A System Dynamic Modeling Approach to Offshoring R&D Activities

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Abstract

Offshoring of technology development is moving towards a higher level of globalization. Major firms in technologically developed countries such as the USA, Germany and Japan have started setting up their R&D laboratories in the newly emerging countries. As in the case of IT offshoring, there is a growing fear that the developed countries may lose their edge in technology as well as jobs in the R&D, technology development, and innovation functions. But does it actually reduce employment in these areas?

The paper examines the question as well as provides information for successful offshoring of technology development. It identifies the factors that are important in technology outsourcing/offshoring and the mechanisms by which they function and how the decision parameters affect these mechanisms. We use a system dynamics model to analyze these issues. This model provides information on employment and skill transfers, the rate of such transfers and their effects on employment and innovation abilities.

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Introduction:

The 1990s has seen the rapid growth of outsourcing and offshoring (Bryce and Useem, 1998). Firms tend to get things done at the lowest cost, provided quality and schedule requirements are met. Though the wages in many developing countries were very low compared with the USA or Europe, the quality of output, the productivity, and the promptness of meeting schedule commitments were also very low. Thus, sending work to low wage countries was not an attractive proposition, as the total costs (of poor quality, missed deliveries and missed commitments) would have been much higher in addition to the problems of logistics.

However things changed. In the beginning US companies went to India for outsourcing many of the common functions that could be done remotely – call centers for example. After a period of time they found that the quality and performance of the employees were superior, and the firms started outsourcing more and more higher level jobs (Dossani and Kenney, 2003).

With the availability of a large pool of educated engineering and science graduates in China and India, US firms started setting up product development facilities. These facilities mainly focused on developing new products for the local or regional markets using the technology from the parent organization (Balachandra, 2005). Companies such as GE, Motorola, HP, Texas Instruments and others established large facilities for R&D and product development. These firms found that it was not only better from a cost perspective, but also were able to take advantage of local market information (Balachandra, 2007).

The outsourcing/offshoring phenomenon in the R&D area is complex and is tending to become more and more important for firms that want to profitably employ engineering and scientific talent wherever it is available to enhance their competitive strength.

The research presented here approaches the problem using the system dynamics approach. After identifying the factors leading to the setting up of research centers geared towards innovation, product development, technology development and finally basic research, the approach develops a system dynamics model to describe the process and to forecast how the system behaves with variations in the decision parameters. It employs data collected about R&D off shoring activities in India and China. It will also examine the trends in off shoring activities – the types of technology and innovation activities that will be off shored in the next few years.

Literature Review:

For over a decade, strategic outsourcing decisions have been studied in the scholarly and trade literature. The trade literature focused on the practical aspects, while the scholarly literature focused on identifying the factors that affect the decision and the manner of their impacts on the decision.

Since most of the early off shoring decisions were based on cost it is no surprise that the early work focused on costs (Williamson, 1996; Benko, 1993). Over a period of time it was realized that costs alone were not the driving force. Researchers started to include strategic issues (Chalos, 1994; Teng et al., 1995; Venkatraman, 1997; Jennings, 2002). While discussing strategic issues, the focus in the early literature was on core competencies (Prahalad and Hamel, 1990; Beltis et al., 1992) which argue against outsourcing core activities while non-core activities are good candidates for outsourcing. Following this argument, most firms outsourced extensively only secondary activities of their value chains, such as call centers, information technology, accounting systems and distribution (Johnson and Schneider, 1995; Lacity and Willcocks, 1998); some firms bravely outsource their core activities so extensively that they do not engage in 'production' as it has been traditionally understood (Tisdale, 1994; Tempest, 1996).

Few firms appear to have a good understanding of the risks and benefits of outsourcing, apart from a general idea that it will save resources and allow them to focus on core competencies (Smith et al., 1998). Some recent papers have explored the strategic and tactical thrusts of outsourcing models (Ngwenyama and Bryson, 1999, Hyland and Beckett 2002, Linder et al. 2002 and Zhu et al. 2001).

