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應用分式規劃於國際區域性市場營運擴展之研究
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應用分式規劃於國際區域性市場營運擴展之研究

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應用分式規劃於國際區域性市場營運擴展之研究

摘　要

服務業主體對特定海外直接投資（FDI）地主國，選擇一些城市優先集中資源投資，藉以開發一群忠誠顧客，進而創造在該地主國的商譽優勢，已被視爲是阻止現有與潛在競爭者競奪該市場之重要策略。本研究稱這些城市爲營運佈局地點，並假設服務業主體欲投資之地主國佈局城市已經決定而且服業主體心中對每一城市皆存在一價值期限，希望這些城市都能在價值期限達至一預定的資本規模，以確保長期營運的競爭優勢。基此，本研究旨在應用數理規劃方法，發展一商品訂價與資本投資政策模型，以求取 FDI 初期資本預算限制下之最適資本投資與商品訂價政策，極大化整體佈局城市在其價值期限內達成預定資本投入規模的績效。

關鍵詞：服務產業、海外直接投資、佈局地點、資本投資與訂價政策

Abstract

Given priority to a pool of cities located in a FDI host country for investing in has been a core strategy to serve as a barrier to entry. The said cities are called the deployment locations in this paper. Yet, we assume that a service provider has decided the deployment locations in a host country and hopes that each the said city is invested in a target cost-basis of capital with in a value-based time limit determined by the service provider, in order to gain the long-range competitive advantages. Accordingly, this paper aims to propose a commodity pricing and capital investment policy model by using mathematical programming method thereby finding a performance-maximization solution with regard to investing in the target cost-basis of capital within the value-based time limits associated the said cities.

Keywords: Service industry**,** foreign direct investment, deployment locations, capital investment and commodity pricing

[1]

1. Introduction

Service firms usually offer large percentages of intangible outputs which long have been acknowledged as being different from purely physical outputs (Dunning, 1989; Hirsch, 1993). Today, the value of services exceeds the value of manufactured, tangible outputs. Service accounts for more than half of the gross domestic product in all developed countries and in most developing economies (Clark and Rajaratnam, 1999). As trade negotiation continues to lower barriers to services, more markets are open to services (King, 2003). Because service firms usually provide the outputs with the characteristic of inseparability (Brouthers et al., 2002), directly making an investment in a host country is the main means for delivering a service abroad - generally referred to as foreign direct investment (FDI). Thus, market-seeking (or market-developing) is usually the principal motive of a service provider for FDI in some countries.

The FDI's growth success of a service firm is closely related to good decision-making in entry mode, locations, capital budgeting, and agency scheduling. It is also due to the reasons such as more specialized professional skills, knowledge, and customization. Service providers have been shown that they usually prefer high control entry modes in highly competitive markets (Erramilli and Rao, 1993; Brouthers et al., 2002; Bouqet et al., 2004). Thus, wholly-owned based FDI is the main approach for seeking product market abroad in service industries.

The selections of country-based locations are the basic concern of a service provider when driving a wholly-owned based market-seeking FDI. Market size, internationalization of the host country, and the index of host country business environment have been identified as the main locations determinants to a manufacturer's FDI decision-making (Dunning and Norman, 1987; Culem, 1988; Pearce, 1991). Studies on the determinants of foreign expansion in services are far fewer, but most scholars agree that FDI determinants of manufacturing can be applied to services (Seymour, 1987; Nigh et al., 1986; Goldberg and Johnson, 1990). Also, Kundu and Contractor (1999) argued that sector-specific factor is also a critical determinant for services except for the above determinants.

The intangibility of services creates difficulties for service firms because potential customers have trouble identifying differences in services offered (Mitchell and Greatorex, 1993; Campbell and Verbeke, 1994). Thus, many scholars believe, of a specific product market, a powerful and loyal customer base may serve as a barrier to entry (Dan, 1978; Cloninger, 2004, Chang and Chen, 2008). In short, when driving a wholly-owned based market-seeking FDI to enter a host country, a service provider usually has to further decide to give priority to a number of sites so that a powerful and loyal customer base may be developed. Indeed, it is reasonable to suppose that a powerful and loyal customer base would provide a service firm with an extremely good reputation that would be spilled over to the whole target market. Further, the product/services reputation has been shown as an influence on consumer's perceived quality, and perceived value, which lead to purchase and repurchase intentions (Dodds et al., 1991; Zeithaml, 1988; Chang and Wildt, 1994; Jayant and Ghosh, 1996; Petrick, 1999; Woodruff, 1997). Such an effect was called the demand spill-over by Johanson (2003). Similar concept was also suggested by Chang (2003), called the regional characteristics effect. Clearly, this preferential spillover effect may lead to an increase in perceived risk for a potential competitor while attempting to enter that said market.

It is assumed here that the country-based locations have been decided for driving a wholly-owned based market-seeking FDI. Also, a number of detailed sites in each country have taking priority in making investment, thereby developing a loyal customer base to serve as a barrier to entry. Of critical importance in the context of this paper is the FDI-modeling, particularly, the finding of an effective capital budgeting and allocation policy so that the possible desires of a service provider are realized. It is only recently however, that academics have paid attention to this FDI-modeling and, in particular, have focused on manufacturing, and not services. Efficiency-seeking, in general, is the principal motive of a manufacturer for FDI in multi-site locations. Indeed, most of labor-intensive manufacturing sectors are motivated in finding a product supply market that has comparative advantage such as abundant raw materials, low cost labor and specific skills. The international facility location problem (IFLP) is the main model related to efficiency-seeking FDI and examines the issues such as facility locations choices, open periods, productive capacity design, and production distribution, and so on (Rosing, 1994; Veter and Dincer, 1995; Myung et al., 1997; Hinojosa et al., 2000; Carrizosa and Conde, 2002; Bhutta et al., 2003; Bhutta, 2004). As described previously, service firms usually provide the outputs with the characteristic of inseparability; thus market-seeking is usually the principal motive of a service provider for FDI in multi-site locations, and any IFLP may not be applied to services. Thus, this paper will propose a capital budget constrained foreign expansion models with multi-site locations, which is capable of optimizing the commodity pricing and capital investment policy.

