

Analyzing capacity investment decisions in decentralized Supply chains

Abstract

Decentralized supply chains are prone to inefficiencies due to double marginalization, which leads to sub-optimal performance of the overall supply chain. When capacity investment decisions are made in such decentralized supply chains under demand uncertainty, the double marginalization results in capacity under-investment. This is not an uncommon situation as at times, the supplier needs to build or enhance capacity upfront to meet the specific production requirements, and build it much ahead of actual demand realization due to long lead time of build-up. Such capacity investment decisions by suppliers are always prone to capacity under-investment. The objectives of this thesis are (i) analyze the amount of under-investment in decentralized two party supply chains and its effects on supply chain performance, (ii) elaborate on various aspects of defining and modeling the supplier capacity and its impact on assessment of under-investment, and (iii) analyze contracting mechanisms that can help coordinating the supply chain or reduce the amount of under-investment. We first measure the level of under-investment in decentralized supply chain in base case, and analyzed how it changes with key characterizing parameters of supply chain, which are: the distribution of margins between manufacturer and supplier, and capital intensiveness of the production system. In the first model, we introduce a two-way-penalty contract that has capabilities of sharing the risks associated with building capacity under demand uncertainty. We show that with commitment in the form of target capacity, manufacturer can influence supplier's capacity investment decision. For a generic model, we show that supplier's profit function is unimodal, and this leads to characterization of her capacity decision. We show the analytical results for coordination conditions for a special case when demand is uniformly distributed. The illustration suggests there is a continuum of contracts that coordinates the supply chain with flexibility in profit allocation. In the second model, capacity is modeled as a function of two substitutable factors of production. We capture efficiencies which can be achieved by replacing costlier factor of production with the cheaper one. This model also captures the flexibility that the supplier has in terms of capacity building when one of the factors has a shorter lead time, and can be adjusted to meet the demand levels after resolution of demand uncertainty. By relaxing the assumption of non-substitutability of production factors, this model helps us understand the capacity investment in offshoring context where cheaper resource substitutes the costlier resource to meet the capacity requirements. In the third model, we introduce uncertainty in supply and associate a stochastic yield with the capacity, and investigate the supplier's optimal capacity decision, performance of the decentralized supply chain, and level of under-investment in capacity. This thesis analyses several

aspects of capacity under-investment and performance of supply chains in such context. This work develops a contracting mechanism that improves the performance of the decentralized supply chain and has a potential to coordinate the supply chain with a continuum of profit sharing possibilities. This work also presents a new approach of modeling the capacity that characterizes off-shore capacity investments very well, where technology choice and level of capacity decisions are taken simultaneously, and cheaper resource substitutes the costlier resource to meet capacity requirements. It also develops understanding of the capacity investment decisions when there is an uncertainty associated with capacity, and elaborates supply chain performance under such circumstances. Overall, this work enhances understanding of capital investment decision in decentralized supply chains and its performance implications, and lays out a strong platform for further research in this domain.