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The impact of a strong local supply chain on regional economic impacts of mining

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THE IMPACT OF A STRONG LOCAL SUPPLY CHAIN ON REGIONAL ECONOMIC IMPACTS OF MINING

by

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A THESIS

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ABSTRACT

With growing social conflicts due to social and environmental concerns mines need to be able to create shared value for all stakeholder in their quest to promote sustainable development. Given the sensitivity of a mine’s regional economy contribution to its supply chains, any improvement in supply chains strategy will be beneficial for mines and their stakeholders. The objectives of this work were to: (i) test the hypothesis that supply chain management strategy, by mines in a region, significantly affects regional economy; and (ii) develop a methodology to identify the critical backward commodities of a regional mining sector.

Valid methods have been formulated for estimating the economic effects of supply chain strategy on regional economy and for identifying critical backward commodities. Using the developed approaches, the case study shows that local procurement strategy can significantly affect the regional economy. The tests show that small increases (10% or less) in local sourcing of the chosen 10 backward commodities will enhance local economic impact, significantly. Also, the work shows that the total potential impacts of backward commodities can be estimated, and the critical backward commodities can be identified using the developed approach. For example, in the case study, themes relating to equipment (including tires and parts) and transportation are revealed to be important. An industry wide approach to enhance local capacity and purchase more locally in these areas could significantly increase the impact of stone mining and quarrying in Missouri.

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1. INTRODUCTION

1.1. BACKGROUND

The history of the mining industry can be traced back thousands of years. Today, the industry is a major contributor to the world economy, occupying a primary position at the beginning of the supply chain of many products. Additionally, the industrial products that are the end result of mining have led to the high standard of living of modern human beings (Runge, 2012). In many countries, the mining industry is getting recognized as a significant contributor to the job creation and economic development as well (International Council on Mining and Metals (ICMM), 2012).

In the United States (U. S.), the mining industry is dynamic, diverse, and is of critical importance to the economic status of the country. In 2012, around 634,000 people were employed by businesses associated with mining, and these employees contributed approximately $45.8 billion to the collected taxes in the year (National Mining Association (NMA), 2014 & Bureau of Labor Statistics (BLS), 2015). In the same year, the Gross Domestic Product (GDP) related to the U.S. mining industry exceeded $225 billion, which is approximately 1.4% of the national total (NMA, 2014). The recorded economic contribution of the U.S. mining industry during 2012 is presented in Table 1.1.

Table 1.1. Economic contribution of the U.S. mining industry (2012) (NMA, 2014; IMPLAN modeling system (2012 database))

Impact	Direct Impact	Indirect and Induced Impact	Total
Employment	634,600	1,268,800	1,903,400
Labor Income ($ billions)	46.2	71.9	118.2
Gross Domestic Product ($ billions)	102.1	123.0	225.1
Taxes Paid ($ billions)	18.9	26.9	45.8

The mining activities can be classified into three main categories: coal, metal and non-metal. The U.S. has the world's largest reserves of recoverable coal, which can provide affordable domestic energy for nearly 235 years (NMA, 2014). Metal and non-metal mining are further divided into four broad categories: metal, non-metal (excluding stone and sand and gravel), stone, and sand & gravel. These broad categories encompass approximately 80 different commodities, which are used as the basis for products that have common use in every-day life (MSHA, 2014). These products will be served as raw materials and energy resources, which are critical to the national economy (NMA, 2014). In 2012, there were more than 14,000 mines in operation in the U.S. (MSHA, 2014). In 2014, the industrial minerals industry alone was worth over $30 billion in the U.S., supporting approximately 71,000 employees (Geological Survey (GS), 2015). Table 1.2 shows the annual production of metals, industrial minerals (which include non-metal, stone and sand and gravel), and coal in the U.S. and Table 1.3 shows the economic contribution of U.S. mining industry by the three segments.

Table 1.2. U.S. mineral production (2012-2014) (U.S. GS & U.S. EIA, 2015)

Total mine production	**Year 2012** ($ billions)	**Year 2013** ($ billions)	**Year 2014** ($ billions)
Metals	34.7	32.1	31.5
Industrial minerals	40.9	42.9	46.1
Coal	40.6	36.6	37.7

Table 1.3. Economic contribution of U.S. mining industry by segment (2012) (NMA, 2014; IMPLAN modeling system (2012 database))

Impact	**Metal Mining**	**Non-metallic Mineral Mining**	**Coal Mining**	**Total**
Employment (No. of Jobs)	708,140	348,450	846,850	1,903,440
Labor Income ($ billions)	47.1	22.9	48.2	118.2
GDP ($ billions)	83.2	56.3	85.7	225.1

Recently, there has been increasing pressure on the mining industry to develop, manage and practice projects in a sustainable manner. According to the Brundtland Commission, Sustainable development (SD) is "[d]evelopment which meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987). SD is simply helping industry to develop a society in which they do not overstep social, economic and environmental limits, using resources efficiently, and creating economic growth (Drexhage & Murphy, 2010). Although it is challenging for the mining industry to pursue sustainability, mining companies must respond to these challenges to ensure their continued ‘social license’ to operate (Azapagic, 2004). For instance, the Mining Sustainable Development (MSD) factor has been used as a measure to evaluate economic sustainability impact from the mining industry (Intergovernmental Forum (IGF), 2010).

One of the most significant and dominant criteria to evaluate regional social and economic sustainability, in recent years, is the gain in stakeholders’ shared values (Porter & Kramer, 2011). Porter and Kramer (2011) pioneered the concept and explained that the focus of creating shared value is to build the connections between societal and economic progress. Bockstette and Stamp (2011) assert that shared value can be created by enabling local community development from improving community investments and strengthening local suppliers, in ways that also enhance business productivity. Creating shared value (CSV), hence, does not just benefit the stakeholders economically, but can also have a much wider, positive impact for society (Warhurst, 2002).

Supply chain management (SCM) in the mining industry can easily yield significant improvements in regional economy and, therefore, create shared value. Local communities, supply chain partners, and the general public have been increasingly inspecting SCM performance in the mining industry (Kusi-Sarpong et al., 2014). Accenture Plc., based on its own experience, claims that a high standard SCM in mine management can address societal (community and stakeholders), economic (industry profit & shared values), and environmental issues for mining organizations, to target and capture tangible financial benefits (Accenture, 2007). It is an effective approach for mining companies to adopt sustainable practices in their SCM (Kusi-Sarpong et al., 2014). Therefore, the efficiency of SCM in mine management and the ability to create shared value are both critical and inter-related factors for sustainability performance of a mine or mining business.

1.2. STATEMENT OF PROBLEM

There have been claims that mining corporations are operating in ways that will place them in positions of short-term economic gain, while ignoring or exacerbating social and environmental concerns around their operations. By operating irresponsibly in the environment, the mining industry can undermine trust (Lins & Horwitz, 2007; Setyadi et al., 2013). This mistrust will reduce the confidence of stakeholders, damage reputations, and, therefore, harm the investment potential of the companies. Eventually the industry will be challenged to create sustainable economic growth of the local communities that those mining companies located in (Lins & Horwitz, 2007).

Mistrust occurs when the mining industry operates irresponsibly in the social sphere, which includes operations that do not practice sustainable mining. These operations will likely lead to bad economic consequences for the mining companies. Due to increasing awareness, managing social issues well has become a serious issue in the mining industry, and mining companies around the world are constantly looking for innovative methods to reduce the potential consequences and increase positive impact of their operations.