This paper will be organized as follows: a nonlinear programming approach is employed to formulate our concern in Section 2, and some assumptions relating to the proposed model are given in Section 3 in order to obtain analytical results. Based on the analytical results, a solution method consisting of the Newton-Raphson method and the technique of piece-wise linear approximation are then presented in Section 4. Finally, an illustrative example is given in Section 5.

2. The problem

We consider a foreign expansion program with multi-site locations in service industries. A service firm is assumed to consider the following case of wholly-owned based FDI. Toward seeking a specific N-country product market, there are L_j service-agencies that have taken priority in being opened in a selected city at time 0, where located in country j $(j = 1,2,...,N)$, in order to develop a loyal customer base to serve as a barrier to entry. Nevertheless, it is assumed here that the invested capital to each agency may be differentiated as two items. They are respectively "capital investment for delivery (CIFD)" and "capital investment for production (CIFP)." Also, each country $j = 1,2,...,N$ is assumed to be assigned a target cost basis of capital, $CA_j^*(t)$ at time t as the following form.

$$CA_j^*(t) = \begin{cases} CA_j^*(0), \ t < T_j \\ CA_j^*(T_j), \ t \ge T_j \end{cases} \tag{1}$$

Thus, if we let $CIFD_j^*(t)$ and $CIFP_j^*(t)$ represent the target CIFD and the target CIFP at time t, respectively, then we get

$$CA_j^*(t) = \begin{cases} CIFP_j^*(0) + CIFD_j^*(0), \ t < T_j \\ CIFP_j^*(T_j) + CIFD_j^*(T_j), \ t \ge T_j \end{cases} \tag{2}$$

In order to achieve the goal—realizing $CA_j^*(T_j)$ at time T_j, the service firm, it is assumed, considers the following type of finance policy. The target CIFD to the agencies, planned to be opened at time 0, has been budgeted; but the CIFP has been established a design-to-budget goal, B_0. Instead, B_0 is understood to be a constraint on the total invested capital for production to all agencies planned to be opened at time 0. Thus, the total CIFP to all agencies planned to be opened at time 0 has to be below B_0. Indeed, if we let $c_j(0)$ denote the invested amount in CIFP at time 0 to each agency in country j, then we get

$$\sum_{j=1}^{N} L_j \cdot c_j(0) \le B_0 \tag{3}$$

Further, in order to gain enough capital budget to make an increase in capital at time T_j for each agency, it is assumed that the earnings gleaned by the L_j agencies (opened at time 0) are capitalized, thereby providing themselves with budget for capital increased at time T_j for each country $j = 1,2,...,N$, considering there are infinite alternatives that are available relating to make investment in CIFP to each agency. Each alternative may be viewed as a specific production-design proposal. The larger investment in CIFP leads to higher commodity quality. Indeed, notation $c_j(0)$ not only denotes the invested amount in CIFP at time 0 to each agency in country j, but can viewed as a specific level of production-design, costing $c_j(0)$. Thus, if the service provider attempts to increase the commodity quality via promoting the level of production-design up to a level x_j from the current level $c_j(0)$, then the additional CIFP that needs to be increased would exceed the amount of $x_j - c_j(0)$ in general. Accordingly, we define the capital function relating to CIFP increased as follows:

$$\widetilde{C}_j(c_j(0), x_j) = \xi_j \cdot \{x_j - c_j(0)\}, \quad c_j(0) \le x_j \le c_j^*(T_j) \tag{4}$$

where $c_j^*(T_j)$ denotes the desired level of production-design to each agency at time T_j, $\widetilde{C}_j(c_j(0), x_j)$ denotes the additional CIFP needed to be increased in order to promote the current level of production-design up to a level x_j, and ξ_j is a parameter not less than 1.

In addition, the target CIFD to each agency at time T_j is assumed here to be the same as the target CIFD at time 0. Accordingly, if we let $CA_j(0)$ be the actual invested capital at time 0 for country j, we see that

$$\begin{aligned} CA_j(0) &= CIFD_j^*(0) + L_j \cdot c_j(0) \\ &= L_j \cdot [\overline{CIFD_j^*}(0) + c_j(0)] \end{aligned} \tag{5}$$

$$
\begin{aligned}
CA_j^*(T_j) &= CIFD_j^*(T_j) + CIFP_j^*(T_j) \\
&= L_j \cdot \overline{CIFD_j^*}(0) + L_j \cdot c_j^*(T_j)
\end{aligned} \tag{6}
$$

where $\overline{CIFD_j^*}(0)$ denotes the target CIFD at time 0 to each agency in country j, and thus $CIFD_j^*(0) = L_j \cdot \overline{CIFD_j^*}(0)$.

