Operationalizing Offshore Production Decisions: A Stochastic Control Approach

Introduction and motivation

Since the early 2000s, firms have pursued aggressive offshoring strategies. The offshoring trend was driven by differences in labor rates between developed and developing countries, differences in material costs, and technological improvements in transportation and communication, among other factors. While initially limited to the larger firms, offshoring has also been pursued aggressively by smaller firms. The offshoring trend has lost momentum (Kinkel and Maloca, 2009) and has given way instead to a reshoring or backshoring trend. Where firms once actively relocated production to offshore locations, these same firms are actively working to bring back production to domestic facilities. The rising cost of fuel, and associated transportation costs has fueled this reverse trend. The increase of labor and manufacturing costs in previously low-cost countries has also led to firms reevaluating their offshoring strategies. Offshoring ventures are not always guaranteed to succeed. In some cases, imprecise estimations of costs can lead to the failure of an offshoring venture (Larsen, 2016). The risks and difficulties in transferring production to low-wage countries has frequently been underestimated. Recent geopolitical occurrences have also contributed to the reshoring trend.

Reshoring production is, however, also proving difficult for firms, as highlighted by the difficulties the elevator maker Otis faced in backshoring production from Mexico to South Carolina (WSJ, 2014). Cohen and Lee (2015) embark on a benchmark study, that seeks to answer, among other questions, what companies are doing in terms of offshoring and reshoring. After the first phase of the study, the authors find that companies are not reshoring wholesale. Companies are still offshoring as well. Coupling this observation with the difficulties facing companies that have previously relocated production to offshore facilities and are trying to relocate production to domestic facilities motivates us to posit that firms
should pursue an offshoring-backshoring strategy, a strategy in which production is straddled across both offshore and domestic production facilities. Since operational factors, such as demand and price differences, form the core of this strategy, we propose an operational approach based on stochastic control theory to help firms make this decision. In this study, we examine how a firm that has both offshore and domestic production facilities should structure production at both facilities. Specifically, we are interested in studying what proportion of demand should be satisfied by each production facility.

**Methodology and results**

We consider a firm that has existing offshore and domestic production facilities. We assume that the per-unit profit margin in the domestic facility is deterministic, and that the per-unit profit margin in the offshore facility is stochastic. This stochasticity in the offshore profit margin drives the firm’s decision to vary production as the offshore profit margin fluctuates. The firm can instantaneously adjust the proportion of demand satisfied by each of the production facilities. Adjusting the production proportions result in costs to the firm. These costs may range from simple administrative costs to personnel and R&D relocation costs. Nembhard et al. (2003) also consider an operational approach to the offshoring-backshoring strategy without including adjustment costs since doing so would further complicate the problem and require a dynamic programming approach to yield a solution, but note that these costs are important and do need to be considered. In our formulation, the adjustment costs consist of both a variable and fixed component. Indeed, administrative costs may be viewed as fixed costs while relocation costs may be viewed as variable costs. We formulate this decision-making problem as a two-dimensional stochastic impulse control problem, resulting in a free-boundary problem in differential equations, a class of problems in which the solution of the differential equations, and the domain over which these equations are solved need to be determined simultaneously. Determining the region over which these equations are solved
yield the optimal decision-making policy. These policies dictate, as a function of the current production allocation proportion and current offshore profit margin, when the firm should make an adjustment to the allocation, and what this change should be. We provide a verification theorem and derive theoretical properties that characterize the optimal decision policy. Using these theoretical properties, we numerically solve for these policies. Our analysis results in decision-making policies that are not strictly monotonic. This result is noteworthy since optimal control policies arising from stochastic impulse control problems are typically strictly monotonic in nature. Our analysis also reveals that the cost structure involved in adjusting the allocation of production across both facilities is sometimes more significant than changes in the underlying profit margin.

References


