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Economic cost of China's oil import: Welfare estimation for 2001–2015

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ABSTRACT

This paper estimates the economic cost incurred by China's foreign oil dependence during 2001–2015. By categorizing the cost into three different welfare components, namely wealth transfer, potential output loss, and disruption loss, our results show the annual welfare loss is between $7.58 billion to $168.24 billion (constant 2000 US dollars), or equivalent to between 0.57% and 3.93% of China's GDP. Wealth transfer is the dominant component, contributing 71% of the cost during the whole research period. As a result of international oil price fluctuation, disruption loss contributes 22% of the welfare loss. The other 6% is attributable to the decline of China's potential output. Taking 2015 as the benchmark, sensitivity analyses show that international oil price change brings asymmetric impacts, i.e., a 10% rise of crude oil price rise will increase the cost by $4.08 billion while the same extent of price drop reduces the cost by $4.72 billion. Every barrel of additional domestic oil production reduces the welfare loss by $16.91, while the conservation of a barrel saves $20.50. Based on the results of this study, policy relevant insights are provided with respect to supply side and demand side.

1. Introduction

In just thirty years, China's relationship with the international oil market has undergone a massive transformation. In 1993, it became, for the first time, a net oil importer. While domestic production rose only gradually from 138.3 Mt (988 Mbbl) in 1990–198.8 Mt (1420 Mbbl) in 2009, oil demand showed a compound average growth rate of 7%, leading to an oil import ratio of over 53% (Leung, 2011). Now the world's largest oil importer, China finds itself in a peculiar position: like the rest of North East Asia it is increasingly dependent upon the international oil markets to supply its economy, but whereas Japan and Korea have almost no domestic energy resources, China remains the world's fifth largest oil producer (BP, 2016). Further, through its use of domestic coal, China is still highly self-sufficient for its energy needs (MLR, 2014). A range of demand side factors have reduced the proportion of China's primary energy supply that comes from oil, but in absolute terms, demand has continued to grow (Jing and Yao, 2013). So far, the markets have proven reliable, but China views them as dominated by external economies (Wolfe and Tessman, 2012) and has painful memories of oil embargos in the past (Leung, 2011).

As China's relationship with the international oil markets has changed and oil imports have risen, the country's preoccupation with energy security has also increased. If the supply disrupts suddenly, due to economic, political, military or any other unpredictable reasons, there would be a huge cost because of the oil dependence. In the years 1994–1999, energy security featured in just 41 articles; for the period 2006–2010, the number was 1435 (Leung, 2011). Currently one significant obstacle to prevent government to impose an appropriate stimulus is that the welfare gains or losses associated with oil insecurity are unaware of. Only after the potential cost that foreign oil dependence is quantitatively measured, governments can make adequate energy policy decisions to enhance the general interest of the nation.

In this paper, we have addressed an essential (but previously overlooked) question in an attempt to furnish China's policymakers with the quantitative information required for a robust policy response. What is the cost (or more specifically, the welfare loss) to China's economy of its oil imports? Following the definition adopted by Greene and Leiby (2006), the monetary metrics including transfer wealth,

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potential output loss, and disruption loss are calculated to represent the oil security cost of China, while the non-monetary metrics in terms of politic risk, strategic risk, and military cost have been excluded because they are difficult, if not impossible, to quantify. By focusing on the simplest factors in terms of monetary metrics, we try to provide preliminary policy implications for China's energy policy-making due to the paucity of related suggestions. Moreover, the energy security metric method adopted in the case of China can be further applied in other oil-importing countries, given that data sets in this paper are available to the case study from an international perspective. Based on the discussion of China's oil security, similar estimations regarding other regions and international comparison can be made to provide important policy suggestions. The generalized application of oil security estimation worldwide would help to view oil import and consumption in an economic and quantitative way.

The rest of this paper follows from this question as follows. In Section 2 we assess the competing definitions and schemes for measuring energy security to provide context to China's current position. In section 3 we set out our method for defining and calculating welfare loss, and present the data sources. In section 4 we present the main data sources. In Sections 5 and 6 we describe the analysis and results with policy implications. And the final section concludes.

2. Defining and measuring energy security

China's daily crude oil import has reached nearly 340 million tonnes in 2015, taking up 58.1% of its total consumption (BP, 2016). Energy security has been the focus of an increasing amount of academic work, with a multiplying number of definitions and means of measurement. We will survey first the array of definitions, and then the approaches to measurement. The literature has many reviews of energy security (e.g. Singh, 2013; Efird et al., 2014; Zeng et al., 2015) and it is not our intention to replicate a full review. Most definitions of energy security focus on dependence and vulnerability, and are therefore shrouded in terms of physical supply. Oil's commodity nature means that supply shortfalls are resolved through price rises which both incentivize increased production (long term) and dampen demand (short term). Price spikes, therefore, have become an integral part of energy security definitions, so that the supply of energy is uninterrupted and affordable.