With the use of the results of (4) - (6), it follows that

$$
\begin{aligned}
TNR_j^{t\arg et} &= CA_j^*(T_j) - CA_j^*(0) + (\xi_j - 1)\{c_j^*(T_j) - c_j(0)\} \\
&= L_j \zeta_j \{c_j^*(T_j) - c_j(0)\},
\end{aligned} \tag{7}
$$

where $TNR_j^{t\arg et}$ represent the target total net revenue (after tax) desired to be gleaned by the L_j agencies (opened at time 0) over time period T_j, in order to realize the goal that the cost basis of capital at time T_j is not less than $CA_j^{taget}(T_j)$.

Notice that time-period T_j has been defined as a kind of "value-based time limit (Chang and Chen, 2007)," as the service provider believes a certain degree of value-loss would be generated, if the time required to earn $TNR_j^{t\arg et}$ for each country j is out of T_j. Instead, a certain degree of value-loss may be generated if the desire of the service provider—the cost basis of capital at time T_j reaches $CA_j^{taget}(T_j)$ for each country $j = 1,2,...,N$. Such a concept of value-loss may be predicated about the loss of market share or return of invested capital resulting from the entry of potential competitors, or an increase in cost basis of capital of existing competitors. As a result, finding a capital budgeting and commodity pricing policy so that a certain objective is optimized is one of most important decisions. Here we assume that the service firm offers multiple commodities, but the production variable cost (per unit) relating to any type of commodity offered is the same as others; and thus, the same pricing policy is made for all commodities offered.

Let f_j be the expected time required to earn $TNR_j^{t\arg et}$ by those agencies planning on being opened in country j at time 0; then the time horizon BF_j which is defined as $T_j - f_j$ may be viewed as the buffer time to feed the variation of return of invested capital in country j. If there exists a capital budgeting policy so that all of targeted total net revenues (TNR_j^{target}) are expectedly earned within their associated value-based time limits (T_j), one may further find a solution to simultaneously maximize the buffer times in regards to each of target total net revenues. On the contrary, if there does not exist such a capital budgeting solution as described above, one may further find a solution to maximize this investment program's expected overall performance within those value-based time limits, with which a service provider is concerned. For simplicity, the former is called the maximum buffer time (MBT) model, and the latter, the maximum achievement (MA) model. Consequently, it is assumed here that it is difficult to evaluate the variance of the return of invested capital; thus, a service provider may benefit by solving a MBT model. Restated, the purpose of MBT-modeling is to find a reliable capital budgeting and commodity pricing policy to ensure that each TNR_j^{target} is gleaned within its associated value-based time limit, T_j. It is not possible that one can find a solution for a MBT model so that $BF_j \geq 0$ for all j if the expected time required to glean all of the targeted total net revenues is more than the longest value-based time limit in regards to this N-country marketing-seeking program. In such a case a service provider may benefit from solving a MA model. Here, we are only interested in the examination of a MA model because the scope of a MBT model is not the purpose of this paper. Let p_j be the commodity pricing for country j and $Z_{jlt}(p_j, c_j)$; with the return per unit time at time t to agency $l = 1,2.\cdots,L_j$, under given (p_j, c_j), where c_j is the substitution of $c_j(0)$ and α_j, denotes the tax rate in country j. Also, let y_j be the expected total return up to time T_j for country j, then we have

$$y_j = \sum_{l=1}^{L_j} \int_0^{T_j} (1-\alpha_j) Z_{jlt}(p_j, c_j) dt \tag{8}$$

If we let x_j be the level of production design, which is achievable by costing amount of y_j; then we get

$$y_j = L_j \cdot \xi_j \cdot (x_j - c_j) \quad \text{(by (4))} \tag{9}$$

This result leads to

$$
\begin{aligned}
x_j &= \frac{y_j}{L_j \xi_j} + c_j \\
&= \frac{\sum_{l=1}^{L_j} \int_0^{T_j} (1-\alpha_j) Z_{jlt}(p_j, c_j) dt}{L_j \xi_j} + c_j
\end{aligned}
\tag{10}
$$

Accordingly, the MA model proposed in this paper can be defined as a type of maxmin (maximize minimum) problem, i.e., to find an optimal (p_j, c_j) to maximize

$$
\begin{aligned}
A^{\min} &= \min\left\{ A_j = \frac{L_j x_j + CIFD_j^*(0)}{CA_j^*(T_j)}, \forall j \right\} \\
&= \min\left\{ A_j = \frac{\frac{1}{\xi_j}\left\{ \sum_{l=1}^{L_j} \int_0^{T_j} (1-\alpha_j) Z_{jlt}(p_j, c_j) dt \right\} + L_j c_j + CIFD_j^*(0)}{CA_j^*(T_j)}, \forall j \right\}
\end{aligned}
\tag{11}
$$

In order to further formulate the MA model, one parameter, say c_j^*, is defined as below.

$$
c_j^* = \min\left\{ \tilde{c}_j : \sum_l \int_0^{T_j} Z_{jlt}(p_j^*, \tilde{c}_j) dt \geq \underset{(p_j, c_j)}{\text{maximize}} \left\{ \sum_l \int_0^{T_j} Z_{jlt}(p_j, c_j) dt \right\} \right\} \tag{12}
$$

where p_j^* denotes the optimal commodity pricing in country j.