In recent years the arguments have shifted from "make/ buy" to how to optimize outsourcing decisions, while 'sticking to their knitting' to avoid costs incurred in developing and maintaining infrastructures (Venkatraman, 1997). This led to looking at contextual models (Cross, 1999; Greer et al., 1999, Jennings, 2002) and developing contextual frameworks (Vinig and Globerman, 1999, Pati and Desai, 2005).

Along with these approaches, there has been a parallel movement to study the effects of outsourcing on skill sets at the originating country as well as the destination country. Some (Hijzen et al 2005, Feenstra and Hanson, 1996) have argued that international outsourcing has had a strong negative impact on the demand for unskilled labor. On the other hand, an Australian case study suggests that outsourcing actually enhanced the skill sets of the company (Lewer and Gallimore, 2001).

There have been attempts to model outsourcing using OR techniques. Yang et al (2007) describe an Analytic Hierarchy Process approach to identify and weight the decision factors involved in

the BPO (Business Process Outsourcing) decision. Dutta and Roy (2005) have attempted developing a system dynamics model to simulate growth in offshoring.

As we can see from this brief review modeling of the outsourcing phenomenon has taken on many aspects. Some are purely based on economics, some are based on organizational theories while a few are applying OR techniques.

Few or no attempts have been made in all this work to systematically establish the relationships of many of the variables on the success of the facility. There is also no work on how decision parameters affect the success and growth of offshore technology development This research attempts to fill this lacuna by developing a system dynamics model to help foresee how the various decision parameters affect in terms of results, employment levels in host firm (in the offshore location) as well as the guest firm.

R&D Outsourcing and Globalization:

It is quite interesting to study the reasons behind the outsourcing of R&D, which is considered to be a core competency till recent past. The need for R&D in a company is to constantly upgrade and maintain a cutting edge in the market (Lu and Yang, 2007). It mostly pertains to meeting the market need. The reasons for R&D outsourcing can be classified into two types - market need driven and economic factors driven.

Market driven factors can be given as rapidly growing demand for new products and neck to neck competition between firms. The Centre for Research in Innovation and Competition, University of Manchester has suggested that "Firms, even large multinational corporations, can no longer expect to be totally dependent on their in-house research and technology resources to maintain innovative performance." There is a great demand present day's market for innovation.

The situation leads to huge investments in R&D by companies and employing fresh talent and minds to meet the need. But it is not always feasible or economically viable to employ more and more researchers or scientists with the stakes being very high in such a move. An alternative to this is outsourcing R&D. The need for innovation drives the R&D outsourcing more and more by the day. Without employing a single scientist or researcher companies are in a position to develop cutting edge products because of this phenomenon.

In case of companies with economical and financial crunch the R&D outsourcing acts as a bail out from unpredictable amounts of investment that goes into research. The need for innovation is met at a lower cost with an optimistic eye on the results. Under these circumstances Research and Development outsourcing is considered more of an opportunity than an option by most companies. This trend has opened the doors for advancement of the technology and great innovation from across the world. But still companies act skeptical to the idea of subcontracting research. In a 2003 survey conducted by the Shared Services and Business Process Outsourcing

Association (SBPOA), a third (33%) of respondents stated that a lack of control and loss of internal knowledge are the main concerns when considering to whether or not to outsource. A few other factors are considered relevant in this context:

- Reduction of time for communication between product development and target market
- Intellectual Property Rights
- Financial and economic advantages
- Need for Innovation
- Risk Management
- Quality Improvement
- Specialization
- Allocation of resources
- Competition
- Poor performance by in-house R&D
- Loss of work force
- Poor economy, etc.

Even if outsourcing of R&D is a viable choice for companies, they still face a daunting task of choosing the right partner at the right place. The choice of outsourcing country and partner companies depends on various factors from both the parent and partnering companies' point of view. These factors are illustrated in this paper and also used for the simulation model.