Affordability has different meanings in different countries. Japan has long successfully relied upon the market to supply it with energy, but has paid prices far higher than many countries can afford. Yet price is only one component of affordability: there are environmental costs and issues of social and political acceptability. This has led to sprawling definitions in which energy security is defined as "how to equitably provide available, affordable, reliable, efficient, environmentally benign, proactively governed and socially acceptable energy services to end users" (Sovacool, 2013). For others, energy security, especially in the Chinese context, boiled down to oil and its economic costs, particularly in terms of price volatility (Zhang et al., 2013; Markandya and Pemberton, 2010). Oil dependence has also been presented as a political concept, where it is defined not as a specific level of oil import dependence, nor as a specific monetary cost, but where the costs of imports and the constraints on policy are low (Greene, 2010).

This definitional mix, where the concept is seen as both an absolute economic one and a relative political one, has also led to a multitude of measurement systems (for a brief review see Sovacool, 2013; Jansen and Seebregts, 2010; Löschel et al., 2010; Markandya and Pemberton, 2010). The most frequent approaches focus on diversification of energy sources to evaluate the energy security status. This diversification can take one of two forms. The first is diversification among fuel types. The skew in North East Asia's reliance on oil, and China's reliance on coal, has been identified as a source of energy insecurity (Neff, 1997). In these assessments of security through energy diversity, alternative and domestic sources such as the percentage of renewable energy (Segers, 2008; Kumar, 2016), are also used to reflect the performance of energy security. For the purposes of this paper's focus on the costs of oil (in) security, of greater importance is diversification among suppliers. Energy supply chain has been considered regarding spatial disparities (Månsson et al., 2014; Zhao and Chen, 2014; Ang et al., 2015; Pan et al., 2017; Su et al., 2017; Wang and Zhou, 2017). Here China actually performs better than its North East Asian neighbours, and even the USA, in terms of the diversification of its supplier portfolio (Vivoda, 2009).

A second commonly adopted approach relies on specifically designed scoring systems to quantify energy security (Turton and Barreto, 2006; Scheepers et al., 2007; Martchamadol and Kumar, 2014; Narula et al., 2017; Radovanović et al., 2017; Zhang et al., 2017). Again, Sovacool (2013) provides a review of these competing indices. Different indices can have dozens of components and indicators, which are combined to give an overall index score that can be tracked through time and compared across countries. Usually the indicators are associated with physical energy flows and are scored in a normalized standard (e.g., energy security performance is scaled between 0 and 100 (Sovacool, 2013)). A simple example is found in Yao and Chang (2014), which uses a "4-As framework" to assess China's energy security (they find that it has not improved over time). The main components of their framework are availability, applicability, acceptability and affordability, but each component is split into multiple indicators. By way of example, the availability indicators comprise the coal reserve to production ratio, the oil import dependence ratio, the natural gas reserve to consumption ratio, and the availability factors of conventional thermal electricity and of non-thermal electricity.

Whilst both methods result in simple statistics to use and compare, a critical shortcoming is that the energy security performance is not evaluated in a comparable cost-benefit framework. In terms of diversification, it is not immediately obvious that China is more energy secure than Japan merely because it has a more diversified supplier portfolio. Equally, the complexity of scoring systems such as Yao and Chang (2014) mean that stable numbers can disguise counterbalancing changes in the underlying indicators. This problem hinders the integration of the evaluation results into real-world policy-making. Acknowledging this point, there has been an attempt to create market-based evaluation methods. One of the earliest efforts was made by Bohi et al. (1996), who viewed energy security from the welfare perspective and defined it as "the loss of economic welfare that may occur as a result of a change in the price or availability of energy". Others have also highlighted the importance of analyzing the welfare implications of oil insecurity (Markandya and Pemberton, 2010), and the links to physical unavailability, non-competitive pricing, and price volatility (Jansen and Seebregts, 2010). Parry and Darmstadter (2003) tried to integrate oil imports and price shock into the concept of energy security.

The problem remains in the difficulty of assessing the economic effects of price shocks (Huntington, 2005). While Sadorsky (1999) is clear that oil shocks are economically important, and Hooker (1996) is clear that the oil shocks of the 1970s and 1980s led to severe recessions in the USA, there seems to be a lack of clarity on the precise economic effects of oil price. Rises in oil price are seen as more damaging than falls are beneficial (Hamilton, 2003). Overall, stability in oil price is important (Pradhan et al., 2015): volatility is more damaging than absolute price levels (Markandya and Pemberton, 2010; Ferderer, 1997). Nonetheless, the correlation between oil price volatility and GDP seems to be weakening (Hooker, 1996; Ferderer, 1997; Naccache, 2011). By way of example, Parry and Darmstadter (2003) point out that in 2000 the USA's GDP grew at 3.7%, while the oil price jumped 60%.

Against a backdrop of this uncertainty, Greene and his colleagues attempted to analyze the economic cost of foreign oil dependence to the USA by linking the market power of demand and supply to price (Greene and Ahmad, 2005; Greene and Leiby, 2006). Leiby (2007) recommended three reference points as the standard to figure out the cost given levels of oil imports and consumption, listed as "hypothetical