The local economy of the areas in which mines operate is of significance and interest to shareholders; it is critical for mines to produce revenue for the communities. Companies that ignore the concerns of their stakeholders will lose their ability to operate (Lins & Horwitz, 2007). This concept has been formalized as the social license to operate (SLO), which has been defined as “a community's perceptions of the acceptability of a company and its local operations” (Eberhard et al., 2013). These community perceptions, expressed as the SLO are directly related to socio-political risks of a mining project. Mining companies that are associated with more sustainable and eco-efficient management strategies are more competitive in this industry (Jansen et al., 2006). Therefore, they will benefit from gained trust, and satisfy their shareholders and communities (Porter & Kramer, 2006). In order to pursue SD, mining companies should take various factors into account, including the local economy and shared value to the communities (Crane & Spence, 2014; Lins & Horwitz, 2007).

Although extensive academic research has explored the importance of an industrial supply chain, not much is known about how a locally-based supply chain[1] increases shared value in the resource sector. Across many industries, traditional SCM is getting more and more complex. This is true of the mining sector as well. However, this increased sophistication is not directed towards increasing shared value for all stakeholders, particularly, the local communities.

Most past research on supply chains has concentrated on three broad issues: achieving industry operational efficiency, improving industry competitiveness, and optimizing industry profit (Accenture, 2007). For SCM in the mining sector, researchers have focused on five priorities (cost containment, supply chain visibility, risk management, meeting customer demands, and globalization) to make the industry competitive (International Business Machines (IBM), 2010). It is increasingly evident that advances in these areas will continue to be significant components of SCM.

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[1] Supply chains of commodities that are supplied and purchased in study area.

However, for a mine with a traditional SCM approach, creating shared value for all shareholders can be a very challenging goal because such approaches neglect shared value. Traditional SCM can be used to help achieve operational efficiency and create industry profits but not, necessarily, shared value (Accenture, 2007). Yet, research has shown that SCM can enhance regional economic impacts (IBM, 2010). Traditional supply chain management approaches lack a framework to evaluate the impact of SCM decisions on the local economy. In a departure from traditional SCM, Leeuw (2012) used input-output analysis to evaluate the regional economic impacts of supply chain strategies. The work shows that a better understanding of the regional mining industry supply chain can yield significant improvements in a regional economy (Leeuw, 2012; Runge, 2012).

For a given mine managed with traditional SCM, it is challenging to optimize regional economic impacts due to the mine. Even when sufficient supply chain data exists, the economic contribution of a mine can still be vague due to the complexity and frequency of changes in the information (White, et al., 2004), and the effect of mine types. Moreover, the magnitude of changes due to different strategies is not easy to estimate. The decision-maker (e.g. mine manager) will not be able to manage efficiently if he/she cannot estimate the impact of the alternatives. Research has shown that economic activities due to local supply chains have a significant impact on creating shared value to stakeholders (Accenture, 2007; Exxon Mobil, 2015; IBM, 2010; Leeuw, 2012; Runge, 2012; White, et al., 2004). For example, Accenture Plc. (2007) and Exxon Mobil (2015) show that local supply with higher quality creates more local investment opportunities and affects economic development. However, not enough work has been conducted to assess the effect of changing local sourcing of raw materials and products on the local/regional economy quantitatively. Previous work has demonstrated the important effect of mining industry SCM on regional economy. In this study, the relation between SCM strategy of increasing local sourcing and regional economy is investigated using input-output analysis. The goal is to develop a method to evaluate the effect of changing local sourcing on regional economy.

1.3. OBJECTIVES AND SCOPE OF THIS RESEARCH

The major aim of this study is to develop quantitative measures to evaluate the impact of a “local sourcing” SCM strategy on the regional economy and industry’s ability to create shared value. This research will apply input-output analysis to develop a method to test the efficiency of various locally based SCM strategies of a regional mining industry. Based on this aim, the detailed objectives of this project are:

1. To test the hypothesis that a LPS, by mines in a region, significantly affects regional economy; and
2. To develop a methodology to identify critical backward commodities of a regional mining sector.

The analyses in this work were carried out on a dataset provided as part of the IMPLAN software package.

1.4. RESREACH METHODOLOGY

Figure 1.1 shows the thesis framework adopted in this work.

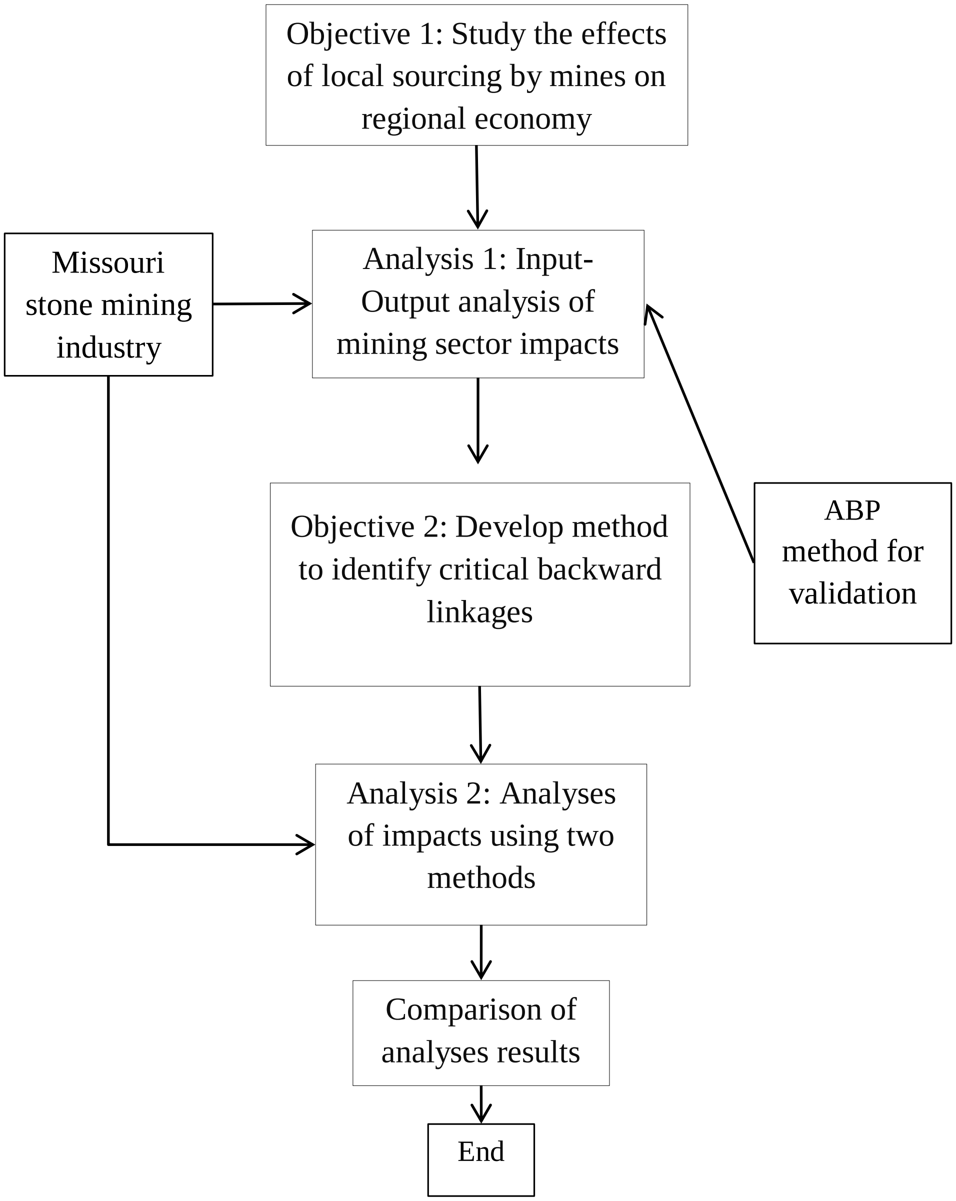

Figure 1.1. Activities/tasks in this research

Input-Output analysis (IOA) was used as a tool to study the effects of increasing local sourcing by mines on the regional economy to achieve the first objective. The second objective, which was to identify critical backward commodities, was achieved with a proposed methodology based on the Input-Output technique. Both approaches are conducted with data on the Missouri stone mining industry. The 2012 IMPLAN data (IMPLAN 2012), the most recent data, was used to build input-output models for Analysis 1. In this analysis, the author analyzed regional economic impacts of local sourcing of the stone mining and quarrying industry in Missouri. The author developed a method to identify critical backward commodities for increasing shared value in Analysis 2. The developed method was also used on the IMPLAN data for the Missouri stone mining industry. The analysis-by-parts (ABP)[2] method is used to check the result accuracy of the IOA (Analysis 1), which was used to validate and support the results (Analysis 2) of proposed method.

