = the risk-free short-term interest rate during the contract period, and K = exercise price. Additionally, $N(d_1)$ is a hedging rate, that is, the magnitude of fluctuation of the spot market price S will affect the magnitude of fluctuation of the call option price C. Also, $N(d_2)$ denotes the probability that the spot market price is greater than the exercise price when the contract expires.

THE SOLUTION PROCEDURE

The solution procedure for the Stackelberg game model involves three main steps.

Step 1: Find the optimal reaction function $K = f(Q)$ for the exercise price K.

Plug Equation (3) into Equation (1) to obtain Equation (4). The seller, to maximize the outsourcing producer surplus function, has the reaction function $K = f(Q)$ based on the optimal outsourcing quantity, as follows:

$$\text{E}(PS)= (SN(d_1)-e^{-rt}\times KN(d_2))\times Q + e^{-rt}\left[(1-F(K))\times K\times Q + m\times Q\int_0^K S_M\cdot f(S_M)\cdot dS_M\right]$$
$$-e^{-rt}\left[\begin{array}{l}-Q\times\int_K^{\infty}(K-S_M)\cdot f(S_M)\cdot dS_M + F(K)\times(1-m)\times Q\times Z + \\ F(K)\times HC + (1-F(K))\times Q\times T\end{array}\right] \quad (4)$$

Taking the derivative of E(*PS*) with respect to *K*, we find:

$$\frac{\partial E(PS)}{\partial K} = -Q\times e^{-rt} + e^{-rt}\left\{ Q(1-F(K)) - f(K)\times K\times Q + m\times Q\left[K\times f(K)\right] + \left[\begin{array}{l} -Q\left[\int_K^{\infty}\frac{\partial(K-S_M)\cdot f(S_M)}{\partial K}dS_M\right] \\ + f(K)\times(1-m)\times Q\times Z \\ + f(K)\times HC + f(K)\times Q\times T \end{array}\right]\right\} =$$

$$e^{-rt}\left\{ -Q + Q(1-F(K)) - f(K)\times K\times Q + m\times Q\left[K\times f(K)\right] + \left[\begin{array}{l} -Q\left[\lim_{x\to\infty}F(S_M)\big|_K^x\right] \\ + f(K)\times(1-m)\times Q\times Z \\ + f(K)\times HC + f(K)\times Q\times T \end{array}\right]\right\} =$$

$$e^{-rt}\left\{ -Q + Q\times(1-F(K)) - f(K)\times K\times Q + m\times Q\left[K\times f(K)\right] + \left[\begin{array}{l} Q(1-F(K) - f(K)\times(1-m)\times Q\times Z \\ - f(K)\times HC - f(K)\times Q\times T \end{array}\right]\right\} =$$

$$e^{-rt}\left[Q(1-2F(K)) - f(K)\times\left[Q\cdot(1-m)\times(K+Z)+HC+Q\times T\right]\right] \quad (5)$$

let $\frac{\partial E(PS)}{\partial K} = 0$

we get

$$Q(1-2F(K)) = f(K)\times\left[Q\cdot(1-m)\times(K+Z)+HC+Q\times T\right] \quad (6)$$

From Equation (6), since 0 < *m* < 1, and *f(K)*, *K*, *Q*, *Z*, *HC* and *T* are all positive, the value of the right-hand side of the equation must be greater than zero; therefore the left-hand-side of the equation must satisfy F(K)<½. It is also assumed that *F(K)* is the cumulative probability function for the normal distribution, so *K*< μ (the mean market price for manpower). In practice, most sellers, when setting the option exercise price *K*, set the price lower than the market price to attract buyers to sign the contract, so *K*< μ conforms with reality.

Theorem 1

When exercise price *K* is less than the mean manpower market price μ, the expected outsourcing producer surplus function of the seller is a concave function.

Proof:

Because

$$\frac{\partial E(PS)}{\partial K} = e^{-rt}\left[Q\times(1-2F(K)) - f(K)\times\left[Q\times(1-m)\times(K+Z)+HC+Q\times T\right]\right] \quad (7)$$

$$\frac{\partial^2 E(PS)}{\partial K^2} = e^{-rt}\left[Q\times f(K)\times(m-3) + f'(K)\times Q\times(K+Z)\times(m-1) - f'(K)\times(HC+Q\times T)\right] \quad (8)$$

When the manpower market price is assumed to be normally distributed, the exercise price *K* is less than μ (the mean manpower market price), implying that *f′(K)*>0. Moreover, since m<1, the right-hand side of Equation (8) is less than zero. Consequently, when $\frac{\partial E(PS)}{\partial K} = 0$ and $\frac{\partial^2 E(PS)}{\partial K^2} < 0$, the expected producer surplus function of the seller is concave.