Notice that with the use of c_j^*'s definition in (13), we may further define the value of $CIFP_j^*(0)$ in (2) as

$$
CIFP_j^*(0) = L_j c_j^* \tag{13}
$$

With the use of the results of (1)-(13), the MA model may be initially formulated as follows:

$$\underset{(p_j, c_j)}{\text{maximize}}\ A^{\min} = \text{minimum}\left\{A_j, j = 1,2,\cdots,N\right\} \tag{14a}$$

Subject to

$$A_j = \frac{\frac{1}{\xi_j}\left\{\sum_{l=1}^{L_j}\int_0^{T_j}(1-\alpha_j)Z_{jlt}(p_j,c_j)dt\right\} + L_j c_j + CIFD_j^*(T_j)}{CA_j^*(T_j)}, \forall j \tag{14b}$$

$$\sum_{l=1}^{L_j}\int_0^{T_j}(1-\alpha_j)Z_{jlt}(p_j,c_j)dt \le TNR_j^{t\arg et}, \forall j \tag{14c}$$

$$TNR_j^{t\arg et} = L_j \zeta_j \{c_j^*(T_j) - c_j\}, \forall\ j \tag{14d}$$

$$\sum_{j=1}^{N} L_j \cdot c_j \le B_0 \tag{14e}$$

$$c_j^l \le c_j \le c_j^*,\ \forall j \tag{14f}$$

where c_j^l denotes the minimal amount of CIFP that the service provider hopes to expend in each agency located in country j.

3. Analytical Results

In order to obtain analytical results of the MA model, it is necessary to make assumption about the form of $Z_{jlt}(p_j, c_j)$. Specially, we assume for each pair (p_j, c_j) that :

A1. $Z_{jlt}(p_j, c_j) = Z_j(p_j, c_j)$, if $t \le T_j$, which means the return per unit time is independent of time before time period T_j has elapsed as well as the profit structure to each agency is independent of what is an agency ‘s name.

A2. $Z_j(p_j,c_j)=[p_j-v_j(c_j)]\cdot Q_j(c_j)d_j(p_j)-M_j(c_j)-H_j$ over $c_j\in[c_j^l,\infty)$

where

$Q_j(c_j)$ = Number of potential customers who would purchase the commodities offered in each agency located in country j under investing amount of c_j in CIFP;

$d_j(p_j)$ = Demand rate (per unit time) for each customer while commodity pricing is p_j dollars;

$v_j(c_j)$ = Average variable cost per unit product under investing amount of c_j in CIFP;

$M_j(c_j)$ = Fixed cost (or ownership cost) per unit time for each agency in country j in regards to maintain the productivity and consistent quality under investing amount of c_j in CIFP;

H_j = Fixed cost (or ownership cost) per unit time for each agency in country j in regards to maintain the service quality under investing amount of $\overline{CIFD_j^*}(0)$ in CIFD.

A3. Demand rate $d_j(p_j)$ is the strictly decreasing exponential function over the interval $(0,\infty)$, and it can be expressed as following form:

$$d_j(p_j)=\psi_j\cdot\exp(-\phi_j\cdot P_j)$$

where $\phi_j>0,\ \psi_j>0$.

A4. Number of potential customers, $Q_j(c_j)$, is the strictly increasing linear function over the interval $[c_j^l,\tilde{c}_j^u]$, and it can be expressed as following form:

$$Q_j(c_j)=\begin{cases}Q_j^l+\varphi_j\cdot(c_j-c_j^l), & \text{if } c_j^l\le c_j\le\tilde{c}_j^u\\ Q_j^u, & \text{if } c_j\ge\tilde{c}_j^u\end{cases}$$

where $\varphi_j=\dfrac{Q_j^u-Q_j^l}{\tilde{c}_j^u-c_j^l}$.

A5. Average variable cost per unit product, $v_j(c_j)$, is the strictly decreasing linear function over the interval $[c_j^l, \hat{c}_j^u]$, and it can be expressed as following form:

$$v_j(c_j) = \begin{cases} v_j^l - \pi_j \cdot (c_j - c_j^l), & \text{if } c_j^l \le c_j \le \hat{c}_j^u \\ v_j^u, & \text{if } c_j \ge \hat{c}_j^u \end{cases}$$

where $\pi_j = \dfrac{v_j^l - v_j^u}{\hat{c}_j^u - c_j^l}$.

A6. Fixed cost per unit time, $M_j(c_j)$, is the strictly increasing exponential function over the interval $[c_j^l, \infty)$, and it can be expressed as following form:

$$M_j(c_j) = \theta_j[\exp(\beta_j c_j) - 1], \quad \theta_j, \beta_j > 0$$

Notice that A 2 means that production policy for each agency is make-to-order and the lead time of satisfying a customer's demand is negligible under investing amount of $c_j, c_j \in [c_j^l, \infty)$, and thus the production capacity is sufficient for satisfying demand per unit time. In addition, this also means that the demand rate of each customer depends on the price paid for attaining a product; however, the number of customers would depend on the commodity quality offered.

According to our assumptions, (14b) and (14c) becomes

$$A_j = \frac{\dfrac{L_j \cdot (1-\alpha_j) \cdot T_j}{\xi_j} \cdot Z_j(p_j, c_j) + L_j c_j + CIFD_j^*(T_j)}{CA_j^*(T_j)}, \forall j \tag{15}$$

$$\frac{L_j \cdot (1-\alpha_j) \cdot T_j}{\xi_j} \cdot Z_j(p_j, c_j) \le TNR_j^{target}, \forall j \tag{16}$$

where

$$Z_j(p_j, c_j) = [p_j - v_j(c_j)] \cdot Q_j(c_j) d_j(p_j) - M_j(c_j) - H_j$$

Therefore, a legal policy (p_j, c_j) has to be found with the largest reward rate corresponding to investing in country j in order to solve this MA model. That is, to solve the following problem:

$$\underset{p_j, c_j}{\text{maximize}} \, Z_j(p_j, c_j) = [p_j - v_j(c_j)] \cdot Q_j(c_j) d_j(p_j) - M_j(c_j) - H_j \qquad (17)$$