The disadvantage of using the IMPLAN data is the lack of transparency, price elasticity, and changes in industry behavior. In this research, the author systematically checked all these assumptions and, therefore, minimized the effects on the inferences.

1.5. STRUCTURE OF THE THESIS

This thesis contains five chapters, as follows:

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[2] ABP, a technique developed by IMPLAN, by which an analyzer can easily create a customized industry on his own budgetary spending pattern. It is accomplished by summing parts of impacts, including direct effects, indirect effect, and induced effects.

Chapter 2 presents an in-depth and critical literature review which covers the theoretical background of sustainability and SCM; assessment tools for SCM strategies; and IOA.

Chapter 3 presents a framework for describing the upstream supply chain of a regional mining sector using the inter-industry backward commodities (commodities) of the input-output model. An Input-Output analysis of the stone mining industry in Missouri was used as a case study for this discussion, which was validated using the ABP method.

Chapter 4 presents a method to identify critical backward commodities.

Chapter 5 provides the conclusion of this research and recommendation for future work.

2. LITERATURE REVIEW

This chapter presents a comprehensive literature review to provide a sound theoretical background of sustainable development in the mining industry, input-output analysis, and its relevant issues. The literature review is divided into six sections: (1) discussion on sustainability, (2) the role of shared value in mining, (3) barriers to creating shared value in mining, (4) importance of supply chain management (SCM) to creating shared value in mining, (5) review and application of input-output analysis (IOA) to SCM, and (6) summary of this chapter. Sections (4) and (5) match the major steps of IOA of SCM strategy proposed in Chapter 3.

2.1. SUSTAINABILITY & MINING

2.1.1. Sustainability Defined. In 1972, the concept of sustainable development (SD) first emerged in Stockholm during the United Nations Conference on the Human Environment (UNCHE) (Blackburn, 2008). In the 1980s, SD entered the debate on development and the environment. Today, the most popular and widely used definition of SD was developed by World Commission on Environment and Development (WCED), a group appointed by the United Nations (UN) (Brundtland, 1987). The report defines SD as "[d]evelopment which meets the needs of the present without compromising the ability of future generations to meet their own needs". Elkington (1997) pointed out that it is not only economic performance that must be achieved but environmental and social performance as well. He introduced a definitional term: the triple bottom line (TBL), in his book *Cannibals with Forks: The Triple Bottom Line of 21st Century Business*

(Elkington, 1997). In 1999, the Global Reporting Initiative (GRI) issued *Sustainability Reporting Guidelines* assuming sustainability entailed all three TBL elements.

SD does not focus merely on economic, environmental, or social issues. It aims to create an economy that is in balance with basic social and ecological systems (Bowden, 2013). For each management decision of a company, it is necessary to search for better equilibrium among the three components: economic, environmental, and social sustainability.

In the 1990s, the Forum for the Future of the United Kingdoms (UK) developed the Five Capitals model for SD: natural capital, social capital, human capital, manufactured capital, and financial capital (Stephen, 1996). The Five Capitals approach provides a basis for understanding SD in terms of the economic concept of wealth creation. It is significant that SD maintains all five kinds of capital (Goodwin, 2003).

Blackburn (2008) proposed the 2Rs' definition of sustainability that encompasses the version put forth by the Brundtland report as well as Elkington's TBL. The 2Rs refer to Resources ("the wise use and management of economic and natural resources") and Respect ("respect for people and other living things") (Blackburn, 2008). From an organization's perspective, the goal of the 2Rs is to pursue long-term well-being and sustain financial growth for both the society and itself.

2.1.2. Significance of Sustainability. It is anticipated that by the year 2100, the global population will be more than 10 billion (UN, 2011a). The population explosion is one of the greatest reasons why SD is becoming more and more significant (Omann & Spangenberg, 2002). It is no secret that the use of mineral resources has been fundamental to human activities (Botin, 2009), and human beings gain economic benefits from extracting mineral resources. However, mineral extractive activities will affect everything in the future. For example, Asha-Rose Migiro, the Deputy Secretary-General of the UN, argues that these economic benefits have operated at nature's expense, and damaged ecosystems through mechanisms such as irreversible degradation, slashed forests, and air and water pollution (UN, 2011b). Therefore, it is essential for mining companies to embrace a resource-efficient economic model (Warhurst, 2002; UN, 2011b). In order to develop a resource-efficient economic model for the mining industry and create better socio-economic outcomes, the industry must pursue an SD strategy such as creating shared value for all shareholders.

Improving SD outcomes can be an effective approach to balance the socio-economic and ecological impacts while meeting growing human needs (Drexhage & Murphy, 2010; Skye, 2013). Over the past few decades, some governments and businesses have committed to SD goals (Drexhage & Murphy, 2010). The commitment to these goals have played a big role in sustainability and impacted the environment positively. For example, installation of solar photovoltaic systems at facilities in Texas produces 2 million kilowatt hours of electricity per year and prevents more than 1,000 metric tonnes of carbon emissions annually (CISCO, 2014). Companies in many industries are moving to the SD mindset and adopting SD principles in management (Bowden, 2013; FSG, 2014).

There is long-term potential for a growing global economy through SD (Skye, 2013). Mining plays a significant role in the national economy, generally (Table 1.3). Therefore, improving SD in the mining industry will impact the U.S. economy significantly. Mining not only contributes to local or regional economies directly by employing people and generating employment income, but also contributes indirectly through economic interactions with other industries, which may be both commercial and broadly social and environmental in nature (ICMM, 2013). For example, the company itself needs to purchase supplies from other regional businesses to support the operation. Also, by spending income earned at the mine, employees as well their families can encourage local production of household goods and services (Eggert, 2001). According to the NMA, in 2012, GDP generated by industries which is attributable to U.S. mining totaled nearly $123 billion which is about 55% of total GDP contributed by U.S. mining. The indirect tax paid associated with U.S. mining is about $26 billion (NMA, 2014). Moreover, it is believed that local content in the supply chains of mines is one of the most instinctive ways to develop opportunities for creating shared value. FSG, Inc. showed that there is potential to create $500 million of shared value, annually, if the specific extractive company in their study applied sustainable SCM (FSG, 2014). The high potential for mining companies to create shared value has encouraged the companies to identify opportunities for improving sustainability by creating shared value.

Improving SD in mining can mitigate risks and create value for host communities, and, therefore, reduce the negative social impacts (Eggert, 2001). The value created through suppliers, consumers, and other communities account for 50 to 60 percent of total value associated with mining company activities (NMA, 2014). Shared value is a key indicator of a business' economic and social SD profile. Shared value is currently voluntarily reported in the U.S., but may become compulsory in the future.

