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The effect of local supply chain on regional economic impacts of mining

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ABSTRACT

This paper presents an approach, based on input-output analysis, for identifying critical commodities in a supply chain to guide a local procurement supply chain management strategy aimed at creating shared value and more sustainable outcomes. The Missouri stone mining and quarrying industry is used to illustrate the approach. The work shows that the approach can be used to produce a ranked list of critical commodities, which can then be used to guide decisions to build local capacity to create shared value. For the Missouri stone mining and quarrying industry, there are 89 backward commodities. The proposed method predicts potential change in local supply of $1 million or more for each of 18 of these commodities. In particular, enhanced local procurement of tires; securities, commodity contracts, investments, and related services; and transportation have the highest potential impacts on the Missouri economy. There are 30 commodities which cannot be used to target shared value creation through improved local procurement because there are negligible imports into the Missouri stone mining and quarrying sector or exports out of Missouri.

1. Introduction

The extractive industries have long struggled to ensure that the benefits of resource exploitation are broadly shared with all stakeholders. In fact, there is a perception among many that the existence of resource extraction activities leads to lower economic well-being in the host communities than would otherwise have been possible (Al Rawashdeh et al., 2016). The causes and existence of the so called "resource curse" has been widely debated in the literature (Robinson et al., 2014). However, it appears there are many factors (both endogenous and exogenous to the extractive industries) that determine how much the host communities benefit from resource extraction (Mehlum et al., 2006). One way to increase the benefits of resource extraction is to increase local participation in the sector's supply chain.

Lately, business leaders have been encouraged to view their mission as creating shared value in order to facilitate sustainable development. To create shared value, companies should focus on creating economic (for themselves) and societal value, simultaneously (Porter and Kramer, 2011). Adopting this view is, perhaps, more important for resource extraction industries that have historically been plagued with allegations of prospering at the expense of the host communities. According to Porter and Kramer (2011), the three broad ways to create shared value are: (i) reconceiving products and markets; (ii) redefining productivity in the value chain; and (iii) building supportive industry clusters at the company's location. All three approaches are relevant to the mining industry, in particular, and extractive industries, in general. For example, many producers of aggregates, for construction materials, have reconceived their products and markets by incorporating recycle concrete and aggregate in concrete and asphalt mixes.

An important way for mining companies to create shared value is to maximize local procurement through strategic supply chain management (McHenry et al., 2017). This strategy falls into the third category of approaches to achieve shared value (i.e. building supportive industry clusters at the company's location). When a mine or group of mines improve local participation in their supply chain they increase the economic impacts of the mining activity. However, even with the best of intentions, this is not easy to achieve. Often, the local or regional economy just does not have the capacity to meet the demand (both quality and quantity) of the mine(s). And even legislation designed to promote local participation has sometimes failed to achieve the intended outcomes (White, 2016). Hence, to create shared value, mine managers need to have programs to build local capacity, if they are serious about creating shared value through enhanced local procurement. To do

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this in a way that maximizes the return (economic impact on the local or regional economy) on their investment, mine managers need tools to assess the potential impacts of enhanced procurement of the different commodities they use (referred to as backward commodities in input-output parlance) on the local or regional economy.

Although, input-output analysis (Leontief, 1941) can provide a simple and effective way to provide such assessment, the authors could not find any work in the literature that presents such an approach. Many types of economic or environmental analyses are based on input-output analysis (IOA), which is one of the most broadly applied modelling methods (Miller and Blair, 2009). The fundamental information of an input-output model is contained in an inter-transaction table (input-output table), which illustrates the flows of value from each industrial sector (as a supplier) to itself and other industrial sectors (as consumers). IOA has also been used to study regional economies within a nation (Midmore et al., 2006; Williams et al., 2008). A major use of IOA is to quantify the economic impacts of events, public investments, or business programs. Its purpose is to analyze the interconnectedness of industries in the economy (Miller and Blair, 2009).

Initially, IOA was used for evaluating inter-industry activities (Leontief, 1941). However, it was rapidly applied by researchers in other areas, including material flow, ecological footprint, life cycle analysis, and energy analysis (Joshi, 2000; Lindner et al., 2013; Nakamura et al., 2007; Williams et al., 2008). Additional columns can be added to the input-output tables to perform environmentally extended input-output analysis, which can provide a method to evaluate the linkages between economic activities and environmental impacts (Kitzes, 2013). For example, Stocker and Luptačik (2009) assigned material input and emissions output into the basic input-output tables to illustrate the connection between socio-economic trends and environmental emissions in Austria.

