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The microstructure of the North American oil market

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ABSTRACT

Recent developments in production of oil and natural gas from the tight sand and shale rock formations (primarily hydraulic fracturing and horizontal drilling) have a profound impact on the North American energy markets. The paper reviews recent crude oil production trends and their impact on the price relationships across different geographical locations in the US and Canada. Price disparity between different market hubs is attributed to the collision between growing volumetric flows of crude oil (as well as changing quality mix of produced crudes) and rigidity of the existing midstream and refining infrastructure. We continue with a discussion of how the North American oil industry adjusts to new disruptive technologies in exploration and production of hydrocarbons.

1. Introduction

The US and Canadian oil markets are undergoing a rapid and dramatic transformation with consequences extending far beyond North America. This paper reviews the factors underlying this transformation (primarily the impact of new disruptive exploration and production technologies resulting in an increase in the production volumes, combined with changes in quality characteristics of oil output) and adjustment of the entire integrated oil production/processing system to the supply shock. We start with a discussion of the modern oil market which is an example of a complex, tightly coupled system, and continue with a review of recent production trends and their impact on the price relationships across different geographical locations and across the entire term structure of forward prices. The price impact is attributed to the collision between growing volumetric flows of crude oil (as well as changing quality mix of produced crudes) and the existing midstream and refining infrastructure. We continue with a discussion of how the system adjusted to these shocks and what are the future potential developments.

2. Commodity markets as a complex system

Modern energy markets have evolved over the last 20–30 years into a global, highly integrated system, with shocks being transmitted between its different parts through complex and constantly evolving channels. Understanding this highly complicated system requires familiarity with its three component layers:

- The physical layer: the portfolio of physical assets and technological processes underlying production, transportation, storage and processing of different energy commodities.
- The financial layer: the system of conventions and institutions underlying the price formation and discovery processes, of physical (involving delivery) and purely financial transactions in different commodities and derivative instruments, and of financial flows supporting and influencing real activities taking place in the physical layer.
- The socioeconomic layer: a system of laws, regulations, social norms and conventions underlying commodity markets and physical operations which define the set of allowed technologies and activities. Laws and regulations are legally binding and are enforced by the states. Social norms and conventions don't have the power of the

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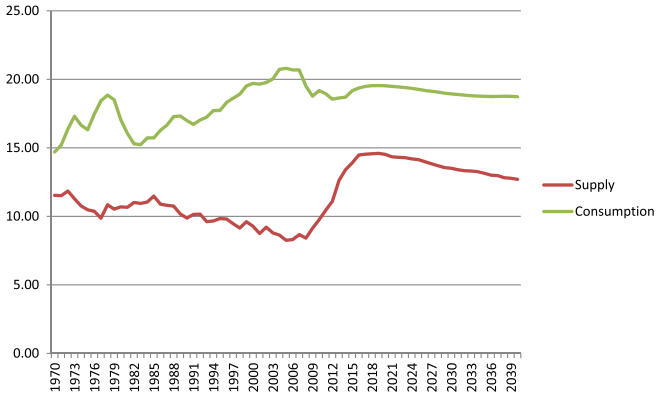
state behind them but they influence the ways commodity markets function.

These three layers form what is called by physicists and computer scientists a tightly coupled system: (Johnson et al., 2003) a system composed of many complex parts, which are interdependent and linked through multiple channels through which the shocks propagate from one node to another. Such systems have a number of important characteristics, which have been extensively covered in a number of technical publications. The features of the tightly coupled systems include complicated and evolving feedback loops between different parts of the system, the ability to adjust to changing circumstances and evolve over time, non-stationarity (modification of the statistical properties of the system over time), multiplicity of interacting agents, adaptability (the economic agents learn from experience) and openness (the boundaries between a given system and its environment are fuzzy at best).

All these features mentioned above are present in the North American oil markets. One characteristic, the presence of highly entrepreneurial and innovative companies, explains why changes happen often at a very high speed and why it was so difficult to predict the revolution that unfolds in front of us. The surge in the US and, to some extent, Canadian oil production took most market experts by surprise. We are still at the early stages of this unprecedented revolution and its impact will be felt beyond the North American oil market and beyond the energy industry. The shocks emanating from the oil and natural gas fields of North America enhance competitive advantage of the US and Canadian industries (Anon.). Geopolitical consequences of reduced North American dependence on oil imports are difficult to ascertain at this point, but they will be undeniably profound.