2.1.3. Approaches to Sustainability in Mining. Due to increased social and environmental awareness, the mining industry faces extreme challenges (Botin, 2009).

In retrospect, SD has helped mining balance the demand for environmental protection and encouraged economic growth (Luken, 2007). In order to sustain its continued social license to operate, mining companies have to pay serious attention to community conflicts and conduct business with due consideration of social, economic, and environmental aspects by engaging stakeholders, assessing its performance, addressing sustainability concerns, and demonstrating continuous improvements over the long-term (Holtom, 2010; Ostrovskaya & Leentvaar, 2011; Azapagic, 2004). In order to accomplish these goals, the industry has employed various tools, which are discussed herein.

2.1.3.1 Environmental management systems. In order to achieve their environmental goals, mining companies are increasingly adopting environmental management systems (EMS). The key features of EMS are the requirement for evaluating and reporting performance, as well as to continually improving performance. An effective EMS properly describes the structure, practices, procedures, processes and resources necessary to sustain regulatory compliance and improve operational performance. It can also be viewed as a means of incorporating and improving existing environmental management programs. It helps reduce environmental risk and liability, provides companies with the ability to benchmark progress, and gain bottom line benefits to show an EMS is effective.

However, the lack of direct incentives to adopt an EMS (either from government regulations or other business reasons), lack of customer requirements for EMS, and beliefs that an EMS is not capable of adding to the bottom line can lower the motivation of EMS adoption (National Environmental Education & Training Foundation (NEETF), 2001). Mining companies that are afraid of discovering internal problems within the organization will not implement an EMS (NEETF, 2001). Additionally, having a successful EMS is only one element of SD. Although a successful and efficient EMS can lead to improving social and economic impacts, the primary targets of an EMS are still environmental issues (U.S. Environmental Protection Agency (EPA), 2012). That is, implementing an EMS will address one component of the triple bottom line (TBL), namely the environment (Westly et al., 2004). Moreover, although stakeholder involvement is necessary for implementing an EMS (Zutshi & Sohal, 2003), an EMS per se is not able to engage stakeholders broadly. It focuses primarily on the environmental goals of the organization rather than the goals of other stakeholders associated with the organization (EPA, 2012).

2.1.3.2 Corporate social responsibility. Corporate social responsibility (CSR) refers to actions undertaken voluntarily by business to contribute to the local economy and behave properly while improving the quality of life of employees and their families as well as communities or to reduce the negative effects of mining programs (Wood, 1991). Mining companies practice CSR by incorporating ecological and social concerns in the planning stage and identifying corporate governance best practices (Petrova & Marinova, 2012). Based on the specific design or characteristics of a project, local community sustainability, community support, and the benefits of CSR can vary. The success of the project and its CSR program depends on the local communities' needs, characteristics, and location. The more specific the local communities' concerns have been considered in the design phase, the more likely it is that the CSR program will be successful.

However, building and sustaining economic development around mining projects goes far beyond CSR possibilities. To engender SD around mining projects, mining companies' initiatives in the host community have to be efficient, supportable and justifiable, and prevent from creating a culture of dependency, which are not covered by CSR programs per se (Jenkins & Obara, 2006). Moreover, over-reliance on CSR may undermine the role of governance institutions (Fraser, 2012). CSR encourages mining companies to provide needed services for local communities, and in effect become a substitute for government, and therefore distorts the capacity of governments to provide social services. Also, CSR is often not integrated into the core business strategy. Shared value was developed broadly to integrate SD into core business strategy (Crane & Spence, 2014; Porter & Kramer, 2006).

2.1.3.3 Creating shared value. To sustain a mining company's economic performance, management has to take note of whether they are creating shared value for all stakeholders (Lins & Horwitz, 2007). According to Porter and Kramer (2011), shared value, as a concept, is defined as "policies and operating practices that enhance the competitiveness of a company while simultaneously advancing the economic and social conditions in the communities in which it operates." Such policies and operating practices focus on identifying the relationship between societal and economic progress, and expanding the connectedness. A business' activities then do not just benefit shareholders, but also has a broader and positive impact on society (Bockstette & Stamp, 2011). Creating shared value is also an additive approach for a company to engage a broader range of shareholders. Mining businesses create shared value in two ways: directly through its business activities and indirectly. Due to the fact that investments associated with mining are more indirect, there is more potential to create shared value indirectly through investment activities in the community (Accenture, 2014).

2.2. ROLE OF SHARED VALUE IN MINING SUSTAINABILITY

Of the ten largest companies of the world, three are extractive companies. Mining companies are a major force of the global economy. Operators, suppliers, and relevant supporting industries associated with mining contribute an estimated 5% of total global GDP, and close to 4 million workers are employed by mining companies (FSG, 2014).In recent years, however, businesses have gradually come to be seen as the cause of social, economic and environmental problems (Porter & Kramer, 2011). This is particularly true of the mining industry, which is widely recognized as prospering at the expense of the broader society (Lins & Horwitz, 2007; Jenkins, 2004; UN, 2011b; Tuck, 2012; Azapagic, 2004). Even worse, shrinking trust may lead to government policies that weaken company competitiveness and slow the growth of economy (Porter & Kramer, 2011). This is evident in the higher taxes and royalties demanded by host countries and the increasing calls for nationalization of mining assets around the world. The mining industry's survival depends on its ability to endear itself to society, once again.

One solution for the challenging situation of mining industry lies in the principle of shared value (EWB, 2014; Kusi-Sarpong.et al, 2014; Porter & Kramer, 2011). Shared value, for mining businesses, can be described as policies and practices that detectably improve social and economic impacts and relevant business performance, including reduced costs, improved productivity, and enhanced business environment (FSG, 2014). Companies can create economic and societal value simultaneously to create shared value (Porter & Kramer, 2011). Implementing a sustainable supply chain strategy, which increases company's profits and creates value for the host community, creates shared value.

Dealing with stakeholder relationships is one of the key themes that will influence mining companies' success in the future (Accenture, 2014). Since Porter and Kramer (2006), many organizations are getting rid of the old mindsets of viewing social issues as purely risks. Also, governments are seeking to build partnerships with industries that apply shared value practices while developing resources (FSG, 2014). Hence, the mining industry needs to rethink the way it deals with stakeholders and adopt a shared value approach to ensure future success.

Moreover, many previous studies have shown that shared value is an imperative for mining companies (EWB, 2014; Kusi-Sarpong.et al, 2014). Research from the McKinsey Global Institute concluded that a company that operated with sustainable SCM can create shared value (FSG, 2014). The report also offered a blueprint for creating shared value, which helps local communities and other stakeholders to speed up long-term social impact improvements for communities in which mineral resources are extracted. Mining companies with a perspective of creating shared value produce not just minerals. They offer a shift in purpose for communities in which they operate by producing new business, stimulating local production, inspiring economic development, creating opportunities for professional growth, and facilitating more effective government (Kusi-Sarpong.et al, 2014; Lins & Horwitz, 2007).

The ability to incorporate socio-economic factors is becoming a criterion to determine a company's competitiveness (Crane & Spence, 2014; EWB, 2014; FSG, 2014). More and more, mining companies are beginning to recognize that creating shared value is a competitive advantage; and they are more likely to build partnerships with companies that can practice with the perspective of creating shared value (FSG, 2014).

Meanwhile, many mining companies have already been moving in the direction of creating shared value (Accenture, 2014; Crane & Spence, 2014). Mining companies are in collaboration with many other sectors and are active in broadly-based socio-economic development for communities (Accenture, 2014).

