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Jet fuel hedging, operational fuel efficiency improvement and carbon tax

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ABSTRACT

To investigate airlines' incentives in operational fuel efficiency improvement, it might be important to consider financial hedge as its substitute. In this paper, we build a simple theoretical model to compare the implications of fuel financial hedge and operational fuel efficiency improvement on airlines' expected profit. We find that financial hedge is more efficient in reducing airlines' profit volatility/risk exposure, while operational improvement will generate a higher expected profit level when its effectiveness is sufficiently high. With market competition, operational improvement will be less prevalent. Furthermore, a fuel/carbon tax makes financial hedge less attractive and operational improvement more attractive.

1. Introduction

Aviation has a major impact on the climate system and accounts for up to 9% of the total climate change impact of human activity. Moreover, at a time when we urgently need to reduce this impact, greenhouse gas (GHG) emissions from aviation continue to grow. Since 1990, GHG emissions from international aviation have increased 83 per cent. Aircraft engine emissions are directly related to fuel burn. Each kilogram of fuel saved reduces carbon dioxide (CO2) emissions by 3.16 kg. So the key for airlines to minimize their environmental impact is to use fuel more efficiently (IATA, 2015). Between 1968 and 2014 the average fuel burn of new aircraft fell approximately 45%, or a compound annual reduction rate of 1.3%. Despite this progress, the industry continues to lag United Nations' operational fuel efficiency goals. On average, industry is about 12 years behind the 2020 and 2030 operational fuel efficiency goals established by ICAO, the UN agency that oversees international aviation (Kharina and Rutherford, 2015). The reality is that operational fuel efficiency improvements achieved by legacy carriers have coincided with rising fuel prices (Firestine and Guarino, 2012). Kwan and Rutherford (2014) find that domestic US aviation saw zero net improvement in its efficiency in 2013, when the global oil price was low. In other words, airlines' move towards higher operational fuel efficiency is almost purely driven by economic consideration, as the aviation industry is characterized by a constant struggle with skyrocketing and fluctuating fuel costs. In 2015, fuel accounted for 27% of airlines' average operating costs, and the overall fuel bill amounted to 180 billion U.S. dollars (IATA, 2015). Although substantial, these numbers are in fact already much lower than the historical highs in 2013 (33% and 231 billion).

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However, even with the threat of high fuel price, operational improvement[1] may not necessarily be the only solution for the airlines. To manage the enormous risk from high fuel price and improve profit margin, airlines can also use financial hedge, a financial investment to reduce the risk of future high fuel price, mainly through derivative products such as future contracts, options and swaps (Smith and Stulz, 1985).[2] In fact, financial hedge has been a popular strategy among airlines in managing fuel price (e.g., Rao, 1999; Berghöfer and Lucey, 2014; Lim and Hong, 2014; Treanor et al., 2014a; Turner and Lim, 2015).[3] Due to this potential substitutability between operational fuel efficiency improvement and financial hedge, airlines' operational improvement is at times referred to as "operational hedge", a concept that has been studied in a variety of fields (e.g., operations management, finance, strategy and international business) but rarely given consistent framework and definition (Boyabatli and Toktay, 2004). Some empirical studies investigate operational hedge for airline jet fuel price without strictly defining it (Morrell and Swan, 2006; Weiss and Maher, 2009; Naumann et al., 2012; Treanor, 2008, 2012; Treanor et al., 2014b). Roughly speaking, in the case of airline jet fuel, operational hedge is a group of strategies focusing on improving operational fuel efficiency, including fleet fuel-efficiency,[4] optimized schedules and fleet assignments,[5] as well as fuel-effective practices such as flying slower or less into the wind (Ramos and Veiga, 2014). These strategies generally involve upfront investments, including capital cost to increase fleet diversity or reduce the age of the fleet (Treanor et al., 2014b) and real option used to maintain the flexibility of fleet composition (Treanor, 2012).