Lemma 1 Letting $p^*_{j|c_j}$ denote a pricing solution under given c_j corresponding to $\frac{\partial Z_j(p_j, c_j)}{\partial p_j} = 0$. Then $p^*_{j|c_j}$ has the following closed form:

$$p^*_{j|c_j} = \frac{1 + \phi_j \cdot v_j(c_j)}{\phi_j}.$$

Proof: Taking the first partial derivative of Z_j corresponding to p_j over the domain $[p^l_j, p^u_j]$, we have

$$\frac{\partial Z_j}{\partial p_j} = \psi_j Q_j(c_j) \cdot \exp(-\phi_j p_j) - \psi_j \phi_j p_j Q_j(c_j) \cdot \exp(-\phi_j p_j)$$
$$+ \psi_j \phi_j \cdot v_j(c_j) \cdot Q_j(c_j) \cdot \exp(-\phi_j p_j)$$

Let $\frac{\partial Z_j}{\partial p_j} = 0$, the result of this lemma is obtained.

Theorem 1 For the demand rate function as (A3) corresponding to each buyer, the reward rate function $Z_j(p_j, c_j)$ is concave over $p_j \in (0, \infty)$ under given a certain value of c_j. Also, the optimal pricing solution whenever c_j is given is $\frac{1 + \phi_j \cdot v_j(c_j)}{\phi_j}$

Proof: Taking the second partial derivative of Z_j corresponding to p_j over the domain $(0, \infty)$, we have $\left.\frac{\partial^2 Z_j}{\partial p_j^2}\right|_{p_j = p^*_{j|c_j}} = -\psi_j \phi_j Q_j(c_j) \cdot \exp(-\phi_j p_j)$ Clearly, the results of this theorem are obtained from the result of Lemma 1 and the fact that $\left.\frac{\partial^2 Z_j}{\partial p_j^2}\right|_{p_j = p^*_{j|c_j}} < 0$.

In the practice, the parameters $\tilde{c}_j^u$ (in A4) and $\hat{c}_j^u$ (in A5) maybe are not equal; however, in this paper we are only interested in the case that $\tilde{c}_j^u = \hat{c}_j^u = c_j^u$. According to such consideration, and the result of Theorem 1, we see that

$$Z_j(p^*_{j|c_j}, c_j) = \begin{cases} \dfrac{\psi_j}{\phi_j} \cdot [Q_j^l + \varphi_j \cdot (c_j - c_j^l)] \cdot \exp\{-1 - \phi_j v_j^l + \phi_j \pi_j (c_j - c_j^l)\} \\ \qquad - \theta_j \exp(\beta \cdot c_j) - H_j, & c_j \in [c_j^l, c_j^u] \\ \dfrac{\psi_j}{\phi_j} \cdot [Q_j^u \cdot \exp\{-1 - \phi_j v_j^u)\} - \theta_j \exp(\beta \cdot c_j) - H_j, & c_j \in [c_j^u, \infty) \end{cases} \tag{18}$$

Define

$$\tilde{Z}_j(c_j) = \frac{\psi_j}{\phi_j} \cdot [Q_j^l + \varphi_j \cdot (c_j - c_j^l)] \cdot \exp\{-1 - \phi_j v_j^l + \phi_j \pi_j (c_j - c_j^l) \tag{19}$$

$$\hat{Z}_j(c_j) = \theta_j \exp(\beta \cdot c_j) - H_j \tag{20}$$

Then (18) becomes

$$Z_j(p^*_{j|c_j}, c_j) = \begin{cases} \tilde{Z}_j(c_j) - \hat{Z}_j(c_j), & c_j \in [c_j^l, c_j^u] \\ \dfrac{\psi_j}{\phi_j} \cdot [Q_j^u \cdot \exp\{-1 - \phi_j v_j^u)\} - \theta_j \exp(\beta \cdot c_j) - H_j, & c_j \in [c_j^u, \infty) \end{cases} \tag{21}$$

This yields

$$\tilde{Z}_j' = \{\pi_j \psi_j \cdot [Q_j^l + \varphi_j (c_j - c_j^l)] + \frac{\varphi_j \psi_j}{\phi_j}\} \cdot \exp\{-1 - \phi_j v_j^l + \phi_j \pi_j (c_j - c_j^l)\} \tag{22}$$

$$\hat{Z}_j' = \theta_j \beta_j \cdot \exp(\beta_j c_j) \tag{23}$$

By the same token, we have

$$\tilde{Z}_j'' = \{\pi_j^2 \cdot \psi_j \cdot \phi_j \cdot [Q_j^l + \varphi_j (c_j - c_j^l)] + 2\pi_j \cdot \psi_j \cdot \varphi_j\} \\ \times \exp\{-1 - \phi_j v_j^l + \phi_j \pi_j (c_j - c_j^l)\} \tag{24}$$

$$\hat{Z}_j'' = \theta_j \beta_j^2 \cdot \exp(\beta_j c_j) \tag{25}$$

Lemma 2: If $\tilde{Z}_j''(c_j^{l+}) < \hat{Z}_j''(c_j^{l+})$ and $\tilde{Z}_j''(c_j^{u-}) < \hat{Z}_j''(c_j^{u-})$, then $Z_j(p^*_{j|c_j}, c_j)$ is concave over $c_j \in [c_j^l, c_j^u]$, where c_j^{l+} is a neighborhood of c_j^l and $c_j^{l+} > c_j^l$; c_j^{u-} is a neighborhood of c_j^u and $c_j^{u-} < c_j^u$.

