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Decision Support

Transferring and sharing exchange-rate risk in a risk-averse supply chain of a multinational firm

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ABSTRACT

This paper analyzes risk management contracts used to handle currency risk in a decentralized supply chain that consists of risk-averse divisions in a multinational firm. Particular contracts of interest involve transferring risk to a third party by using risk-transfer contracts such as currency options and re-arranging risk between supply chain members using risk-sharing contracts. Due to decentralization, operational and risk management decisions are made locally; however, a headquarter who is interested in total supply chain profit has some controllability over those activities. We question if each kind of risk management contract can improve the utility of all supply chain members compared to the utility without any of those, and how the conditions to achieve such improvements are different. Further structural differences are investigated via sensitivity analysis with respect to the transfer price, the variability of exchange rates, and the location of the headquarter. We also find that using the two kinds of contracts jointly does not necessarily result in better outcomes.

1. Introduction and contributions

As global operations in multinational firms grow in popularity, the internal transactions of such firms are increasingly carried out internationally. This phenomenon makes profits and losses heavily dependent on the movements of exchange rates. While it is relatively rare to observe significant changes in production costs within a short time, it is not uncommon to see radical changes of exchange rates in the same period. For example, the US dollar fell by 11% against Brazil's real in 2011 from January to August (Economist, 2011) and Brazilian suppliers suffered big losses. That year, on the other hand, the Japanese yen fell by 5% against the US dollar (Kim, 2012), incurring losses for US buyers. In fact, currency fluctuations of 20% in one year are not rare (Dornier, Ernst, Fender, & Kouvelis, 1998). Thus, not surprisingly, risk from exchange-rate uncertainty is one of the top concerns of supply chain executives, as reported in *The Economist*'s recent survey of 500 global firms' executives (Economist Intelligence Unit, 2009).

This paper considers a decentralized supply chain of a multinational firm whose divisional and total profits are affected by exchange-rate uncertainties. If the variability of total profits is high due to fluctuating exchange rates, maximizing expected profits without consideration of variances may not lead to practical decisions. For this reason, profit variance, which stands for riskiness, is an important element of our model. Our supply chain model involves a multinational firm with a retail division and a supply division whose decisions are affected by such riskiness. Indeed, the operations management literature has shown growing interest in decisions made by risk-averse suppliers and retailers. The work of Lau (1980a) is one of the seminal papers that consider a single risk-averse newsvendor whose ordering decision depends on total exposure to demand uncertainty. Lau and Lau (1999), Tsay (2002), and recently Gan, Sethi, and Yan (2004) consider a supply chain where both the retailer and the supplier are risk-averse. For the analysis of decisions in a risk-averse supply chain, we follow the literature (e.g., Ding, Dong, & Kouvelis, 2007; Choi, Li, Yan, & Chiu, 2008; Buzacott, Yan, & Zhang, 2011) and use mean–variance utility.

In such situations, risk-averse decision makers in a supply chain naturally wish to manage the mean and the variance of profits to improve their utilities, possibly with effective risk management tools. Various types of contracts have been implemented for this purpose. One popular method is to transfer risk to a third party by buying, for example, currency options from local financial markets or banks (O'Brien, 1996), which we call hereafter as *risk-transfer contracts*. For example, when a firm plans to pay in a foreign

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currency, losses due to adverse movements of the foreign exchange rate can be mitigated by buying currency call options. This contract gives its holder the right to convert the domestic currency into the foreign currency at a pre-determined rate. Clearly, this conversion would be made if the spot exchange rate were higher than the pre-determined rate, which lessens the impact from currency rate changes (Sodhi & Tang, 2012, chap. 8). Thus purchasing hedging contracts enables a firm to transfer some or all currency risks to a third party, that is, the options seller.

Another popular method of managing exchange-rate uncertainty is to share risk with other parties involved in operations. The survey of Carter and Vickery (1988) shows that more than 50% of responding firms used some form of risk sharing with their suppliers. This approach, which we call *risk-sharing contracts*, is made between transaction parties, who commit themselves to sharing profits or losses resulting from exchange-rate movements (Eliteman, Stonehill, & Moffett, 2004) if, for example, exchange-rate is outside a pre-determined range. For example, a retailer in the United States can agree to adjust the price in euros for a supplier in Europe if the exchange rate becomes very high or very low, depending on whether the supplier's currency is strong or weak (Fisher et al., 2007). Thus a risk-sharing contract enables a firm to re-arrange currency risks between transaction parties of a risk-averse supply chain. Note that this does not entail extra payments or fees outside the chain. There is an additional incentive to consider risk-sharing because in the options exchanges typical options contracts are specified in terms of currencies, maturities, and strikes. Also, there may be a limited supply and volume for a specific contract. Thus, one may find it difficult to execute a risk-transfer contract that fits his/her purposes, and this makes risk-sharing an attractive option to consider.

