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Abstract

Recent business trends have been characterized by global competition. Furthermore, the severe shortages and increasing costs of Information Technology professionals are forcing software development companies to explore global system development strategies. A conceptual framework representing factors affecting global software development decision and selection of development center locations is developed. Drawing from the literature in economics, global manufacturing and global R & D, this paper presents an economic cost model to support global software development decision and help select appropriate locations. The model considers economic, political, managerial, and technical environment in home and host country.

The Conceptual Model

Increasing numbers of companies are relying on Information Technology to gain competitive advantages and support globalization. To support this trend, software development strategy must deliver high quality solutions in a shorter period and at lower costs (Kemerer 1998, Slaughter 1998). Unfortunately, software development projects are frequently characterized by cost overruns, delayed schedules, and a shortages of IT staff (Kim and Stohr 1998). The potential of significant cost savings and the availability of highly skilled labor in developing countries are fueling the growth of Global Software Development (GSD). Some countries have a relatively abundant supply of skilled IT workforce, training facilities and are rapidly improving the technical infrastructure, such as the communication network. Maturing project management knowledge and skills in these countries are making them attractive locations for software development centers. In this research, we explore home and host country factors associated with selecting development location. Figure 1 summarizes our conceptual model.

Home and Host country Factors

A decision to embark on global software development is influenced by economic, political, managerial and technical factors that may be discriminated among the possible countries. Based on our survey of literature, we identify the following home country and host country factors. The size and overall capacity of the organization, the capability to manage global technology projects and the cost and availability of skilled IT workforce in the home country are major home country factors motivating GSD.
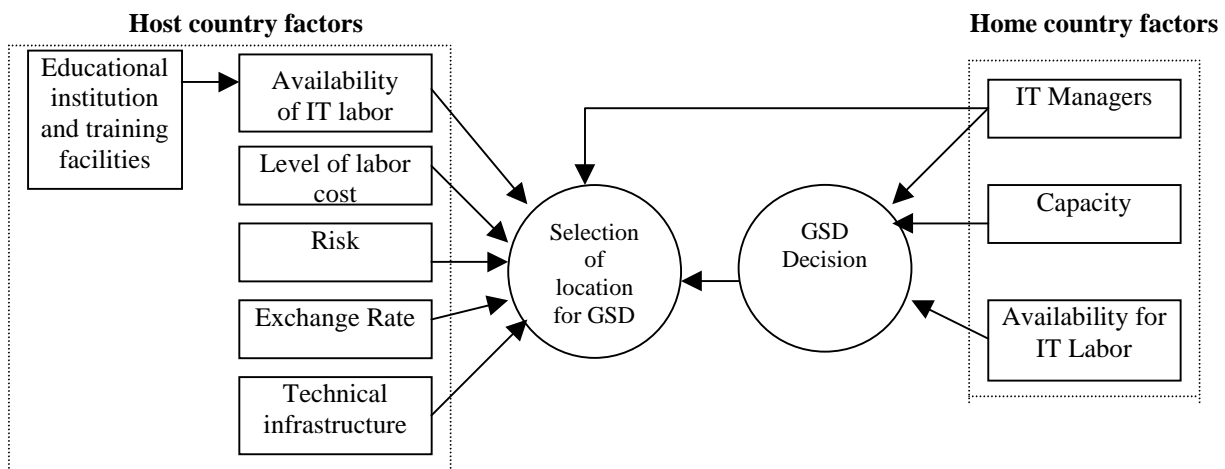