According to Porter and Kramer (2011), there are three broad ways to create shared value. Table 2.1 shows some examples of creating shared value in these ways.

- Reconceiving products and markets;
- Redefining productivity in the value chain; and
- Building supportive industry clusters at the company's location.

Table 2.1. Ways to create shared value

Approach	**Examples**
Re-conceiving products and markets	• Many aggregate producers now incorporate recycle concrete and aggregate in concrete and aggregate mixes.
Redefining productivity in the value chain	• Cliffs Natural Resources Pty Ltd, which is known for its consistent product quality, has refurbished its product quality system (PQS), to improve efficiency of production while maintaining its high standard of product quality. In 2010, 9Mt of ore was exported to Asia (Adiguzel et al., 2013).
Building supportive industry clusters at the company's location	• Sepon mine in Lao PDR has built strong relationships with the local community, which encourages local businesses to meet the minerals and metals group (MMG)-Kinsevere procurement standards (ICMM, 2013).

2.3. BARRIERS TO CREATING SHARED VALUE IN MINING

Although creating shared value in mining is not a brand new idea and companies are trying to come up with unique strategies, current practices are limited and few companies have predominant practices (FSG, 2014). Even some progressive companies are performing their projects inconsistently. One of the most critical barriers to creating shared value is the relationship and partnerships with stakeholders (Porter & Kramer, 2011). Mining companies should pursue sound strategies and comprehensive agendas to see both short and long term returns (Lins & Horwitz, 2007). Often, companies see little return on investment in local communities, in the short term, and view these expenditures as cost. This view of expenditures on projects associated with local communities is short-sighted and impedes shared value creation. On the other side, communities and nations criticize mining companies for not bringing substantial benefits and undermining local economic well-being (Power, 2008). This undermines the relationship between the stakeholders and makes it difficult to create shared value.

Several critical challenges are impeding the adoption of shard value approaches in the mining sector. First, the business interests of mining companies are sometimes at odds with the needs of the community (Botin, 2009). Lack of economic development and work opportunities, lack of effective governments, and environmental degradation are critical issues that cause community conflicts (Muduli & Barve, 2011). It is essential to take these issues into consideration for successful operation and creating shared value for communities in the regions where these companies operate.

Secondly, without integrating business and social functions effectively, there will be internal barriers within mining companies for adopting a shared value approach. Inadequate organizational design can prevent companies from identifying shared value opportunities (FSG, 2014). These built-in organizational barriers limit companies' ability to perceive the societal issues (Werling, 2007).

The third barrier to creating shared value is that mining companies are not measuring shared value opportunities accurately. Most companies usually underestimate the economic benefits of shared value initiatives, not fully capturing the advantages of the opportunities, and not fully evaluating the cost to the business if shared value strategies are not pursued (FSG, 2014). For example, companies do not measure the difference between a premium paid for an expatriate workforce or for local content. Mining companies should implement approaches that are able to capture the full view of economic impacts, which includes both benefits and costs. Companies with appropriate interventions will be able to expose and justify more opportunities for creating shared value, accurately.

Fourthly, low motivation for collaboration is another barrier. Collaboration is often perceived as being impractical, time-consuming, and incompatible with reputational objectives. However, collaboration is a best practice for an organization seeking to create shared value. Sharing information internally, as well as sharing with suppliers and customers, is critical to business success. To create shared value, mining companies should collaborate with a wide range of partners. Without communicating and sharing openly, businesses' desire of creating an environment of teamwork will be undermined (Werling, 2007).

The final obstacle to creating shared value is the lack of alignment with government. Governments can effectively enhance the opportunities of creating shared value; mining companies should help to build regional capacity for effective governance and, therefore, to improve the ability to create shared value. Companies that invest in improving their ability and the governments' abilities can better understand the negative impact of their operations and address the societal issues more effectively.

2.4. SCM IN MINING

2.4.1. SCM Overview. In the 1990s, the term "supply chain management (SCM)" became prevalent. The term "logistics" was used instead, prior to that time (Hugos, 2011). According to Cetinkaya et al. (2011), SCM is "the management of a network of interconnected businesses involved in the ultimate provision of production and service packages required by end customers." There is a difference between the concept of logistics and SCM. According to Hugos (2011), logistics generally refers to "activities that occur within the boundaries of a single organization while supply chains refer to networks of companies that work together and manage their actions to deliver a product to market." Traditional logistics mainly focused on activities such as procurement, distribution, maintenance, and inventory management. SCM covers not only the activities of traditional logistics, but also activities such as marketing, new product development, finance, and customer service (Hugos, 2011). Thus, SCM includes all the necessary movement, work-in-process inventory, storage of raw materials, and finished goods from the point-of-origin to the point-of-consumption.

SCM of a business consists of four major areas (plan, source, make, and deliver), which are all equally important. Businesses have taken supply chain management a step further with the primary goal of improving operations. These initiatives have included looking at the process of optimization and approaching sustainable practices to optimize all four areas in SCM by minimizing inventory, reducing cost, increasing production and accelerating order fulfillment (Werling, 2007).

A business must realistically fund and value a sustainable supply chain. The supply chain should cooperate within a realistic financial structure and create value to the society (Cetinkaya, et al., 2011). Sustainable SCM must take into consideration all related environmental, social, and economic problems.

2.4.1.1 Plan. Planning in SCM involves forecasting, internal collaboration and measuring with metrics (Werling, 2007).

Forecasting requires historical data and rates of sales of supply and demand, among others. Like all data measurement, the accuracy is the key.

Internal collaboration is a best practice because sharing information within an organization is vital to its success. Without communicating often and openly, a company can undermine its desire to create an environment of teamwork.

Measuring with metrics, or the use of Key Performance Indicators (KPIs) tells companies how they are performing. Some metrics, including inventory carrying cost, cash-to-cash cycle time, and fill rates, can provide companies with valuable details into their efficiency. A customized KPI can provide a roadmap for measuring the metric, which will show the part that needs improvement.

2.4.1.2 Source. The management of sourcing in SCM can be reflected in companies' logistics operations. *Logistics operations* should be clear and flexible to achieve competitive performance. Flexibility involves the ability to ensure supplies come in on time, products are created efficiently, and orders are filled accurately.

2.4.1.3 Make. Making refers to processes that transform product to a finished state to meet the final demand. Practices including aspects of technology and leanness and agility of manufacturing are used to increase improvement in this stage.

Technology provides many benefits beyond automation. For example, a Warehouse Management System (WMS), one of the main warehouse technologies, can speed up processing and make a warehouse less likely to make errors, and therefore, reduce cost as well as save time. It also offers greater visibility into facility management and meets the needs of the critical management techniques, including the visibility of capacity of each facility and the allocation of products to each facility.

Lean manufacturing uses a just-in-time approach to ultimately reduce inventory. Leanness makes the most sense when product variety is not required, product demand is predictable, and product demand levels are high, (Werling, 2007). Agility, can be defined as flexibility, which refers to the ability to respond quickly to changes. Agile manufacturing makes more sense when the requirement of variety is high.

2.4.1.4 Deliver. Delivering refers to the processes of delivering final products and services and includes activities such as order management, transportation management, and distribution management. Delivering in SCM involves external collaboration and value chains.

External collaboration provides opportunities for sharing information with partners, suppliers and important customers. Staying in touch with partners is likely to cause a business to receive products and fill customer orders on time. This can build partnerships and improve the relationships between organizations, shareholders, and other stakeholders. Collaboration helps to create a virtual supply chain with high transparency.

