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A newsvendor approach to compliance and production under cap and trade emissions regulation

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ABSTRACT

Since the 1990s, governmental agencies have increasingly turned to market based cap and trade programs to control the emission of pollutants. Firms subject to cap and trade regulation are typically required to acquire emissions allowances via open auction markets. The cost to acquire allowances may impose a substantial financial burden on a firm. While emissions reduction efforts may eliminate some firm's need to acquire additional allowances, there are still numerous firms that need to purchase additional allowances on the open market. This study presents a new forward buying heuristic, designed for those firms that need to purchase emissions allowances via auctions, which reduces the impact of emissions allowance acquisitions on the firms' financial performance. The heuristic, designated as the Newsvendor Production Planning with Emissions Allowance Forward Buying (NPPAFB) method, applies a forward buying algorithm to determine the number of periods for which to forward buy allowances, the current production order up to level, and the current and future emissions allowance requirements (which serves as the order up to level for allowance purchases). Additionally, NPPAFB also authorizes unused emissions allowances to be sold when market conditions are favorable. Compared against three existing production planning and allowance procurement strategies, a simulation exercise finds that the NPPAFB method significantly reduces a firm's emissions allowance expenditures. These results indicate that heuristic can be readily adopted by any firm that is required to procure emissions allowances via open markets in an effort to improve the firm's profitability.

1. Introduction

Climate change is a growing concern among scientists, businesses, and the public at large (Pan et al., 2013). The consensus of scientists is that the use of fossil fuels has a direct and detrimental effect on the environment. The Intergovernmental Panel on Climate Change (IPCC) (2013) reports that it is extremely likely that human activities, such as those that result in fossil fuel emissions, are increasing concentrations of carbon in the atmosphere, contributing to global warming. Since the 1990s, governmental agencies have increasingly turned to market based cap and trade programs to control the emission of pollutants. Cap and trade programs have gained favor with both governing bodies and regulated organizations because such programs enable parties to choose among a variety of mechanisms to achieve regulatory compliance (Majumdar and Marcus, 2001). These mechanisms include the reduction of emissions through operational improvements as well as the attainment of compliance through the open market acquisition of emissions allowances. While emissions reduction efforts may eliminate the need for some firms to acquire additional allowances, other firms will have emissions levels that require the purchase additional allowances on the open market. This study presents a new forward buying heuristic, designed for those firms that need to purchase emissions allowances via auctions, which reduces the impact of emissions allowance acquisitions on the firms' financial performance. This matter is of great importance to firms subject to cap and trade regulation, because they are faced with the operational challenge of developing cost effective environmental strategies in business environments where it often is difficult to pass compliance costs onto customers (Schofield, 2013).

In cap and trade programs, a total emissions volume cap is set by a regulatory authority, which then issues a number of allowances (often in the form of certificates) corresponding to that total emissions volume cap (in most programs, one allowance authorizes the emission of one ton of a targeted pollutant) (Chaabane et al., 2012). Regulated firms then are required to obtain allowances equivalent to the volume of a pollutant they emit through operational activities or else pay a severe penalty. A primary

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motivation of cap and trade programs is that the costs to acquire allowances are substantial enough that firms choose to avoid the compliance costs and instead invest in efforts to permanently eliminate emissions. However, in many industries, zero emissions operations may be unattainable; in which case firms will need to acquire allowances for any remaining emissions. Allowances are acquired in several ways: they are allocated by the regulatory authority to firms free of charge (a process known as grandfathering), purchased via auction, or traded between firms on the open market. Allowances typically can be "banked" by a firm and held for use in future periods (Environmental Protection Agency (EPA), 2002). Allowances are also highly fungible; therefore firms can easily sell excess certificates on the open market, which can contribute directly to profitability (Zhang and Xu, 2013).

The task of developing cost-effective production and allowance procurement programs is complicated by dramatic fluctuations in the market prices of emissions allowances. For example, since the inception of the European Union's Emissions Trading System (EU ETS), which is one of the most recognized emissions reduction programs, the auction price for CO_2 has ranged from a high of more than €30.00 per allowance to a low of €0.01 per allowance. In situations such as these, price fluctuations (combined with the limited ability to pass the costs onto consumers) create a problem in which firm profits can fluctuate even when the selling price of the finished product, material and labor inputs, and customer demand are stable.