Proof: Because $\phi_j, \varphi_j, \pi_j, \beta_j > 0,$ it follows that both $\tilde{Z}_j''(c_j)$ and $\hat{Z}_j''(c_j)$ are strictly increasing function over $c_j \in (c_j^l, c_j^u)$ by (24) and (25). Also, because $\tilde{Z}_j''(c_j^{l+}) < \hat{Z}_j''(c_j^{l+})$ and $\tilde{Z}_j''(c_j^{u-}) < \hat{Z}_j''(c_j^{u-})$, we see that $\tilde{Z}_j''(c_j) < \hat{Z}_j''(c_j)$ over $c_j \in (c_j^l, c_j^u)$. Further, both $\tilde{Z}_j(c_j)$ and $\hat{Z}_j(c_j)$ are continuous at $c_j = c_j^l,\ c_j^u$, thus, $Z_j(p^*_{j|c_j}, c_j)$ is concave over $c_j \in [c_j^l, c_j^u]$.

Lemma 3:

(1) If $\tilde{Z}_j'(c_j^{l+}) > \hat{Z}_j'(c_j^{l+}),$ $\tilde{Z}_j'(c_j^{u-}) < \hat{Z}_j'(c_j^{u-}),$ and $\tilde{Z}_j''(c_j^{l+}) < \hat{Z}_j''(c_j^{l+}),$ $\tilde{Z}_j''(c_j^{u-}) < \hat{Z}_j''(c_j^{u-})$, then $Z_j'(p^*_{j|c_j}, c_j) = 0$ (i.e., (22)-(23)=0) has the solution over $c_j \in (c_j^l, c_j^u)$, this solution is the global maximum,

(2) If $\tilde{Z}_j'(c_j^{l+}) > \hat{Z}_j'(c_j^{l+}),$ $\tilde{Z}_j'(c_j^{u-}) > \hat{Z}_j'(c_j^{u-}),$ $\tilde{Z}_j''(c_j^{l+}) < \hat{Z}_j''(c_j^{l+}),$ and $\tilde{Z}_j''(c_j^{u-}) < \hat{Z}_j''(c_j^{u-})$; then c_j^u is the global maximum.

Proof: (1) By the results of $\tilde{Z}_j'(c_j^{l+}) > \hat{Z}_j'(c_j^{l+}), \tilde{Z}_j'(c_j^{u-}) < \hat{Z}_j'(c_j^{u-}),$ we have that $Z_j(p^*_{j|c_j}, c_j)$ is increasing at $c_j = c_j^{l+}$ and decreasing at $c_j = c_j^{u-}$. Also, by the results of $\tilde{Z}_j''(c_j^{l+}) < \hat{Z}_j''(c_j^{l+}),$ $\tilde{Z}_j''(c_j^{u-}) < \hat{Z}_j''(c_j^{u-})$ and Lemma 2, we get $Z_j'(p^*_{j|c_j}, c_j) = 0$ has a solution and this solution is a local maximum over $c_j \in [c_j^l, c_j^u].$ Further, by our assumptions and (18), we get $Z_j(p^*_{j|c_j^u}, c_j) \le Z_j(p^*_{j|c_j^u}, c_j^u)$ over $c_j \in [c_j^u, \infty)$, thus this solution is also the global maximum.

(2) By the results of $\tilde{Z}_j'(c_j^{l+}) > \hat{Z}_j'(c_j^{l+})$, $\tilde{Z}_j'(c_j^{u-}) > \hat{Z}_j'(c_j^{u-})$, $\tilde{Z}_j''(c_j^{l+}) < \hat{Z}_j''(c_j^{l+})$, and $\tilde{Z}_j''(c_j^{u-}) < \hat{Z}_j''(c_j^{u-})$, we get $Z_j(p^*_{j|c_j}, c_j)$ is strictly increasing concave over $c_j \in [c_j^l, c_j^u]$. Thus, c_j^u is the local maximum over $c_j \in [c_j^l, c_j^u]$. Similarly, by our assumptions and (18), we get $Z_j(p^*_{j|c_j^u}, c_j) \le Z_j(p^*_{j|c_j^u}, c_j^u)$ over $c_j \in [c_j^u, \infty)$, thus c_j^u is the global maximum.

Theorem 2: If $\tilde{Z}_j'(c_j^{l+}) > \hat{Z}_j'(c_j^{l+})$, $\tilde{Z}_j''(c_j^{l+}) < \hat{Z}_j''(c_j^{l+})$, and $\tilde{Z}_j''(c_j^{u-}) < \hat{Z}_j''(c_j^{u-})$, then $Z_j(p^*_{j|c_j}, c_j)$ is a strictly increasing concave function either over $c_j \in [c_j^l, \tilde{c}_j^*]$ or over $c_j \in [c_j^l, c_j^u]$, where $\tilde{c}_j^*$ is the solution of $Z_j'(p^*_{j|c_j}, c_j) = 0$.

Proof: The results of this theorem are straightforwardly obtained by the results of Lemma 2.