Value chain is the process a business uses to pass value to the customer at the least cost to itself. Value is the top priority for the business and its customers, and the goals of the value chain should be profit and customer satisfaction.

2.4.2. SCM Best Practices in Mining. Mines are part of the supply chains of almost all other businesses (ICMM, 2013). However, mining companies manage their own supply chains to achieve business goals. Local communities, the general public, and other stakeholders such as supply chain partners have been increasingly scrutinizing the SCM performance in the mining industry (Kusi-Sarpong et al., 2014). Mining companies have made great efforts to manage benefits, costs, and risks in operations, in order to make positive contributions to resource efficiency (UN, 2011b; Bowden, 2013; ICMM, 2013). Mining companies rely on other businesses and sometimes inspire new businesses to supply commodities and services and stimulate initiatives to enhance human well-being. Below are some of the practices:

- *Information technology (IT) and systems* pervade most business processes and supply chains making IT a significant focus of environmental footprints and sustainable practices (Molla et al., 2008). Mining companies optimize IT energy efficiencies to achieve better overall energy consumption of mines (Kusi-Sarpong et al., 2009). The inclusion of the IT function into environmental assessment programs is responsible for curtailing the needless creation of millions of tons of greenhouse gases, annually (Siegler & Gaughan, 2008).
- *Supply chain partnerships* to build relationships to achieve long-term collaborative advantage (Simatupang & Sridharan, 2005; Cao et al., 2010). It helps companies to regulate impartial, reliable, and consistent treatments of all

suppliers (ICMM, 2013); and it is also an effective approach that makes companies move the focus on supply chains in response to shareholder's pressures (Kusi-Sarpong et al., 2014). For instance, the Sepon mine in Lao PDR, which is owned by MMG Ltd., has built strong relationships with the local community. The mine encourages local businesses to meet MMG's procurement standards. This approach helps local communities develop businesses and become long term suppliers to the Sepon mine (ICMM, 2013), therefore boosting local procurement. In 2012, the structure of the local businesses helped the groups generate approximately $2.4 million for the mine (ICMM, 2013).

- *Operations and logistics integration* provides clear and flexible functions for production and logistic activities that help companies to manage materials flow through a mine's value chain (Stock et al., 2000; Kusi-Sarpong et al., 2014).
- *Sustainable procurement management* takes into account the environmental, social, and economic impacts of industry's spending while managing the purchasing and investment activities of an entity. Sustainable procurement allows entities to meet the need for goods, services, and utilities in a way that achieves not only the company's values but also improves the local economy and society without compromising the carrying capacity of the environment (Chartered Institute of Purchasing & Supply (CIPS) & National Institute of Governmental Purchasing (NIGP), 2012). Sustainable procurement in mine management helps to ensure supplier capabilities such as the capability to deliver services and goods to mine site (FSG, 2014). A notable example is Rio Tinto, which has been able to promote responsible business practices amongst its suppliers through its

procurement principles. The principles help the company to outline and manage stakeholder expectations with regard to governance, health, safety, environment, human rights and commercial issues (Rio Tinto, 2014).

- *Materials stewardship* is fundamental for responsible supply of minerals. From a mining perspective, companies should demonstrate compliance with regulatory or concession requirements, and corporate responsibility, while operating profitably (ICMM, 2013; Kusi-Sarpong et al., 2014). The Metals Environmental Risk Assessment Guidance (MERAG) and Health Risk Assessment Guidance for Metals (HERAG) guidance documents of ICMM are risk-based approaches that highlight help companies to achieve materials stewardship (ICMM, 2013). For example, the International Cyanide Management Code, an initiative for the gold mining industry and the producers and transporters of the cyanide used in gold mining, focuses on the safe management of cyanide that is produced, transported and used for the recovery of gold (International Cyanide Management Institute (ICMI), 2015). The Cyanide Code ensures that signatories manage cyanide in a responsible manner.
- *Transparency* in mining operations is essential for accelerating the flow of value between businesses and governments, in many cases. To date, forty-eight countries have implemented the Extractive Industries Transparency Initiative Standard (EITIS) (EITI, 2015). This initiative is just one example of how stakeholders desire transparency in the operations of mining companies. Between the fourty-eight countries that have implemented the EITIS, over $1 trillion worth

of reported revenues flowed between the extractive sectors and government in 2013(ICMM, 2013).

- *Collaboration* helps mining companies to reduce the costs of inputs and create employment for the host communities. It can also help bring development into the host communities and build trust among partners. The company's reputation as a good corporate citizen can then be enhanced (Breuer & Farrel, 2007). Both internal and external collaboration are necessary to improve decision making, accelerate delivery and enhance governance. For example, in 2013, Freeport-McMoran, in collaboration with regional government, national government and other stakeholders, expanded the scope of its Cerro Verde Mine expansion to include construction of a wastewater treatment to meet the mine's and the local communities' needs. This collaboration not only increases the productivity of the mine, but also impacts the local economy significantly (Freeport-McMoRan, 2013).

2.4.3. Importance of Sustainable SCM to SV. In a survey conducted by the American Production and Inventory Control Society (APICS) & PricewaterhouseCoopers (PwC) (2014), more than two-thirds of 500 supply chain executives mentioned that sustainability will play an important role in improving SCM; and sustainable SCM indeed generates shared values. Another survey conducted by APICS (2014) showed that as a result of programs tied to sustainable SCM, 35% of professionals reported improvements in their companies' environmental impact, and 25% of them reported improvements in customer satisfaction. Mining companies, as long-term investors, should conduct their activities to contribute to sustainable development in the communities in which they operate. Sustainability is now one of the fastest-growing SCM trends. A better understanding of SCM in mine management can lead to better use of SCM for sustainable outcomes. Sustainable SCM can improve the regional economy, and reduce impacts on the society and environment significantly and, therefore, create shared value for all regional stakeholders.

First, sustainable SCM helps mining companies unlock long-term potential value. Companies that embrace the concept of creating shared value for communities are engaging in responsible mining (ICMM, 2013). Mining companies with effective sustainable SCM will think broadly about potential business and social impacts, and thus, identify strategic and commercial opportunities (FSG, 2014; APICS & PwC, 2014). For instance, SCM practices such as collaboration, supply chain partnerships, and logistic integration helps the company manage reputational risk. Good reputation is a valuable asset, which can influence the functioning and profitability of a company (Werling, 2007; Tuck, 2012). Sustainable SCM also provides continuing supplies. Mining companies should be willing to build partnerships with suppliers that practice sustainable strategies, which improve the yields for suppliers and revitalize the community. From that perspective, managing supply chains with sustainability concepts helps mining companies create value for communities and the companies.

SCM activities also help mining companies create a clear strategy for creating shared value (FSG, 2014). It is more likely for a company that operates with sustainable SCM practices to have a well-communicated strategy than others that do not (Cetinkaya, et al., 2011; FSG, 2014). A well-communicated strategy will help the company set the direction for projects because the strategy directly impacts the regional economy, reduces costs, increases revenue, gains market share, and reduces negative impacts on society and environment. And all this will be clearly communicated to the host communities.

Supply chain management can provide a broad scope of initiatives to find more value. Supply chains are interconnected businesses that connect suppliers and consumers. Looking at a company's entire supply chain, managers can identify opportunities along the supply chain that produce desired outcomes such as profit and stakeholder value (Cetinkaya, et al., 2011). For example, natural resources turn into final products that will be delivered to the end customers through supply chain activities, and all stages of the process can create value. Sustainable supply chain management allows managers to discover opportunities for creating shared value through economic activities at all stages.