Figure 1: Conceptual Model

Table 1: Home and Host country factors

Factors	Variables	Description
Home Country Factors	Information technology (IT) manager	The manager responsible for global software development needs to be skilled in distributed development techniques and should be familiar with host country's political and social environment.
	Capacity	The size and overall capacity of the organization needs to be large enough to justify investment and overhead of Global Software Development.(Evans, 1987; Dunne and Hughes, 1994).
	Availability for IT labor	There are severe shortages of IT personals in the U.S. and many developed countries, resulting in significantly higher costs. This trend forces the companies to look for other sources (Government report 1998).
Host Country Factors	Availability of IT labor	Software development is knowledge-intensive work. Experienced or trained IT labor enables the development of new technology projects required for gaining and maintaining competitive advantage. It requires a technology learning process that plays creative roles in continuing technical changes (Rbillard 1999)
	Educational institution and training facilities	Education and training are generally used to support the knowledge accumulation process. The level at which these processes are prevalent and well established in the host country determine the level and quality of the IT work force available (Banker et al. 1998). Substantial differences between various countries exist on this dimension.
	Level of IT labor cost	The pool of experienced and/or trained IT personal, the cost of living and the prevalent wage rates determine the long-term labor cost.
	Risk	Risk factor including government stability, cultural interaction, bureaucracy, or red tape need to be considered in selecting the development location (Tractinsky and Jarvenpaa 1995). Risk increases the uncertainty of the investment. Other non-market uncertainties such as, work-rule, protection tariffs, anti-trust enforcement, and profit repatriation rules must also be considered. (Kogut and Kulatilaka 1994)
	Exchange rate	The Exchange rate and the stability of local currency are other important factors affecting the decision regarding a development location (Kogut and Kulatilaka 1994). Furthermore, Exchange rates could be one of the indexes used to indicate the economic stability of a country.
	Infrastructure	Infrastructure, such as communication and energy infrastructure, has played a crucial role in economic globalization. Especially, communication infrastructure that makes effective and efficient information exchange between the home and host country locations possible is a profound requirement for supporting global operation (Meyer 1991; Vitalari and Wetherbe 1995; Streeter, et al. 1996).

Successful global software development requires significant investment in setting up operation and hiring skilled IT professionals in the host country. Major host country factors that need to be considered in selecting the locations for global software development are availability of trained or potentially trainable IT professionals, risk, macroeconomic environment and technical and/or basic infrastructure. Table 1 summarizes the relevant literature.

Cost model of global software development

Reduced cost and minimization of risk in terms of investment and quality are major objectives of Global Software Development. A software development cost model that evaluates the home and host country's factors and assesses the long-term risks is required to help support GSD decision. A number of software cost estimation models exists in the literature. Kemerer (1987) provides a review and comparison of popular software

cost models such as SLIM, COCOMO, Function point, and ESTIMACS. Hu, et al. (1998) developed the minimum software cost model (MSCM) using economic production processes and compared classic and popular software cost models.

This paper presents the global software development process, and derives software cost function from a set of host and home country factors over a period. For simplicity, we assume the linear cost function that can be optimized for producing the output (Y_c) in given time period (T_c):

$$Min \int_o^{T_c} \left[L_i w_i + N_i + G_i)\theta_i \right] \, dt$$

$$subject\ to \int_0^{T_c} M (L_i^\alpha I_i^\beta R_i^\gamma) dt = Y_c$$

,where L_i is the number of IT labor of the host country that is influenced by the educational and training facilities. w_i indicates the wage rate of IT person in terms of local currency. Exchange rate, θ_i, needs to be added in order to express world market dollar term.. I_i and R_i represent degree of infrastructure and risk of the host country that are also required express world market dollar term. In addition, we assume that production function of software can be defined in Cobb-Douglas production form. This form is the function of various input factors, such as the production level of manager's cooperative effort(M), the input level of IT persons of host country, infrastructure and risk. α represents the effectiveness of the IT persons of host country. Also, β and γ are company's capability to use exiting infrastructure and to handle risk, respectively. Theoretically, these parameters can take positive value that indicates the productivity of software development project [Hu et al. 1998].

Lagrangian integrand can be used to generate necessary condition, and Euler equations support to find the optimal solution simultaneously. The solution includes wage rates, exchange rate, size of the project, and development time. We will divide both sides of the solution by wage rates following traditional measurement method in terms of man-month type [Hu, et al., 1998]. The model provides a rigor of mathematical and statistical analysis for supporting the global software development decision. It incorporates economic, political, managerial, and technical variables.

Data obtained from secondary sources may be problematic because of validity and reliability [Rai, et al., 1997]. Secondary data for number of IT persons, exchange rates, risk, and infrastructure. on specific countries like India, Brazil, Rusia, and Ireland are being collected from *Computerworld, Department of Economics and Social Affairs* and previous research [Wheeler and Mody 1992]. Also, historical project data that have been used in many previous researches will be used to estimate parameters [Kemerer 1987]. The model allows comparative analysis of possible locations. The contribution of this research is in emphasizing the current trends in software development, in identifying the possible factors, and in developing appropriate software development cost model.

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