For solving $\frac{\partial E(PS)}{\partial K} = 0$, it requires the use of numerical method to find the reaction function *K = f(Q)*.

Step 2: The seller reaction function *K = f(Q)* is plugged into the expected outsourcing cost function of the buyer. The buyer wishes to minimize outsourcing costs. After taking the derivative of the expected outsourcing cost function, the outsourcing quantity *Q* of the buyer is yield.

Step 3: The optimal outsourcing quantity of the leader in Step 2 is plugged into the follower's reaction function to find the optimal exercise price *K* and premium *C*.

Thus, after solving the model in the framework of the buyer and seller model, the optimal manpower exercise price and premium can be determined for the seller and seller, and the buyer can use the option contract data provided by the seller to find the optimal outsourcing quantity.

EMPIRICAL RESULTS

Table 1 . The relationship between total manpower quantity, exercise price and cost.

Q	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**
K	55019	56864	57607	58009	58261	58433	58558	58654	58729
E(cost)	6197439	6192227	6186321	6180183	6173942	6167645	6161316	6154965	6148600
Q	**50**	**55**	**60**	**65**	**70**	**75**	**80**	**90**	**100**
K	58789	58839	58881	58917	58947	58974	58997	59036	59067
E(cost)	6142224	6135841	6129452	6123059	6116662	6110263	6103861	6091052	6078237

To solve this model, the model parameters are first set, as follows:

1) Survey analysis revealed that the monthly salaries of employee are normally distributed: S_M ~Normal (u=NT$ 63,000, σ =NT$1,000).
2) *S* indicates the current market salaries of employee. In calculating the salary and benefits, various necessary qualifications must be considered, including educational level, experience, required training courses and necessary technical skills. Current market price for manpower is *S* =NT$ 65000.
3) *r* is the risk-free nominal interest rate, which is about 1.6%.
4) *t* is period until the contract expires, which is set to 1 year.
5) *m* is the probability that, due to a poor market, the buyer does not exercise the contract, and the seller can deploy its manpower to other companies. Therefore the likely probability is estimated from the current economic conditions, the past transactions and experience of the seller, and the manpower quality of the seller, *m*=0.9.
6) *HC* is the probable cost borne by the seller when recruiting and deploying manpower, which can be set to *HC*=NT$ 50,000.
7) *Z*, the unit manpower price, was identified through surveys, and was estimated to be NT$ 30,000.
8) *T* is the per-unit training cost, which is estimated as NT $3,000.
9) *D* is the manpower demand. Based on past buyer demand for manpower, the manpower demand *D* is estimated to be 100.

Now that the parameter values have been set, numerical analysis is performed to solve the reaction function *K* = *f(Q).* Table 1 summarizes the results of the numerical analysis. In this Figure 1, we see that *K* and *Q* exhibit a strong nonlinear relationship. Therefore, the regression function $\hat{K} = a - \frac{b}{Q} + \frac{c}{Q^2}$ can be used. With an R-Square value of 89.5%, the optimum regression function for *K* = *f(Q)* is;

$$\hat{K} = 593426547 - \frac{282152958}{Q} + \frac{330502715}{Q^2} \quad (9)$$

After finding the reaction function *K* = *f(Q)* via simulation, this is substituted into the expected outsourcing cost function of the buyer Equation (2), yielding Equation (10).

E(Cost)=

$$\left[S - e^{-rt} \times (a - \frac{b}{Q} + \frac{c}{Q^2})\right] \times Q + e^{-rt} \left[\begin{array}{l} (1 - F(a - \frac{b}{Q} + \frac{c}{Q^2})) \times (a - \frac{b}{Q} + \frac{c}{Q^2}) \times Q + \\ (D - Q) \times \\ \int_{a-\frac{b}{Q}+\frac{c}{Q^2}}^{\infty} S_M \cdot f(S_M) \cdot dS_M + D \times \int_{0}^{a-\frac{b}{Q}+\frac{c}{Q^2}} S_M \cdot f(S_M) \cdot dS_M - (1 - F(a - \frac{b}{Q} + \frac{c}{Q^2})) \times Q \times T \end{array} \right] \quad (10)$$

To illustrate Equation (10), the unit outsourcing cost of the buyer may gradually decrease as the outsourcing quantity *Q* increases. The relationship between *K, Q* and expected outsourcing costs E (Cost) is shown in Table 1 and Figure 1. Given that the buyer must satisfy demand quantity *D* = 75, that is, the total outsourcing volume is 75, which minimizes the cost of the buyer.