2.4.4. How to Use SCM to Achieve SV. Mining companies, like all businesses, should develop strategies to gain a competitive position of optimum advantage. According to Porter (1985), one competitive strategy of an organization is to search for a competitive position, which aims to obtain a profitable and sustainable situation relative to its competitors. Relevant questions include: (1) could an advanced SCM strategy that creates shared value bring about a compelling competitive advantage to a company? (2) Could a successful SCM project generate temporary advantage or only a parity advantage, or could it generate a sustainable relationship between mining companies and the communities in which they operate? To answer these questions, Porter and Kramer (2006) provided some criteria, such as local supplier quality and logistics networks.

- *Supply chain visibility*. Technology can be used by businesses to increase supply chain visibility and to create more sustainable outcomes, which will provide benefits in decision making, cost reduction, risk reduction, and avoidance of unethical suppliers.

- *Mature supply chains*. Supply chains are significant to both economy and business (Lins & Horwitz, 2007; ICMM, 2012; Kusi-Sarpong et al., 2014). SCM strategies have major implications for the societal and environmental well-being (Kusi-Sarpong et al., 2014). In this respect, companies practicing SCM maturely and responsibly will have high transparency, strong department integration, solid collaboration structures, and strong local governance (Muduli & Barve, 2011). A mature supply chain can provide benefits by implementing sustainability and managing the complexities within the company, and thus create shared value for shareholders and other communities (Accenture, 2015).
- *Managing and sustaining effective supplier relationships*. Focusing SCM strategy on supplier relationships will drive value in any company. (Anklesaria, 2008). In order to create green supplier base, some companies create guidelines for selecting ethical suppliers (Jenkins, 2004). With effective and robust supplier relationships, companies can focus more on shared value delivery (Anklesaria, 2008).
- *Sourcing from local suppliers*. The strategy of sourcing raw materials or products from local suppliers helps reduce transportation cost and carbon footprint, creates jobs and positively impacts the local community, and increases revenues in the local economy.

All these are strategies that can affect a company's reputation, build a supportive business environment, and create shared value to shareholders. Of all the SCM strategies, sourcing from local suppliers is, probably, the most direct and comprehensive approach for creating local community's shared value. It falls into the third category of ways to create shared value: building supportive industry clusters at the company's location (Porter and Kramer, 2011). Sourcing from sustainable local suppliers will be a requirement of sustaining effective relationships with local suppliers and building mature local supply chains. Sourcing from local suppliers can stimulate local employment growth, develop regional capacity and, therefore, positively impact the local economy.

2.5. INPUT-OUTPUT ANALYSIS

2.5.1. Input-Output Analysis Defined. Input-Output Analysis (IOA) was first developed by Wassily Leontief, who won the Nobel Prize in Economics for his work (Leontief, 1986). In 1941, he published the first IOA paper *Structure of American Economy* which signifies the birth of the Input-Output technique (Leontief, 1941). 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).

Today, many different types of economic or environmental analyses are based on the concepts presented by Leontief, which is one of the most broadly applied modelling methods (Miller & Blair, 2009). Input-output modeling is recognized as a powerful tool that has been incorporated into national accounting in many developed countries and has also been used in analyzing economic impacts. It has also been used to study regional economies within a nation (International Labor Organization (ILO), 2011). A major use of IOA is to measure the economic impacts of events, public investments, or business programs. The purpose is to analyze the interconnectedness of industries in the economy (Miller & Blair, 2009).

2.5.2. IOA for Evaluating Sustainable Outcomes. There is broad consensus that integrated approaches are necessary for evaluating SD impacts; specifically, to assess social and environmental impacts (Stocker & Luptacik, 2009). Input-Output analysis, which can comprehensively illustrate the effect of linkages by combining social, economic, and environmental data with input-output modeling, is recognized as an effective framework to evaluate sustainable outcomes (Stocker & Luptacik, 2009). It is a flexible assessment tool that can compute the impacts of changes in final demand rapidly. Researchers and organizations have applied IOA to analyze the structure of economic systems to evaluate the flow of value between sectors in many fields.

Initially, the IOA approach was used for evaluating inter-industry activities in the U.S. (Leontief, 1941). It was, however, rapidly co-opted by other areas, including material flow, ecological footprint, life cycle analysis, and energy analysis (Hendrickson et al., 1998; Joshi 1999; Lindner et al., 2013). Additional columns can be added to the Input-Output Tables (IOT) to perform environmentally extended input output analysis (EEIOA), which can provide a method to evaluate the linkages between economic activities and environmental impacts (Kitzes, 2013). It allows the material flows to be tracked and allocates the ecological emissions to the final demand category. For example, Stocker and Luptacik (2009) assigned material input and emissions output into the basic input-output tables to illustrate the impacts between socio-economic trends and environmental emissions in Austria. Hendrickson et al. (1998) and Joshi (1999) pioneered an approach for conducting environmental life cycle assessments using input-output tables. Onat et al. (2014) used an input-output based triple bottom line, hybrid life cycle assessment (LCA) model to assess the sustainability of building U.S. residential and commercial buildings. Other examples that use IOA techniques for sustainability assessment include, application of EU-wide EEIOA for supporting European policy (European Commission, 2008), pollution impacts of specific fuel-use on regions (Turner, 2003), disposal allocation using IOA (Allan et al., 2004), and evaluation of climate change on economic variables using IOA (Jahan, 2013).

2.5.3. IOA for Evaluating SCM Strategies for Sustainability in Mining. The importance of SCM performance for creating shared value shows that effective performance assessment tools are needed to evaluate the performance of SCM strategies. Multiple methods like just-in-time (JIT), Kaizen, lean production, total quality management, and computer generated enterprise resource planning schedule (ERP) have been used to assess SCM performance in different industries (Kusrini et al., 2014). SCM performance evaluation can be used to evaluate the effectiveness of SCM strategies and identify shared value opportunities. It contributes to the decision making process in SCM. For instance, performance measurement initially improves the company performance by providing managers feedback on the project progress and to motivate necessary revisions to the company's strategies (Chan, 2003; Sardana, 2009). A good performance assessment tool for SCM should specifically describe the context, content, and process of assessment (Kusrini et al., 2014), and IOA can be used as an effective tool to evaluate the supply chain performance of a company or industry.

IOA is a powerful tool to assist in policy decision-making. It provides information on the flow of goods and services among the different sectors of any economy. Input-output tables consist of intermediate transactions between producing and purchasing sectors, as well as each sector's final demand and value added. They show the state and process of an economic system and are particularly useful when analyzing the impacts of changes in final demand of certain sectors on the overall economic system (Li, 2004).

IOA is an accounting and planning tool that can describe production processes and analyze the reciprocal inter-connectedness of consumptions among different economic sectors. Researchers have adopted IOA to assess logistics flows, identify critical sectors, and evaluate supply chain performance in order to support management and coordination of decision makers (Albino et al., 2008; Larsen et al., 2012). Larsen et al. (2012) used EEIOA and life cycle assessment to show the importance of SCM on the energy or climate change footprint of industry sectors. They specifically illustrated that, for most sectors, the majority of the life cycle energy load is from the upstream supply chain. Albino et al. (2008) utilized input-output modeling to analyze the flows of material, energy, and pollution of regional supply chains. Economic input-output models can play a major role in assessing the performance of SCM strategies of industry sectors.

2.6. SUMMARY

Mining companies should contribute to sustainable development (SD) to meet the economic development expectations of their host communities whilst minimizing the environmental and social impacts of their activities. To do this in a mutually beneficial way, these companies must pursue business strategies that create shared value. Supply chain management (SCM) shows great potential to help create shared value. However, to achieve this goal, viable assessment tools are required to measure and study the impact of SCM strategies designed to create shared value. The literature shows that the input-output technique, applied on SCM, can serve as an assessment tool for sector-wide SCM strategies.