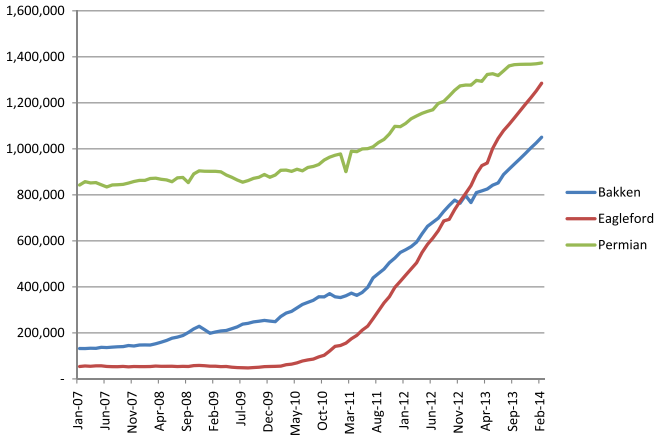
3. The North American oil market: the supply shock

A critical development in the US oil markets was not only the surge in production (and a corresponding drop in imports) of crude oil as well as an increase in exports of refined products, but also a change in quality mix of production and modification of spatial patterns of production and spatial patterns of volumetric flows. Fig. 1 shows the trends in the US production and consumption of liquid fuels since 1970, including forecast till 2040. The gap between the consumption and production curves corresponds to the imports of liquids into the US, which have been shrinking since 2006. Fig. 2 illustrates the production trends in three critical regions most closely associated with the surge in production: The Bakken (located mostly in North Dakota) and the Permian and Eagle Ford basins in Texas.



Source: EIA

Fig. 1. U.S. petroleum and other liquid fuels supply (history and forecast), 1970–2040 (million barrels per day).

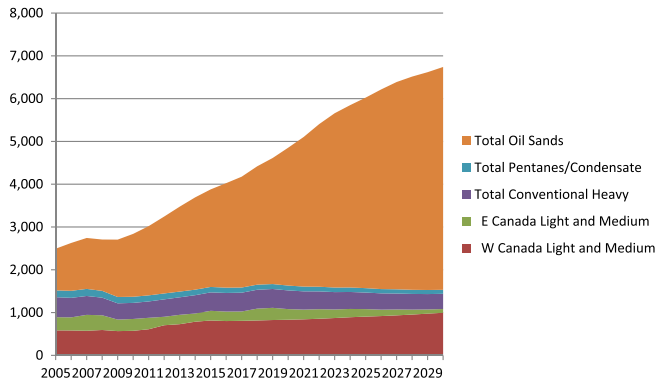


Source: EIA

Fig. 2. Crude oil production in selected US basins (barrels per day).

The jump in production is associated primarily with proliferation of new technologies, such as horizontal drilling and hydraulic fracturing (Anon.). These techniques have been known for a long time, but several recent developments made possible their wide proliferation and implementation on an industrial scale. The technology has been improved and tested, resulting not only in longer horizontal sections of the wells, but also in much shorter completion times, both with respect to drilling and to fracturing operations (Anon.). Another important technological development was use on a wide scale of pad drilling — development of multiple wells extending in many directions from one small area, with drilling rigs placed on rails and moved from one place to another within the same pad (often just by a few meters). This reduces time-consuming activities related to dismantling, transportation and reassembling of rigs transferred from one well location to another. Another critical factor behind the recent output surge was increase in the oil prices to the levels which provided sufficient cushion to support the cost of new production techniques.

Production growth in Canada happened primarily through the expansion of output of oil from the tar sands in Alberta (Fig. 3), and this segment of the Canadian oil industry is expected to account for most of the future volumetric increments of the Canadian oil production. Understanding challenges created by the expansion of oil production in Canada and of the future developments related to Canadian physical



Source: Canadian Association of Petroleum Producers

Fig. 3. Canadian total crude oil historical production (2005–2013) and forecast (thousand barrels per day).