Conclusions

The analytical results of this study clearly indicate that real options on temporary workers can indeed enable labor-intensive enterprises to negotiate more effective and helpful contracts with temporary worker agencies to enhance hedging ability and flexibility. Real options can thus help companies respond to changing economic cycles, uncertain labor demand and supply and associa-ted risks. Whereas options have traditionally been used

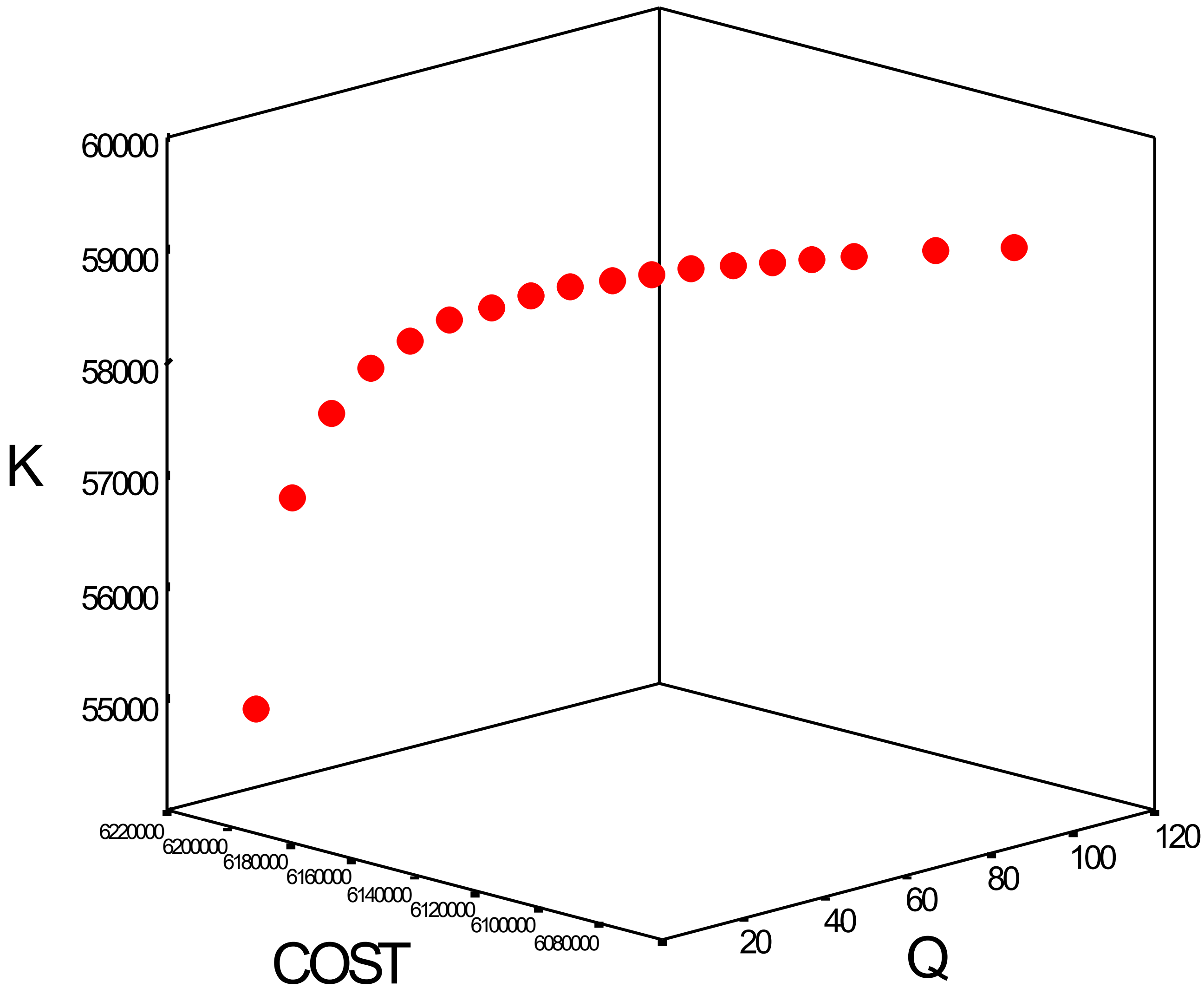

Figure 1. The relationship between *K* , *Q* and E (Cost).

exclusively to hedge against uncertainty and volatility in financial or real assets, this study applies options to intellectual assets such as human resource.

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