The grouping of the factors effecting R&D globalization will help in understanding the approach required to analyze the system. Table I illustrates these factors and the conditions.

To study this complex situation we have utilized the System Dynamics approach. The next section briefly describes the system dynamics approach and its application to the R&D outsourcing phenomenon.

The System Dynamics Model:

System Dynamics was first developed by Jay W Forrester of MIT's Sloan School of Management to explain and predict the behavior of industrial systems. It has since been extended to many other fields such as population growth, economics, global warming, and even military strategy. It explains the behavior of complex systems with the help of elements of feedback loops from Systems Theory (Radzicki & Taylor, 1997). According to the System Dynamics philosophy, every system has an underlying structure and this structure determines how the components that make up the system interact with each other. It is these interactions or the structure that determines the overall behavior of the system. Therefore, to understand the system as a whole, it is necessary to understand the structure of the system (how its components interact

with each other); properties of the whole cannot be found in the properties of the individual components but in their causal relationships (Kirkwood, 1998).

System Dynamics eliminates the traditionally adopted event based approach of simulation to solve problems. The event based approach only reveals the events that might have caused a problem and other preceding events that might have led to it. This event-causes-event approach does not reveal the underling structure and it is therefore likely that the problem will surface again in the future (Kirkwood, 1998). System Dynamics, on the other hand, helps capture the underlying structure using a powerful representation technique called Causal Loop Diagram or CLD. The CLD captures relationships between events (sub components) and how information from an event is fed back into the system to alter the causes (nothing but some other event) that created the event. Figures 1a and 1b show the two approaches. Thus, the System Dynamics approach can help us expand our mental models (how we perceive things to work); learn and thoroughly understand the dynamic nature of a system and its interactions with the environment in which it operates, thereby helping us find the best policies that can produce a sustainable effect (Sterman, 2000).

Applying System Dynamics Modeling to Offshoring R&D

We first develop a system dynamics model to reflect the factors involved in offshoring technology development, the decision parameters and their interrelationships. An offshoring situation can be modeled as a dynamic business system subject to many environmental factors and decision parameters. These are related to each other in complex ways. Starting with a simple model, additional factors and parameters will be introduced to make the model as close to the real situation as possible. Figure 2 shows a preliminary model of the offshoring of technology phenomenon, representing the perspectives of two countries.

A micro model representing the behavior of two firms reflecting a firm's perspective. This will include the complex issues that affect offshoring of technology, the factors and the decision parameters. For example, the additional investment in an offshore facility by a firm will be a function of the current investment level, the change in the research productivity of the facility (number of patents, number of papers published etc.), change in the revenues derived from the products developed by the facility, and other exogenous factors and decision parameters. These relationships are usually expressed as difference equations between the various entities and factors. The difference equations will have a form as shown below:

$$\Delta Y = Y + \Delta X + \Delta W + \ldots$$

X, Y etc. are the variables and parameters, and Δ represents the change in the variable from one period to the next. Feedback loops and feed forward loops[1] in the system make the system very realistic.

The system dynamics simulation package (VENSIM, Sterman, 2000) will be used to run the model with all the decision parameters and the factors.

Data

The data consists of information about the off shoring firm and its partner (if there is one) and the facility being established. It also includes the planned budget and the employment level including the number of technical personnel. In addition it includes the areas and nature of research being done or planned to be done in the facility. The current data base has over 400 instances of offshore R&D activities.

The Model

The framework of the model is shown in Figure 2. This represents the variables at the gross (country) level. It identifies the various skills that are needed for the firm seeking offshore R&D. It also shows the sources of skills developed by the host country and the variables that affect them. It also identifies the flows and inventories between the different system nodes.

