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Strategic use of forward contracts and capacity constraints

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ABSTRACT

This paper analyzes the implications of forward markets under demand uncertainty when oligopolistic firms endogenously choose capacity levels. The paper shows that a forward market that occurs after the investment decision is committed does not increase social welfare if demand uncertainty is relatively small. This result is contradictory to Allaz and Vila (1993) findings that forward markets mitigate market power and enhance efficiency. However, a forward market improves social welfare if demand uncertainty is relatively large. The findings have important policy implications for capital-intensive industries where capacity expansion requires long lead time.

1. Introduction

Since Allaz and Vila (1993) (AV hereafter) have suggested that strategic use of forward markets can increase efficiency in oligopolistic markets, many researchers tried to understand the applicability of this result to various industries. The implications of forward markets are especially relevant in the energy industries, and the recent research mostly concentrated on the electricity markets. It was argued that forward markets helped to reduce electricity spot prices in Australia by facilitating investment in new generating capacity in early 2000s and some problems in the California electricity market in 2000–2001 were attributed to insufficient use of forward contracting.[1]

The recent literature that adopts the AV framework suggests that forward markets decrease spot prices and enhance efficiency.[2] In the AV framework each firm has an incentive to engage in forward markets in order to enhance its profit. However, when all firms sell forward, they drive prices down and profits fall. Therefore, an increase in forward commitment levels reduces spot prices and enhances efficiency in these studies. A crucial assumption in the above analysis is that the firms are underutilizing their capacity levels in the absence of the forward market or that the firms can adjust their production levels costlessly. However, it is not uncommon to observe firms utilizing their full capacity in many industries, including the electricity industry. Full capacity utilization is also common in oil and gasoline refinery industries, especially as a response to exogenous shocks. Thus, this paper endogenizes firms' investment in capacity levels in order to study the effects of forward markets on competition and efficiency. In particular, it analyzes the implications of the forward market that takes place after the investment decisions are committed but before the spot market. This is an important extension because endogenous capacity choices significantly change firms' strategic behavior in forward and spot markets. In addition, the paper studies the role of demand uncertainty in firms' forward market decisions.

The analysis shows that while the price-reducing effects of a forward market still exist, the firms' ability to choose capacity levels significantly changes the AV result. In particular, the conclusions depend on the degree of demand uncertainty. When the demand uncertainty is small or when demand is deterministic, the introduction of a forward market does not change social welfare. Thus, the firms can resist the temptation to engage in forward markets by restricting their capacity at the Cournot capacity levels. As the demand uncertainty increases, firms start underutilizing their capacities during low-demand periods, and the firms find it more difficult to eliminate the price-reducing effect of a forward market by restricting their capacity levels. Therefore, the forward market improves welfare by increasing capacity utilization during low-demand periods. Yet, this increase in welfare is less than predicted by the AV model.

The rest of the paper is organized as follows. Section 2 reviews the literature on strategic effects of forward markets. Section 3 presents the model. Section 4 studies the implications of forward markets under capacity constraints. Section 5 discusses the findings.

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[1] See Wolak (2001) and Wolak et al. (2000).

[2] See Allaz (1992), Green (1999), Ferreira (2006), Lien (2000), Le Coq and Orzen (2002), Newbery (1998), etc.

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2. Literature review

The existence of forward markets can be easily explained by market participants' unwillingness to take risks. However, Allaz and Vila (1993) suggest strategic reasons for the existence of forward markets and show that uncertainty and hedging risks are not necessary.[3] Particularly, AV study the effect of forward markets on competition and efficiency and conclude that more frequent forward markets make firms worse off. In the limit, the forward markets drive the spot prices to a competitive level. The following generalizes this intuition:

> When only one producer is given the opportunity to make forward sales, he actually benefits from a first mover advantage over his competitor and finds himself in the position of a Stackelberg leader on the spot market. When both firms can trade forward, the trading decisions give rise to a prisoner's dilemma: each producer has incentive to trade forward but when they both do so, they end up worse off. (Allaz and Vila, 1993, p. 3.)

The AV model is one of a duopolistic Cournot competition with firms simultaneously selecting their production levels. In many industries, including the electricity industry, firms compete by means of selecting supply schedules as strategic variables. Thus, Klemperer and Meyer (1989) have developed a theoretical framework of supply function equilibria under uncertainty. The supply function models have been widely applied in electricity markets. Newbery (1998) and Green (1999) study the implications of electricity (forward) contract markets in a spot market supply function equilibria framework to analyze the effects of forward markets on competition. Both authors study a two-stage game, where firms make quantity commitments at a forward price in the first stage, and the firms compete in a spot market by choosing supply schedules in the second stage. Newbery uses constant marginal cost curves, whereas Green uses linear marginal cost curves. Newbery confirms the AV conclusions that forward markets decrease the ability of firms to raise prices in the spot market. Green's assumption of linear marginal cost curves results in a special case when one firm's forward market commitment level does not affect the other firms' behavior in the spot market. This eliminates the Stackelberg leader advantage from engaging in the forward market. Clearly, without a strategic advantage from engaging in the forward market, the AV results do not hold. Nevertheless, when the firms engage in the forward market due to risk hedging reasons, an increase in the forward market commitment levels decreases the spot prices.

