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1 > 2? Less is more under volatile exchange rates in global supply chains

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Abstract To meet consumer needs, global firms typically manufacture based on their aggregate production plan after receiving demand projections from all markets. One of the consequences of matching demand with manufacturing is that these plans generally ignore the impact of exchange rate fluctuations. Consolidated profits for global firms are significantly influenced by fluctuations in exchange rates, and opportunity exists to incorporate exchange rate uncertainty into global production planning. This article presents an operational hedging mechanism ('production hedging') based on manufacturing *less* than the total global demand. Due to uncertainty in exchange rates, the firm takes conservative action and deliberately manufactures a smaller quantity than its total global demand. The article shows how manufacturing less can create a higher profit. It provides prescriptions for marketing executives to quantify the economic value of market share. In addition, it demonstrates why operational hedging, in the form of production hedging, is more valuable than financial hedging.
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1. Introduction

In October 2011, the U.S. dollar hit its lowest level against the Japanese yen since the Great Depression. Japanese firms that manufacture in Japan and rely on revenues generated through sales in the United States were hit hard by the U.S. dollar depreciation; Toyota Motor Company is an example, with considerable manufacturing activities still taking place in Japan and a significant level of revenues generated in the U.S. It is commonly reported that consolidated profits of multinational firms are impacted by fluctuations in foreign currencies. Our work responds to the challenges of these global firms by offering a different perspective that incorporates exchange rate fluctuations into manufacturing and distribution plans.

Since the early 1990s, U.S. firms have shown interest in expanding their market reach and global revenues by increasing distribution and sales in Southeast Asia. These U.S. firms experienced significant losses when, in 1997, the Thai baht was devaluated and took down other Asian currencies (e.g., Malaysian ringgit, Indonesian rupiah, Korean won, Philippine peso, Japanese yen). Similar currency devaluations have proven detrimental, including the Mexican peso devaluation (1994),

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the Russian ruble crisis (1998), the Brazilian real collapse (1999), and the Turkish lira losses (1994 and 2001). Recent economic uncertainty—including the U.S. credit crisis (2008) and European economic instability exhibited by Spain (2012), Greece (2012), and Cyprus (2013)—further increases global firms' desire to guard against exchange rate uncertainty. Speculation persists regarding the true value of the Chinese renminbi (RMB); numerous studies have attempted to explain the RMB exchange rate (see Yi, 2013). Given the financial and economic instability surrounding our world, Lyles and Park (2013) emphasize the importance of a profitable growth in the lifecycle of internationalization. Our work provides prescriptions for this important problem as it helps explain the implications of currency fluctuations in supply chain planning.

Traditional aggregate planning activities call for demand projections from multiple markets. Large multinational companies collect demand forecasts from their subsidiaries in foreign countries. These demand forecasts are usually entered through an enterprise resource planning (ERP) application, and central planning/headquarters makes the appropriate procurement and production commitments based on these forecasts. In general, firms combine demand forecasts from multiple markets and commit to manufacturing for the total global demand. Such plans typically ignore potential swings in currencies, and rather rely on the expected value of foreign currencies. Our work shows that this traditional practice of building manufacturing activities in order to match the global demand has significant exchange rate uncertainty implications.

Why should an operations manager in charge of supply chain planning worry about fluctuations in exchange rates? After all, business professionals are trained via educational programs based on widely separate curriculums. While myriad sources support the separation of financial and operational concerns, the most influential explanation comes from Modigliani and Miller (1958). These authors argue that, under certain assumptions, financial and operational decisions can be separated; therefore, an operations manager should not be concerned about the risk stemming from financial markets. Expanding upon this, Caldentey and Haugh (2006) and Sun, Wissel, and Jackson (2013) conclude that a firm can make its operational plans by isolating itself from financial market uncertainty—including exchange rate fluctuations.

The featured approach in this study, however, differs from the aforementioned perspective of separating the worries associated with financial market swings from supply chain planning. We show that an operations manager, especially when she commits to manufacturing the global demand in her aggregate production plan, can be highly impacted by exchange rate fluctuations. Therefore, we recommend that an operations manager incorporate exchange rate uncertainty in supply chain planning. Based on Kazaz, Dada, and Moskowitz (2005), our work belongs to a different stream of publications whereby exchange rate and financial market fluctuations influence the firm's operational decisions. This stream of research includes Huchzermeier and Cohen (1996); Dasu and Li (1997); Lowe, Wendell, and Hu (2002); Ding, Dong, and Kouvelis (2007); and Park, Kazaz, and Webster (2014a and 2014b).

To mitigate the negative implications of exchange rate fluctuations, our work recommends the concept of *production hedging*: a deliberate decision on the part of the firm to manufacture less (i.e., smaller quantity) than its total demand. Production hedging is a conservative action of the operations manager who is concerned about exchange rate fluctuations, and mimics the concept of less-is-more. Our work demonstrates that by manufacturing a smaller quantity than its total demand, the firm creates the flexibility to alter its distribution of products to markets based on changes in exchange rates. According to this approach, the firm allocates manufactured goods to markets where the currency is appreciating, thus enjoying higher returns; it concurrently slashes allocation to markets where the currency is depreciating, thus avoiding lessened revenues or even losses. It is important to note that the same distribution allocation flexibility cannot be created when the firm engages in the traditional practice of manufacturing the total demand. Thus, unlike the popular approach of matching demand, our work proposes creating flexibility in distribution operations in order to respond to the changes in financial markets.

2. Is 1 truly greater than 2?

To demonstrate the impact of exchange rate uncertainty on a global firm's profit, we develop a small example with only three exchange rate scenarios. This example incorporates exchange rate uncertainty into the firm's aggregate production planning activities; the mathematical model that serves as the foundation of the notion of $1 > 2$ is outlined in the Appendix.

The firm determines a quantity of products to manufacture in the presence of exchange rate uncertainty; we consider the common event that manufacturing lead times are long enough that the firm has to commit to production levels in the presence of exchange rate uncertainty. After observing the realized (spot) values of exchange rates,

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