We developed the equations based on our understanding of the various issues. We used the data base to develop the preliminary equations. The equations are further modified based on partial simulations of the model and verification. The time increments for this model were a quarter (three months). This is an appropriate interval of time as most corporate decisions use this time frame.

Results and Conclusions

The model is still under development and the equations are under constant improvement. We expect that the research will be completed in the next few months.

Even the partial model has given us a few insights some of them may appear very commonsensical. Investing in higher education in the scientific and engineering fields makes the country more attractive to companies wanting to offshore R&D.

[1] A feedback loop is where the outcome of a process affects the input into the process. A feed forward loop is where the decision maker or controller anticipates a change in the system and provides corrective action before the change.

REFERENCES

[1]. Balachandra, R., (2005) R&D Outsourcing, presented at the Research Management Conference, Pisa, July 2005.

[2]. Balachandra, R., (2007) Offshore R&D, presented at the National Meeting of Decision Sciences Institute, Phoenix, November 2007.

[3]. Balachandra, R., and Kamarthi, S. (2008) Skill Sets and Outsourcing, presented at the International Conference on Outsourcing/ Offshoring, Manipal, January 2008.

[4]. Beltis, R.A., Bradley, S.P. and Hamel, G. (1992), "Outsourcing and industrial decline", *Academy of Management Executive*, Vol. 6 No. 1, pp. 7-21.

[5]. Benko, C. (1993), "Outsourcing evaluation: a profitable process", *Information Systems Management*, Vol. 10 No. 1, pp. 45-50.

[6]. Bryce, D. and Useem, M. (1998) The impact of corporate outsourcing on company value. *European Management Journal* **16**(6), 635–643.

[7]. Chalos, G.C. (1994), "Costing, control and strategic analysis in outsourcing decisions", *Journal of Cost Management*, Vol. 8 No. 4, pp. 31-7.

[8]. Dossani, R. and Kenney, M. (2003), Went for Cost, Stayed for Quality?: Moving the Back Office to India, Stanford: Asia Pacific Research Center.

[9]. Dutta, A., and Roy, R. (2005) Offshore Outsourcing: A Dynamic Causal Model of Counteracting Forces, *Journal of Management Information Systems,* Fall 2005, v. 22, No. 2, pp. 15-35.

[10]. Hijzen, H., Gorg, A., and Hine, R.C., (2005) International outsourcing and the skill structure of labour demand in the United Kingdom, *The Economic Journal*, 115 (October), 860–878.

[11]. Hyland, P. and Beckett, R. (2002), "Learning to compete: the value of internal benchmarking", *Benchmarking: An International Journal*, Vol. 9 No. 3, pp. 293-304.

[12]. Jennings, D. (2002), "Strategic sourcing: benefits, problems and a contextual model", *Management Decision*, Vol. 40 No. 1, pp. 26-34.

[13]. Kirkwood, C. W. (1998). System Dynamics Methods: A Quick Reference. Tempe, Arizona.

[14]. Lewer, J. and Gallimore, P., (2001) Are outsourcing and skill formation mutually exclusive?The Experience of a Heavy manufacturing Firm, *International Journal of Employment Studies*, Vol.9, No. 1, April 2001 pp.141-162.

[15]. Linder, J.C., Cole, M.I. and Jacobson, A.L. (2002), "Business transformation through outsourcing", *Strategy and Leadership*, Vol. 30 No. 4, pp. 23-8.

[16]. Lu, L.Y.Y., and C. Yang, The R&D and Marketing Cooperation Acrtoss New Product Development Stages: An Empirical Stdy of Taiwan's IT Industry, *Industrial Marketing Management*, **33 (7): p. 593-605**

[17]. Moncada-Paterno-Castello, P., M. Vivarelli, and P. Voigt (2011) Drivers and Impacts in the Globalization of Corporate R&D: An Introduction Based on European Experience, IZA Discussion Papers.