4. Solution Method

According to the result of Theorem 1, (15) and (16) may be rewritten as

$$A_j = \frac{\dfrac{L_j \cdot (1-\alpha_j) \cdot T_j}{\xi_j} Z_j(p^*_{j|c_j}, c_j) + L_j c_j + CIFD_j^*(T_j)}{CA_j^*(T_j)}, \forall j \tag{26a}$$

$$\frac{L_j \cdot (1-\alpha_j) \cdot T_j}{\xi_j} \cdot Z_j(p^*_{j|c_j}, c_j) \le TNR_j^{t\arg et}, \forall j \tag{26b}$$

Now we consider the case that $\tilde{Z}_j'(c_j^{l+}) > \hat{Z}_j'(c_j^{l+})$, $\tilde{Z}_j''(c_j^{l+}) < \hat{Z}_j''(c_j^{l+})$, and $\tilde{Z}_j''(c_j^{u-}) < \hat{Z}_j''(c_j^{u-})$, then according to Theorem 2, we see that $\tilde{c}_j^*$ is the solution of (27) by (22) and (23).

$$\begin{aligned} &\{\pi_j - \psi_j \cdot [Q_j^l + \varphi_j \cdot (c_j - c_j^l) + \frac{\varphi_j \psi_j}{\phi_j}\} \cdot \exp\{-1 - \phi_j v_j^l + \phi_j \pi_j (c_j - c_j^l)\} \\ &- \theta_j \beta_j \cdot \exp(\beta_j c_j) = 0 \end{aligned} \tag{27}$$

Equation (27) can be solved by using the well-known Newton-Raphson method.

Also, we have that $c_j^* = \widetilde{c}_j^*$ or c_j^u, where c_j^* is defined by (12). After obtaining the values of c_j^* for all j, we see that $Z_j(p^*_{j|c_j}, c_j)$ is a strictly increasing concave function over $c_j \in [c_j^l, c_j^*]$ (by Theorem 2). Thus, the technique of piece-wise linear approximation may be employed to transform the nonlinear fashion of $Z_j(p^*_{j|c_j}, c_j)$ into an approximately linear form (as depicted in Figure 1). Indeed, if we take K_j breaking points from interval $[c_j^l,\ c_j^*]$, noted by $r_{j(k)}, k = 0,1,\cdots,K_j$, then there exist some $c_{j(k)}$, $0 \le c_{j(k)} \le r_{j(k)} - r_{j(k-1)}$, so that

$$c_j = r_{j(0)} + \sum_{k=1}^{K_j} c_{j(k)}, \quad \text{for } c_j \in [c_j^l, c_j^*] \tag{28a}$$

$$Z_j(p^*_{j|c_j}, c_j) \approx Z_j(p^*_{j|r_{j(0)}}, r_{j(0)}) + \sum_{k=1}^{K_j} \rho_{j(k)} \cdot c_{j(k)}, \ \forall j \tag{28b}$$

where $r_{j(0)} = c_j^l,\ r_{j(K_j)} = c_j^*,$, and $\rho_{j(k)} = \dfrac{Z_j(p^*_{j|r_{j(k)}}, r_{j(k)}) - Z_j(p^*_{j|r_{j(k-1)}}, r_{j(k-1)})}{r_{j(k)} - r_{j(k-1)}}$.

<Figure 1>

Substituting (28b) for $Z_j(p^*_{j|c_j}, c_j)$ in (26a)-(26b), and Substituting (28a) for c_j in (14d)-(14e), the proposed MA model may be rewritten as follows.

$$\text{maximize } A^{\min} \tag{29a}$$

Subject to

$$A^{\min} \le A_j, \forall j \tag{29b}$$

$$A_j = \frac{\dfrac{L_j \cdot (1-\alpha_j)\cdot T_j}{\xi_j} \cdot \left[Z_j(p^*_{j|r_{j(0)}}, r_{j(0)}) + \sum_{k=1}^{K_j} \rho_{j(k)} \cdot c_{j(k)} \right]}{CA_j^*(T_j)} + \frac{L_j \cdot c_j + EIFD_j^*(T_j)}{CA_j^*(T_j)}, \quad \forall j \tag{29c}$$

$$\frac{L_j \cdot (1-\alpha_j) \cdot T_j}{\xi_j} \cdot \left[Z_j(p^*_{j|r_{j(0)}}, r_{j(0)}) + \sum_{k=1}^{K_j} \rho_{j(k)} \cdot c_{j(k)} \right] \leq TNR_j^{\text{target}}, \forall j \tag{29d}$$

$$TNR_j^{\text{target}} = L_j \cdot \xi_j \cdot [c^*_j(T_j) - r_{j(0)} - \sum_k c_{j(k)}], \ \forall j \tag{29e}$$

$$\sum_{j=1}^{J} L_j \cdot \left[r_{j(0)} + \sum_{k=1}^{K_j - 1} c_{j(k)} \right] \leq B_0 \tag{29f}$$

$$0 \leq c_{j(k)} \leq r_{j(k)} - r_{j(k-1)}, \ \forall j, \ k \tag{29g}$$

5. Illustrative Example

Consider the well-known Chinese food X has a parent company which exists in Taiwan. However, for the market-seeking purpose, the firm intends to expand its business to Asia market with wholly owned based FDI. Assume six countries are chosen to invest a certain amount in capital at the initial investment phase and they are coded by number 1 to 6. Further, each country will only open a store, i.e., $L_j = 1, \forall j$. The parameters for this example are stated as Table 1. According to Table 1 and (27), the values of c^*_j are depicted in Table 2 (by using Newton-Raphson method).

Moreover, five breaking points are given in Table 3 and the segment slopes for all piecewise-linear approximation are depicted in Table 4. Finally, by using Lingo 8.0, we find the optimal capital investment policy $(c_1^{**}, \ldots, c_j^{**}, \ldots, c_N^{**})$ and optimal commodity pricing policy $(p^*_{1|c_1^{**}}, \ldots, p^*_{j|c_j^{**}}, \ldots, p^*_{N|c_N^{**}})$ stated in Table 5. Based on Table 5, the optimal capital investment policy is (1000, 1204, 1200, 1322,1924, 2150) and the optimal commodity pricing policy is (0.290, 0.225, 0.160, 0.304, 0.678, 0.214).