In other words, to investigate the airlines' incentive in meeting the operational fuel efficiency goals of IATA and ICAO, it is rather important to take into account this substitution between fuel operational fuel efficiency improvement and fuel financial hedge, which is never specifically studied in literature as far as we know. More importantly, another long-ignored aspect of the issue is the relationship between an airline's fuel strategies and environmental policies such as carbon tax. From a social perspective, operational fuel efficiency improvement should be encouraged more, as financial hedging does not generate much real positive impact on aircraft emission. If financial hedging against high jet fuel is very successful, it actually imposes an environmental cost on the society, as this success would encourage airlines to continue using financial tools to combat high jet fuel prices instead of committing to the development of alternative fuel and new aircraft technologies that can reduce fossil fuel consumption and hence greenhouse gas emission. This is a type of "the curse of success", which is rarely mentioned. Under such consideration, when policy makers are evaluating emission policies such as carbon tax or cap-and-trade (e.g., Sgouridis et al., 2011), it may also be helpful to take into account the effects of such policies on the airlines' choices of fuel hedging strategies. If these policies can make operational improvement more attractive while financial hedging less beneficial, then other than the direct impact on reducing emission, these policies can also bring indirect benefits of promoting the adoption of new technologies, laying a more solid foundation for their implementation. On the other hand, if we prove the opposite, then such policies should be used with more caution.[6]

In this paper, we first build a simple model to compare the implications of financial hedge and operational fuel efficiency improvement on airlines' profit in the context of a monopoly airline, figuring out the corresponding conditions for each of these possible strategies to be optimal. We then extend our analysis to incorporate airline competition. We also study the impacts of a fuel/carbon tax that moves the whole support of jet fuel price to the right to see the indirect impact of this policy when the substitutability between operational fuel efficiency improvement and financial hedge is taken into account. We find that financial hedge seems to be more efficient in reducing the volatility of airlines' profits and risk exposure, while operational improvement is more likely to generate a higher expected profit level when its effectiveness is sufficiently high. With market competition, operational improvement will become less prevalent. A positive shock to the fuel price makes financial hedge less attractive and operational improvement more attractive.

The paper is organized as follows. Section 2 provides relevant literature review while Section 3 sets up the base model. Section 4 analyzes the impacts of fuel financial hedging and operational fuel efficiency improvement on a monopoly airline's expected profit. Section 5 extends the analysis to a duopoly airline market and finds out the Nash equilibrium regarding fuel hedging strategies and their corresponding conditions. Section 6 discusses the implications of an external shock to the fuel price such as carbon tax. Section 7 contains concluding remarks.

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[1] It should be noted that fuel efficiency is far from the only reason for operational improvement. Airlines are constantly involved in operational improvements to reduce all types of cost such as labor and overhead. To clarify, we focus on fuel consumption related operational efficiency when we mention "operational improvement" in this paper.

[2] There exist other less conventional measures. For example, Delta Air Lines announced its intention to acquire an oil refinery in 2012. We ignore these measures in our analysis due to their relative insignificance.

[3] A recent example for the popularity of jet fuel financial hedging among airlines is that in early 2017, in spite of the low oil price, Singapore Airlines extended some of its fuel-hedging contracts to as long as five years, betting on an upswing in crude oil prices amid OPEC production cuts and renewed tensions between the U.S. and Iran. Airlines utilize financial hedge at a very extensive manner. Other than fuel, they're also involved in hedgings for exchange rate (e.g., Belghitar et al., 2008), aircraft acquisition (e.g., Hu and Zhang, 2015) and airport capacity utilization (e.g., Xiao et al., 2017).

[4] A reverse can also happen when fuel price is low. For example, United Airlines took delivery of two used Boeing 737–700s in 2015, due in part to their more favorable economics thanks to fuel prices of around $50 per barrel, about 50% lower than six months ago.

[5] For example, Ryerson and Kim (2014) find that two major US airline mergers in the late 2000s–early 2010s achieved fuel savings ranging from 25 to 28% by eliminating network redundancy, i.e., reorganizing and consolidating hub networks and operations.

[6] Some earlier studies including D'Alfonso et al. (2015, 2016) have suggested that assessing the environmental impacts of transportation policies is usually more intricate than we thought.