From the foregoing, the authors believe input-output analysis can make a significant contribution to resource extraction by providing a means to evaluate which suppliers are important for maximizing shared value. The objectives of this paper are to: (i) present an approach, based on input-output analysis, to identify critical backward commodities for formulating a local procurement strategy; and (ii) illustrate the approach with a case study of the Missouri stone mining and quarrying industry. The approach is based on using input-output analysis to estimate local capacity to supply the mining (or resource extraction) industry with each backward commodity and the regional economic impact of increasing the local participation in the mining supply chain. These estimates of regional economic impacts are then used to produce a ranked list of backward commodities, which can then be used to guide decisions on supply chain management strategies to create shared value. A similar approach can be used for other industries such as power generation.

This is a contribution to the discussion on creating shared value as a means to achieve sustainable development and increasing local content in resource exploitation. The work is at the nexus of input-output analysis, supply chain management, and sustainability. It applies IOA to help formulate supply chain management strategies that achieve sustainable outcomes. The work introduces a novel analytical approach to produce a ranked list of backward commodities, which can be crucial for discussions on enhanced local procurement for creating shared value. The ranking is based on the potential economic impacts of increasing local sourcing of each of the backward commodities. We concede that there are more factors than just the potential economic impacts that affect the decision to focus on a particular backward commodity for enhanced local sourcing. However, the potential economic impact is the key criterion, if the goal of the local sourcing is to create shared value. Also, estimates of the potential economic impact can be used to estimate return on investment, which is a key driver for corporate decision making in the extractive and other industries.

2. Methodology

The method presented in this work is based on regional economic analysis using input-output analysis. The data is used to estimate local capacity to supply the mining industry with each backward commodity and the amount of current supply that is sourced from outside the local area. Once the existing capacity and outside supply are determined, the analyst can then decide how much extra local sourcing is feasible. IOA is then used to estimate the economic impacts of the increased local sourcing of each backward commodity. These regional economic impacts are then used to produce a ranked list of backward commodities. Mine managers can use this list to guide their decisions on supply chain management strategies to create the highest possible shared value.

The basic principle of regional economic impact analysis using IOA is to apply relevant multipliers to final demand changes through the economy. New expenditures on goods and services in an industry will generate demand for additional goods and services in other industries. Regional input-output tables provide a means to undertake regional economic impact assessments of investments. In IOA terms, the direct effects stem from the change in final demand of backward commodities while the indirect effects stem from purchases from these backward commodities' industry sectors. Induced effects stem from households' re-spending their incomes earned as direct and indirect dollars in the study area. So for example, for the auto industry, direct effects arise from the change in demand from backward commodities like steel and aluminum if there is a change in the output of the auto industry. In this example, indirect effects arise from the change in demand from the iron ore and bauxite mining sectors that will result from the increase in demand from the steel and aluminum manufacturing sectors. Similarly, induced effects arise from the increased spending by households that see their incomes increase because of the increased output from the steel and aluminum manufacturing, and mining sectors. Multipliers are used to estimate how economic activity (new expenditures) can lead to impacts on employment, income, value added, and output (Miller and Blair, 2009).

2.1. Input-output basics and definitions

To understand the proposed approach, one has to understand the basics of input-output analysis. In particular, it is necessary to understand three specific concepts: multipliers, regional purchase coefficient and regional use ratio.

For example, input-output multipliers can be used to estimate how economic activity in an industrial sector can lead to impacts on employment, income, value added, and output in the economy. The input-output interconnections, illustrated in Table 1, can be translated analytically into accounting identities. x_{ij} denotes the intermediate consumption of commodity i by industry j; v_j denotes the amounts of depreciation of fixed assets of industry j; m_j denotes the amounts of taxes paid by industry j; n_j denotes the amounts of profits of industry j; the sum of v_j, m_j, and n_j denotes value added by industry j; y_i denotes final demand of commodity i; x_i denotes the total output of the i^{th} industrial sector; and x_j denotes the total input to the j^{th} industrial sector.

From a demand perspective,

$$x_i = \sum_{j=1}^{n} x_{ij} + y_i (\forall i = 1, 2, \cdots, n) \quad (1)$$

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