6. Concluding Remarks

A multi-site locations expansion model has been proposed to find an optimal commodity pricing and capital distribution scheme for services internationalization. Having found some properties of the model, we proposed a solution method consisting of the Newton-Raphson method and piece-wise linear approximation. The results of this paper are quite useful for service firms. Specially, the international market expansion on such business options as fast food, steak restaurants, and café shops, and so on. In this paper we only examined the case where there does not exist a capital budgeting solution so that all of targeted total net revenues are expectedly earned within their associated value-based time limits (i.e. MA model), thus further effort may focus on developing a MBT model which aims to find a solution to simultaneously maximize the buffer times in regards to each of targeted total net revenues.

References

Bardhan, P.K., 1982. Important, domestic, and transnational vertical integration: a theoretical note. Journal of Political Economy, 90(4), 1020-1034.

Bhutta, K.S., Huq, F., and Frazier, G., 2003. An integrated location, production, distribution and investment model for a multinational corporation. International Journal of Production Research, 86(3), 201-216.

Bhutta, K.S., 2004. International facility location decisions: a review of the modeling literature. International Journal of Integrated Supply Management, 1 (1), 33-50.

Bouqet, C., H'ebert., L., and Delios, A., 2004. Foreigen expansion in service industries: separability and human capital intensity. Journal of Business Research, 57, 35-46.

Brouthers, K.D. Brouthers, L.E. and Werner, S., 2002. Industrial sector, perceived environmental uncertainty and entry mode strategy. Journal of Business Research, 55, 495-507.

Carrizosa, E., Conde, E., 2002. A fractional model for locating semi-desirable facilities on networks. European Journal of Operational Research, 136, 67-80.

Chang, C. C., 2003. The centralized sequential investment problem with regional characteristics effect by using genetic algorithms. Journal of Operations Research Society of Japan, 46 (4), 467-486.

Chang, C.C., and Chen R.S.,2007. Project advancement and its Applications to multi-air-route quality budget allocation. Journal of the Operational Research Society, 58(8), 1002-1020.

Chang, C. C. and Chen, Y. C., 2008. The application of project advancement to developing the deployment procedure for transnational investment: the example of fast food industry entry into Mainland China. International Journal of Management Concepts and Philosophy (waiting for publication).

Cloninger, P.A., 2004. The effect of service intangibility on revenue from foreign markets. Journal of International Management, 10, 125-146.

Clark, T., and Rajaratunam, D., 1999. International services: perspectives at century' end. Journal of Service Marketing, 13, 298-310.

Campbell, A.J. and Verbeke, A., 1994. The globalization of service multinationals. Long Range Planning, 27(2), 95-102.

Culem, C.G.., 1988. The locations determinants of direct investments among industrialized countries. European Economic Review, 32, 885-904.

Dan, R.E.,1978. Strategy is different in service business. Harvard Business Review, 54 (4), 158-164.

Dunning, J.H., and Norman, G.., 1987. The location choices of international companies. Environment and Planning, 19, 613-631.

Dunning, J.H., 1989. Transnational Corporations and the Growth of Services: Some Conceptual and theoretical Issues. U.N., New York.

Erramilli, M.K. and Rao, C.P.,1993. Service firms' international entry mode choice: a modified transaction cost analysis approach. Journal of Mark, 57, 19-38.

Grosse, R.E., 1985. An imperfect competition theory of the MNE, Journal of International Business Studies, 16(1), 37-56.

Goldberg, L.G. and Johnson, D., 1990. The determinants of U.S. banking activity in the abroad. Journal of International Money and Finance, 9, 123-137.

Hirch, S., 1993. The globalization of services and service-intensive goods industries. In: Aharoni, Y. (Ed.), Coalitions and Competition: The Globalization of Professional Services. Routledge, London, 66-78.

Hinojosa, Y., Puerto, J., and Femandz, F.R., 2000. A multiperiod two-echelon multicommodity capacitated plant location problem. European Journal of Operational Research, 123, 271-291.

Johanson, J. K., 2003, Global Marketing: Foreign Entry Local Marketing and Global Management. Boston: McGraw-Hill Irwin.

King, J.N., 2003. EU asks U.S. to revise rules for service sectors, Wall Street Journal, Feb. 25, A3, A8.

Kundu, S.K. and Contractor, F.J., 1999. Country location choices of service multinationals: An empirical study of the international hotel sector. Journal of

International Management, 5, 299-317.

Mitchell, V.W., Greatorex, M. 1993. Risk perception and reduction in the purchase of consumer services. Service Industry Journal, 13 (4), 179-200.

Myung, Y..S., Kim, H.G.., and Tcha, D.W., 1997. A bi-objective incapacitated facility location problem. European Journal of Operational Research, 100, 608-616.

Nigh, D., Cho, K.R. and Krishnan, S., 1986. The role of location-related factors in U.S. banking involvement abroad. Journal of Internal Business Studies, 173, 59-72.

Pearce, R.D., 1991. The Determinants of Foreign Direct Investment: A Survey of the Evidence. United Nations, New York.

Rosing, K. E., 1994. Considering offshore production platforms. European Journal of Operational Research, 72, 204-206.

Seymour, H., 1987. The Multinational Construction Industry. Croom Helm: London.

Verter, V., and Dincer, M.C., 1995. Global manufacture strategy. In Drezner. (Eds), Facility location: a survey of applications and methods, Springer, New York.