The impact of spatial price differences on oil sands investments

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ABSTRACT

In this article, a two-factor real options model is developed to examine the impact spatial price differences have on the value of an oil sands project and the incentive to invest. Large, volatile price differences between locations can emerge when demand to ship exceeds capacity limits. This may have a significant impact on production, investment, and policy in exporting regions. Here, we assume the price difference between two locations follows a stationary process implying crude oil markets are integrated as oil prices in different locations move together. The investment decision is formulated as a linear complementarity problem that is solved numerically using a fully implicit finite difference method. Results show the value of an oil sands project and the incentive to invest in a new project will increase when the mean price difference decreases. Surprisingly, the standard deviation of the price difference has very little impact on project value or the incentive to invest.

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1. Introduction

The feasibility of a natural resource investment critically depends on its access to markets. Spatial arbitrage models have shown, the more remote a natural resource is the lower its net price will be (Samuelson, 1952; Takayama and Judge, 1971). Consequently, improving market access has been the motivation behind the decision to build additional pipeline capacity to export crude bitumen and its derivatives from Alberta. Fig. 1 plots monthly spot price data for West Texas Intermediate (WTI), Western Canadian Select (WCS), Mexican Maya, and the price difference between Mexican Maya and WCS from January 2005 to December 2015.1 Prior to 2011, WCS and Mexican Maya tracked one another closely with Mexican Maya receiving a small location premium over WCS and large price differences were short lived. However, beginning in 2011, WCS and Mexican Maya diverged and WCS was heavily discounted relative to Mexican Maya. Proponents of additional pipeline capacity argue this large price difference is mostly attributed to inadequate transportation infrastructure and claim that both firms and governments would benefit from expanding pipeline capacity. Firms would gain access to international markets, higher world prices, and lower transport costs and governments would receive more tax revenue from higher royalties and income taxes.

This paper incorporates spatial price differences into a real options model to study the impact improved market access will have on the value of an oil sands project and the incentive to invest. Here, the value of an oil sands project is contingent upon uncertain oil prices and transport costs. We refer to the spatial price difference as transport costs to avoid confusion over price and spatial price differences. Transport costs include all factors that affect the spatial price difference including pipeline and rail tariffs, exchange rates, and capacity constraints. We assume oil prices follow a geometric Brownian motion (GBM) and transport costs follow an Ornstein-Uhlenbeck (OU) mean-reverting process. These assumptions are consistent with real options and oil price cointegration literature. Stationary process for transport costs implies the world oil market is ‘one great pool’ (Adelman, 1984) as crude oil prices in different geographical locations move together. Optimal stopping is used to identify the threshold prices when it is optimal to invest.

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1 WCS is the benchmark for heavy crude oil in Canada and it is located in Hardisty, Alberta. It is a blend of heavy crude oil, crude bitumen and diluents with an API gravity of 20.5. Mexican Maya is a heavy crude oil similar in quality to WCS located in the Gulf Coast.

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in a new project and abandon an operating project. The optimal stopping problems result in free boundary problems that do not have known analytical solutions. Following Wilmott et al. (1993) and Ings and Rolls (2005), the free boundary problems are redefined as linear complementarity problems and we approximate the solutions numerically using a fully implicit finite difference method (IFDM). Model parameters are chosen to approximate a typical in situ oil sands project in Northern Alberta.

To preview the results, we find that a decrease in transport costs increases the value of the oil sands project, investments in new projects happen earlier, and operating projects are abandoned later. These results are consistent with the claims made by supporters of the policy to expand pipeline capacity. Surprisingly, we also find that changes in transport cost uncertainty has virtually no effect on the value of the oil sands project or on the decision of when to invest and when to abandon. Typically, the value of an option increases as uncertainty increases as upside potential increases while the option limits downside loses.

1.1. Literature review

Evaluating natural resource investments using real options analysis is a standard approach in the literature. Brennan and Schwartz (1985) apply option pricing theory to the problem of valuing uncertain investments. They determine the combined value of the options to shift down and restart a copper mine when spot prices are uncertain and the convenience yield is constant. Paddock et al. (1988) combine option-pricing techniques with a model of equilibrium in the market for the underlying asset to value offshore petroleum leases. Bjerksund and Ekern (1990) value a Norwegian oil field with options to defer and abandon. Clarke and Reed (1990) consider the option to abandon a currently producing oil-well when oil prices and extraction rates are uncertain. Conrad and Kotani (2005) determine the trigger prices to initiate investment in the Arctic National Wildlife Refuge under different assumptions about the evolution of

![Fig. 1. Monthly crude oil spot prices and Mexican Maya-WCS price difference in Canadian dollars from January 2005 to December 2015. WTI data was collected from the EIA, Mexican Maya data was collected from Bloomberg, and WCS data was collected from Natural Resources Canada.](image-url)
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