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Hysteresis due to irreversible exit: Addressing the option to mothball

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ABSTRACT

This paper analyses the following hitherto understudied feature in real switching options: a firm has a mothballing option and an option to permanently abandon. If the firm finds itself in an operating mode with a price just above the abandonment threshold, it is unclear whether to exercise the abandonment option or to exercise the mothballing option. If the price goes down, the firm may exit, but, surprisingly, if it goes up, it may mothball. We find that two different strategies could be optimal: one where mothballing is not a viable option and one where mothballing does occur. In the latter case a hysteresis region arises in which the firm produces at a loss, while a further price decrease induces exit and a sufficient price increase results in the firm entering the mothballing stage. Mothballing being optimal requires sufficiently large values of the price trend and the uncertainty parameter.

1. Introduction

Nowadays companies face several challenges concerning their investment strategies, as the global economic conditions require companies to define different and more efficient strategies. For example, in 2012 Kodak filed for bankruptcy, after several years of negative profits, due to the decline in sales of photographic film and its slowness in transitioning to digital photography. Part of the company was sold, as well as some patents, but it kept running one of its business, now named Kodak Alaris, dedicated to Personalized Imaging and Document Imaging. So after a period of expansion, the company underwent a period of losses, it made some investments in technology, and finally decided for a downsize.

In other cases, the companies undergo periods of mothballing. For example, in 2015 Germany agreed to mothball about five of the country largest brown coal power plants to meet its climate goals by 2020[1]. Also, the dismal economic conditions created by the global financial crisis of 2007/2008 have pushed some power plant operators to resort to cutbacks and find ways to control operating expenditures while maximizing efficiency. As a result of high-operating rates, burgeoning costs,

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[1] https://www.theguardian.com/environment/2015/jul/02/germany-to-mothball-largest-coal-power-plants-to-meet-climate-targets.

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and shifting demand, many power plant operators choose power plant layup procedures or mothball their facilities[2]. Lambin (2016) argues that an unprecedented wave of mothballing has been observed since 2009 in the electricity sector. Another example is the situation in Trinidad and Tobago, where gas production has stuttered and petrochemicals plants have been mothballed, as since 2014 energy prices have tumbled.[3]

Therefore, it is clear that in the lifetime of a company there are several options that need to be considered in order to maximize the payoff from the investment strategy. See, for instance, Paxson (2005) for a valuation model with up to eight different options, and many interesting examples. Some classical models value each option separately, as is the case, for instance, in Bjerksund and Ekern (1990), Majd and Pindyck (1987), McDonald and Siegel (1986), and Dixit and Pindyck (1994) (all address the investment problem), Chronopoulos et al. (2011) (investment problem under risk adverse and incomplete market assumptions), Farzin et al. (1998) (technology adoption problem), and Myers and Majd (2001) (abandonment problem). In other papers, the multiple state options are valued together, as, for example, Brennan and Schwartz (1985) (they consider the case of a project that may be closed down or even abandoned if output prices fall far enough), Hagspiel et al. (2016) (in this paper the firm may either invest in a new technology or exit), Paxson (2005) (he considers multiple state options, including, for instance, expansion, contraction and revertion to normal), or Sødal et al. (2008) (a shipping company may switch between the dry bulk market and wet bulk market for a combination carrier).

This paper considers a firm that may be either in a state of actively producing or in mothballing, while having the option of permanent abandonment. Mossin (1968) is a seminal reference in the sense that this paper is the first to model mothballing as a type of real option, as described in Dixit (2018), where the option to mothball an active ship is analyzed.[4] Our model builds on Dixit (2018) and the analysis presented in Chapter 7 of Dixit and Pindyck (1994).

That model has been extended in several directions. For example, Bar-Ilan and Strange (1996) embed lags in the classic model of irreversible investment presented in Brekke and Øksendal (1994), Dixit (1989) allow for diminishing production capacity over time and show that this is a generalized impulse control problem. Muehlenbachs (2015) considers temporary and permanent abandonment of oil fields, and finds that extensive clean-up costs leave many Canadian fields in a temporary abandoned state indefinitely. Duckworth and Zervos (2001) (see also Zervos, 2003) also study the exit-mothballing problem, but then in a more formal framework, whereas Pham et al. (2009) present a multiple switching model that is more broadly formulated, thus with less emphasis on the mothballing state. Throughout this paper, we always take into account the results provided by Zervos et al. (2016).

Our model is different from the one proposed by Dixit and Pindyck (1994) in the following way: the exit decision is permanent (whereas in the model in Chapter 7 of Dixit and Pindyck (1994) the firm may decide to re-enter), and it is equally costly to exit out of production and out of the mothballing state (whereas Dixit and Pindyck (1994) assumes it is cheaper out of mothballing state). We show that exit being permanent leads to one of the two following strategies: (1) either mothballing is never optimal, or (2) mothballing may be optimal but in that case there is a hysteresis region, in which the firm produces at a loss. This is optimal because it is too early to choose between temporary (mothballing state) and permanent abandonment (irreversible exit) so that it is better to keep both options open. In the hysteresis region a sufficient price increase triggers mothballing and a sufficiently large price decrease results in liquidation. The hysteresis region is absent in Dixit and Pindyck (1994).

As already said, in our model exit is permanent. In case the uncertainty process governs the development of the output price, a positive NPV will occur for a large enough value of the output price. The firm will only go for permanent exit if the price has become so small that a positive NPV is very unlikely to occur in the foreseeable future. For this reason the firm does not take reentry into account. For such an action to be optimal, the NPV does not only need to be positive but should also be higher than the option value of waiting, and this is even more unlikely to take place within a reasonable amount of time. In fact there are several examples or real world situations where re-entering is not possible (or, at least, it is very unlikely). For example, start-ups are examples where the exit is permanent, in most of the cases. According to Cefis and Marsili (2011), a large proportion of new firms exit (either by closing down the activity or by merging or acquisition) within few years of startup (less than half of start-ups survive more than 5 years after entry, and less than a third survive 10 years after entry). Another example of permanent exit can be seen, recently, with regard to renewable power producers. In the past, if a renewable site decision maker walks away (i.e., abandons the renewable site), there were few, if any, consequences or penalties (WebEcoist.com 2011), and therefore it could have been economical to re-enter the market. But nowadays this is no longer the case, as there has been some consideration or implementation of a simple and straightforward exit fee as insurance to enable the proper disposal of the renewable site in case of abandonment (New Hampshire Office of Energy and Planning, 2008); see Min et al. (2012). Finally, we mention a recent situation in the UK regarding regulations on retail water market, which induces permanent exit. Since April 2017, water companies that decide to exit the market have to meet ten core assumptions, permanent exit being one of them.[5] Other examples where the reversion expense is practically too expensive, include South African deep gold mines and certain nuclear and offshore petroleum facilities.

[2] https://www.bryair.com/news-and-events/articles/mothballing-as-an-effective-power-plant-layup.

[3] The Economist, 2nd October, 2017.

[4] We thank an anonymous referee for pointing our attention to this reference.

[5] https://www.waterbriefing.org/home/water-issues/item/10713-customer-data-biggest-challenge-for-firms-who-exit-retail-water-market.