A supplier and a retailer in separate firms can locally manage currency risks for each one's best interest. The management of currency risks for a multinational firm who owns both as its sub-divisions, however, is more complicated since the firm's total profits should also be considered. According to US and international accounting standards, a multinational firm is required to prepare a consolidated financial statement in each period by converting the net profit of each division into the single reporting currency in which the firm's main business is conducted. See, e.g., Accounting Standards Codification 830 of Financial Accounting Standards and International Accounting Standard 21 of International Financial Reporting Standards. The impact of exchange-rate uncertainty on such total net profits can be significant. For example, McDonald's Corporation operates across 119 countries and converts local currencies back into US dollars to prepare a consolidated statement. It is reported that the firm suffered a 4% decrease in its net income in the second quarter of 2012 due to unfavorable changes in exchange rates (AP News, 2012). Therefore it is reasonable to assume that the headquarters (HQ) of a multinational firm is concerned about its total supply chain profit being converted into one main currency, even though HQ may not be directly involved in the operational decisions of a decentralized supply chain.

The attitude of HQ toward currency risk can differ from that of local divisions in a supply chain due to different business environments, sizes, or managers' preferences. Kanodia (1979) and Yahya-Zadeh (1998), for instance, study efficient coordination and risk sharing when central and divisional managers are different in risk aversion in the context of the design of transfer price systems. Such different preferences naturally lead us to the question of whether a desirable outcome for HQ can be achieved when the local divisions actively implement effective risk management tools. In addition, we are interested in studying the conditions under which HQ's overseeing activities and local divisions' risk managing activities eventually become beneficial for all members of a supply chain. We investigate the two ways of managing exchange-rate risk: (i) transferring risk to a third party with a risk-transfer contract such as currency options and (ii) re-arranging risk within the chain with a risk-sharing contract. For each kind of contracts, we study if there exists a set of contract terms such that utility of all members of a supply chain can increase compared to the utility without any of those. We also ask what are the impacts of exchange-rate variability and re-location of HQ. We believe that our model provides helpful information regarding desirable terms of such contracts, and thus should be useful to operational managers of multinational firms seeking effective currency risk management tools.

The paper is organized as follows. Section 2 provides a literature review. Section 3 describes our model and provides a preliminary analysis of a benchmark model. Section 4 analyzes risk management contracts, and conducts sensitivity analysis and comparative statics. Section 5 concludes the study and suggests future research directions.

2. Literature review

The literature on operational decisions under exchange uncertainty is vast. These include but are not limited to the works of Kogut and Kulatilaka (1994), Huchzermeier and Cohen (1996), Dasu and Li (1997), Kouvelis and Gutierrez (1997), Kouvelis (1999), and recently Liu and Nagurney (2011). The modeling details and focuses of studies are quite diverse. However, the literature neglects to consider currency option and risk-sharing contracts together in a single context. These two types of contracts, both popularly practiced, are comparable in the sense that one transfers currency risk to a third party by purchasing a financial contract and the other rearranges currency risk between local divisions in a supply chain without external fees. Hence, the interactions between members of a supply chain of a multinational firm are of great interest when different types of risk management activities are involved. Particularly interesting are the structural differences in the conditions under which a certain risk transfer tool is beneficial for all members of a supply chain.

Let us briefly review the literature related to the contracts to transfer or share currency risks. Regarding risk-transfer contracts, the use of options is part of the classical risk management toolkit. For example, in the operations management literature, Gaur and Seshadri (2005) calculate an optimal hedging portfolio with call options in a single-period model to manage demand risk. Chen and Parlar (2007) discuss the usage of a put option to reduce losses from low demand in the same single-period stochastic demand model. More specifically, in managing exchange-rate uncertainty, the literature considers currency options. For instance, Ding et al. (2007) study production (postponement) and financial hedging (currency call and put options) portfolios to manage exchange-rate risk. However, few papers study risk-sharing contracts. For instance, Li and Kouvelis (1999) consider a risk-sharing contract in finding an optimal procurement policy to manage price uncertainty under fixed demand. Arcelus, Pakkala, and Srinivasan (2002) consider risk-sharing with a simple two-price type contract under exchange-rate uncertainty, as we do. While Arcelus et al. (2002) focus on finding the best ordering cycle in a continuous review inventory model of a risk-neutral retailer with risk-sharing, we are concerned about establishing contract terms such that the risk-averse utility of members of a supply chain improves. Furthermore, we focus on comparing the impact of the two kinds of contracts on utility of all members in a risk-averse supply chain.

As mentioned in Section 1, maximization of expected profits under the assumption of risk-neutral supply chain members is not likely to yield an optimal decision in practice. This is also noted by Lau (1980a) and Eeckhoudt, Gollier, and Schlesinger (1995) in the context of managing demand uncertainty. Further information