For firms that need to acquire additional allowances via auction, this study presents a flexible heuristic that can be used by firms operating under any existing or future market based cap and trade regulatory program. The intention of the study is not to develop or challenge the regulatory policies of the various cap and trade programs but rather the study presents a tool for firms to use when the existence of an auction based allowance market is an externality with conditions beyond the influence of individual firms. Specifically, this paper examines the feasibility of applying an extended version of a Newsvendor heuristic to the emissions allowance procurement and production problem. This approach is motivated by the similarity between scenarios in which firms are impacted by market price fluctuations of emissions allowances and scenarios in which manufacturing firms are required to procure commodity raw materials through spot markets. In the extant Operations Management literature, two primary approaches have been developed to address the commodity procurement problem. In one approach, multiperiod order quantities are secured at favorable market prices via contracts (Sethi et al., 2004). In the other approach, forward buying heuristics procure materials for future periods' demand when the purchase price differential (current versus future) will outweigh the costs of holding the material as inventory (Golabi, 1985). Both of these approaches have been shown to reduce acquisition costs by taking advantage of drops in spot market prices; however, the forward buying approach is more appropriate for the emissions allowance procurement problem. This is because the contractual approach often requires third parties to act as allowance brokers; a practice which is not permitted under some cap and trade programs (such as the EU ETS) which mandate that firms purchasing allowances must have the intention of actually using them for their own operations (European Union, 2010). Recently, several forward buying heuristics have been developed that utilize the Newsvendor model to improve the effectiveness of commodity procurement programs (Gavirneni and Morton, 1999; Manikas et al., 2009). Similarly, where firms are required to acquire emissions allowances on the open market, a strategy to forward buy allowances when market prices are favorable and bank the allowances as "inventory" for use in future periods may reduce a firm's compliance costs. The procurement and disposition of emissions allowances differs from commodity purchases primarily because no physical item is bought, stored, or may deteriorate. In addition, commodity purchases require lead-time considerations for delivery of the commodities prior to use. As noted in Manikas et al. (2009), commodity purchases may be limited to firms that can procure the required minimum quantities. Emission allowance purchases do not have minimum or multiple purchase and selling quantities, allowing all firms to benefit from forward buying of them. Ultimately, this study demonstrates that an enhanced Newsvendor model for emissions allowance forward buying and current period production planning can increase firm performance.

The next section discusses the theoretical basis for this study. The third section presents the proposed heuristic. The fourth section describes the simulation conducted using empirical emissions allowance market data to test the effectiveness of the new heuristic. The fifth and sixth sections respectively present the results of the simulation and the managerial insights of the study. The final section summarizes the study's conclusions.

2. Theoretical development

The U.S. Acid Rain Program (ARP) was the first fully implemented cap and trade emissions regulation system (Kroes et al., 2012). The program, which focuses on reducing the emissions of sulfur dioxide (SO_2) generated during electricity production, has utilized cap and trade regulation successfully to reduce emissions by 67% compared to 1980 levels (Environmental Protection Agency (EPA), 2009). Firms regulated by the ARP complied with the program's emission restrictions by either acquiring allowances to offset their emissions or reducing their emissions levels. The ARP's successful reduction of pollutant emissions through the use of cap and trade has spawned a number of similar regional, national, and international programs, including the California cap and trade program, the European Union Emissions Trading System (EU ETS) and the New Zealand Emissions Trading Scheme; all of which focus on reducing CO_2 emissions (Marcacci, 2013; Ranson and Stavins, 2012).

The EU ETS, which is the most mature of the currently enacted international CO_2 cap and trade programs, provides an example of the likely format for future regulations. The program established a carbon market in its first phase (2005 to 2007); however, the number of freely allocated allowances exceeded the demand, and the allowance market price dropped to essentially zero. Despite a 6.5% reduction in the total emissions cap in the EU ETS's second phase (2008 to 2012), the market price of allowances again dropped substantially due to reduced demand resulting from the global economic recession. At the beginning of 2013, the EU ETS entered its third phase, in which the free allocation of allowances is being replaced gradually by auction markets as the primary mechanism for allowance acquisition (European Union, 2013). CO_2 allowance auctions now occur several times each week, making the open market acquisition of allowances relatively straightforward for regulated entities (by contrast, SO_2 allowance auctions occur only once per year under the ARP (Environmental Protection Agency (EPA), 2002)). During 2013, the percentage of allowances acquired via auction represented over 40% of the total number of issued allowances (European Union, 2014). Correspondingly, during this phase of the EU ETS, the total emissions cap will be decreased by 1.74% annually until 2020 (European Union, 2008). At the initiation of this study, the EU ETS CO_2 allowance market has steadied as prices during this phase have remained relatively stable compared to the precipitous drops experienced during the first two phases (Intercontinental Exchange, 2014).