Lien (2000) studies the role of forward markets when a large firm has significant market power. Lien argues that a large firm uses its capacity less profitably than smaller firms due to the large firm's desire to increase prices. Small firms, behaving competitively, benefit from the large firm's ability to increase prices. Lien suggests that the large firm can eliminate the negative effects of its size by restricting excess entry through the sale of long term forward contracts. Thus, the existence of long term forward contracts enhances efficiency.

The predictions of the AV model concerning the efficiency-enhancing effects of forward markets have been tested experimentally as well. Le Coq and Orzen (2002) conduct forward market experiments with constant marginal costs in a Cournot duopoly framework. The authors confirm the AV predictions that forward markets increase competition and decrease spot market prices. However, Le Coq and Orzen conclude that the competition-enhancing effects of forward markets are weaker in their experimental settings than theoretically predicted.

Brandts et al. (2003) conduct similar experiments to study forward markets considering both supply function and Cournot competitions. Consistent with the AV predictions, the authors find that the introduction of forward markets lowers prices both under the Cournot and the supply function competitions. Brandts et al. also find that the supply function competition with two or three firms yields lower prices and higher efficiencies than the Cournot competition. This finding is consistent with Klemperer and Meyer theoretical predictions that the equilibrium in supply functions is between the Bertrand and the Cournot outcomes.

It is important to note an implicit assumption of public information in the models that use the AV framework. Bagwell (1995) and Hughes and Kao (1997) argue that when forward market outcomes are not observable by firms, there is no strategic incentive for the firms to engage in the forward markets — a Stackelberg leader advantage is lost if the second firm does not know that the first firm is the Stackelberg leader. Thus, under the unobservability assumption, firms undermine the competitive effects of forward markets by strictly preferring not to engage in forward trading. Hughes and Kao show that if risk hedging reasons are present, the firms nevertheless may engage in forward markets under the unobservability assumption. Ferreira (2006) compares the implications of various unobservable market structures and argues that imperfect observability of futures positions results in a stronger competitive outcome than the one predicted by the AV model. The current paper assumes that firms' forward positions are known by all market participants. In a model with linear demand and constant marginal costs, the results hold even if firms only observe the aggregate forward market quantity commitment levels.

Several studies question the efficiency-enhancing effects of forward markets. Liski and Montero (2006) argue that the AV result can be reversed in infinitely repeated games. In particular, the authors show that firms can use forward markets to collude in infinitely repeated games. Harvey and Hogan (2000) also argue that firms might collude to soften competition, while Mahenc and Salanie (2004) present a model in which firms buy their own production forward in order to increase spot market prices, essentially, withholding the spot capacity. Mahenc and Salanie's findings differ from the AV predictions because the firms compete in prices (strategic complements) rather than in quantities (strategic substitutes).

3. Model

There are three types of players in the market: firms, an intermediary and buyers. The firms produce and sell a product in forward and spot markets. There are two identical firms in the market. The buyers buy the product in the spot market for consumption purposes. It is assumed that the buyers are infinitesimal, always bidding their marginal valuation. The intermediary buys forward contracts from the firms in the forward market and resells the product in the spot market. It is assumed that the intermediary offers all of its forward purchases in the spot market and earns zero profit.[4] The firms are not allowed to buy the product in the forward market or in the spot market. The firms and the intermediary are rational forward-looking agents and the firms' moves are publicly observable after each stage. Specifically, I consider a model with the following three stages. First, the firms choose their capacity levels by selecting the level of capacity investment. Then, the forward market takes place. Last, the uncertainty is realized, and the

[3] There are other explanations for the existence of forward and futures markets in the absence of uncertainty. Williams (1987) argues that the following four features of commodity markets imply the existence of futures markets under risk neutrality: positive transactions costs, nonlinear total processing costs, lower transactions costs in the futures market than in the spot market, and a heterogeneity in processors' initial economic circumstances. In the markets that display the above features, it might be advantageous for the processor to use the futures contacts since the futures markets reduce the expected transactions costs in the spot market.

[4] One might assume, in the spirit of the original AV model, a large number of speculators making competitive bids instead of the intermediary. The results will not be affected as long as the arbitrage is perfect.