[18]. Ngwenyama, O. and Bryson, N. (1999), "Making the information systems outsourcing decision: a transaction cost approach to analyzing outsourcing decision problems", *European Journal of Operational Research*, Vol. 115, pp. 351-67.

[19]. Pati, N. and Desai, M.S., Conceptualizing strategic issues in Information Technology Outsourcing, *Information Management & Computer Security* Vol. 13 No. 4, 2005 pp. 281-296
[20]. Prahalad, C. and Hamel, G. (1990), "The core competence of the corporation," *Harvard Business Review*, Vol. 68 No. 3, pp. 79-91.
[21]. Radzicki, M. J., & Taylor, R. A. (1997). *Introduction To System Dynamics.* U.S. Department of Energy.
[22]. Smith, M., Mitra, S. and Narasimhan, S. (1998) Information system outsourcing: a study of pre-event firm characteristics. *Journal of Management Information Systems* **15**(2), 60–92.
[23]. Sterman, J. D. (2000). *Business Dyanmics: Systems Thinking and Modeling for a Complex World.* McGraw Hill.
[24]. Teng, J.T.C., Cheon, M.I. and Grover, V. (1995), "Decisions to outsource information systems functions testing a strategy-theoretic discrepancy model", *Decision Sciences*, Vol. 26 No. 1, pp. 75-103.
[25]. Venkatraman, N. (1997), "Beyond outsourcing: managing IT resources as a value center", *Sloan Management Review*, Vol. 38 No. 3, pp. 51-64.
[26]. Vining, A., and Globerman, S. (1999) A Conceptual Framework for Understanding the Outsourcing Decision, *European Management Journal* Vol. 17, No. 6, pp. 645–654.
[27]. Williamson, O.E. (1996), "Economic and organizations – a primer", *California Management Review*, Vol. 38 No. 2, pp. 131-46.
[28]. Yang, D., Kim, S., Nam C., and Min, J., (2007) Developing a Decision Model for business process outsourcing, *Computers and Operations Research*, 34 (2007), pp. 3769-3778.
[29]. Zhu, Z., Hsu, K. and Lillie, J. (2001), "Outsourcing – a strategic move: the process and ingredients for success", *Management Decision*, Vol. 39 No. 5, pp. 373-8.

Table 1

Impacts of globalization in the host and home countries.

	On host country	On home country
Positive impact	▪ Increased local technical capability ▪ Knowledge & economic spillovers ▪ Better tailored products ▪ Productivity increase ▪ Employment and sale growth	▪ Get access to other sources of expertise and innovation ▪ Enhance access to foreign markets (sales growth) ▪ Results of R&D done abroad may be exploited at home, producing economic benefits ▪ Prolong the life cycle of existing goods/services
Negative impact	▪ Foreign control over domestic R&D resources ▪ Results may be exploited elsewhere; loss of economic benefit ▪ Decrease in R&I impact when/if their links with production get weaker	▪ Loss of technical capability ▪ Hollowing out of industries ▪ Loss of economic benefits if results are exploited only locally ▪ Negative impact on industrial diversification ▪ Loss of jobs in the short-term

From Moncada et al, (2011)

Figure 1

Figure 1a: Event based approach - a decline is population is caused by a decrease in availability of resources

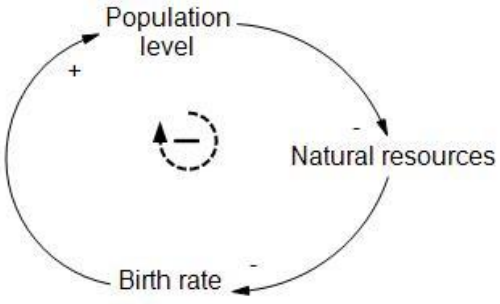

Figure 1b: Systems approach – An increase in population level creates resource scarcity. Lack of resources reduces birth rate. Reduction in birth rate results in a decline in population level

Figure 2
A System Dynamic Model of R&D Offshoring