This chapter shows that creating shared value is an effective way for mining companies to achieve sustainable outcomes in a consistent manner. Several best practices for creating shared value are discussed in the chapter. However, sourcing from local suppliers is presented as, probably, the most direct and comprehensive approach for creating local community's shared value. This is consistent with the call to create shared value by building supportive industry clusters at the company's location (Porter and Kramer, 2011).

This research presents methods to use input-output analysis to evaluate local sourcing as an SCM strategy of mining industry sectors. IOA, as a tool to assess SCM performance, can provide data and analysis to evaluate whether local sourcing indeed promotes sustainable outcomes. The methodology presented in this research will simplify the process by consolidating key components in the supply chains and helping stakeholders to focus on the key sectors of the supply chain.

3. EVALUATING THE EFFECTS OF LOCAL PROCUREMENT STRATEGY ON REGIONAL ECONOMY USING INPUT-OUTPUT ANALYSIS

3.1. INTRODUCTION

This Chapter addresses the first research objective, which to test the hypothesis that a local procurement strategy, by mines in a region, significantly affects regional economy. The objective is addressed using input-output analysis (IOA) applied to a case study. The goal is to evaluate whether changes in the level of local procurement will have an impact on the local economy.

Input-output analysis is used, in this study, as a robust tool to evaluate local procurement in developing supply chain management (SCM) strategy. When analyzing the impact of changing the final demand of certain commodities in a specific economic system, input-output modeling is extremely useful and convenient (Siwale, 2014). Input-output tables consist of intermediate transactions between supply and demand sectors; the final demand and value added of each sector can be examined using IOA. Input-output tables that reflect inter-related supply chains can provide direct, indirect, and induced effects of industries within economies. The technical coefficient matrix, which is derived from input-output tables, demonstrates the relationship between all components in a supply chain. For example, a simple supply chain of the mining industry includes backward linkages (natural gas, diesel fuel, transportation, etc.) and forward linkages (final demand of end customers). Leontief's inverse matrix can describe the detailed transactions between the different supply chain components (Leontief, 1941). Multipliers, including output multipliers, value added multipliers, labor income multipliers, and employment multipliers, can be calculated using to the inverse matrix in the economic system. Multipliers are the basis for estimating the magnitude of additional (indirect and induced) effects to the regional economy in this work. Multipliers used in this study are constructed and derived from IMPLAN 2012 (the latest data available at the time of this work) input-output tables. They are valuable for measuring the broad impacts of economic activity.

3.2. METHODOLOGY

The method used in this work, which is based on input-output analysis, involves the following steps:

- Build an input-output model of the industry sector under study using available input-output tables and data;
- Use the model to conduct simulation experiments by varying the level of local content in the materials consumed by the modeled industry sector; and
- Evaluate the simulation results to draw inferences on the effect of local procurement on the local economy.

In order to present this approach, it is important to properly explain certain input-output concepts that are central to this approach. Section 3.2.1 presents the explanation of these concepts and how they are used in this approach. This is followed by a discussion of the evaluation criteria used in this work to evaluate the effect of local procurement.

3.2.1. Relevant Input-Output Concepts.

3.2.1.1 Multipliers. Multipliers indicate the relationship of an industry to the economy. Multipliers can be used to estimate how an economic activity of a mining sector can lead to impacts on employment, income, value added, and output for example. The input-output interconnections, illustrated in Table 3.1, can be translated analytically into accounting identities. In this table, x_{ij} denotes the intermediate consumption of commodity i by sector j; v_j denotes the amounts of depreciation of fixed assets of sector j; m_j denotes the amounts of taxes paid by sector j; n_j denotes the amounts of profits of sector j; the sum of v_j, m_j, and n_j denotes value added by sector j; y_i denotes final demand of commodity i; x_i denotes the total output of the i^{th} production sector; and x_j denotes the total input to the j^{th} production sector. $\sum_{i=1}^{n} x_{ij} = \sum_{j=1}^{n} x_{ij}$, since both terms denote the sum of all elements of the intermediate consumption matrix.

From a demand perspective, for each of the n commodities:

$$x_i = x_{i1} + x_{i2} + x_{i3} + \ldots + x_{in} + y_i \quad (\forall i = 1,\ \ 2,\ \ \cdots, n) \tag{3-1}$$

Table 3.1. Interrelated supply chain in input-output table

		INDUSTRIES					**Final Demand**	**Total Output**
		Agriculture	Mining	Construction	Manufacture	…		
COMMODITIES	Agriculture	x_{ij}					y_i	x_i
	Mining							
	Construction							
	Manufacture							
	…							
VALUE ADDED	Depreciation	v_j						
	Taxes	m_j						
	Profits	n_j						
Total Input		x_j						

From the supply perspective, for each of the *n* commodities:

$$x_j = x_{1j} + x_{2j} + x_{3j} + \ldots + x_{jj} + \ldots + x_{nj} + v_j + m_j + n_j \quad (\forall i = 1,\ \ 2,\ \ \cdots, n) \qquad 3\text{-}2$$

It is required that the number of sectors and commodities in Table 3.1 should be equal. For a specific commodity, the total output gained in the demand vector must equal the total output obtained by the supply vector. Eqs. 3-1 and 3-2 are the mathematical representation of the input-output technique, presented in any input-output table. It is necessary to explain the fundamental concept of the technical coefficient $\frac{y_{ij}}{x_j} = a_{ij}$ in order to introduce the input-output model. The technical coefficient, a_{ij}, describes the total amount of product *i* used as input in the production of one monetary unit of industry *j*'s output. Using this definition, Eq. 3-1can be re-write as Eq. 3-3

$$\begin{aligned} x_i &= a_{i1}x_1 + a_{i2}x_2 + a_{i3}x_3 + \ldots + a_{ii}x_i + \ldots + a_{in}x_x + y_i \\ &= \sum_{j=1}^{n} a_{ij}x_j + y_i \ \ (\forall i = 1,\ \ 2,\ \ \cdots, n) \end{aligned} \qquad 3\text{-}3$$

Applying Eq. 3-3 to each of the *n* commodities under consideration and rearranging terms yields Eq.3-4.

$$\begin{aligned}
(1-a_{11})x_1 - a_{12}x_2 - a_{13}x_3 - \ldots - a_{1i}x_i - \ldots - a_{1n}x_n &= y_1 \\
-a_{21}x_1 + (1-a_{22})x_2 - a_{23}x_3 - \ldots - a_{2i}x_i - \ldots - a_{2n}x_n &= y_2 \\
&\vdots \\
&\vdots \\
-a_{i1}x_1 - a_{i2}x_2 - a_{i3}x_3 \ldots + (1-a_{ii})x_i - \ldots - a_{in}x_n &= y_i \\
&\vdots \\
&\vdots \\
-a_{n1}x_1 - a_{n2}x_2 - a_{n3}x_3 \ldots - a_{ni}x_i - \ldots + (1-a_{nn})x_n &= y_n
\end{aligned} \tag{3-4}$$

Or, in matrix terms

$$\begin{bmatrix}
(1-a_{11}) & -a_{12} & \cdots & -a_{1i} & \cdots & -a_{1n} \\
-a_{21} & (1-a_{22}) & \ldots & -a_{2i} & \cdots & -a_{2n} \\
\vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\
-a_{i1} & -a_{i2} & \cdots & (1-a_{ii}) & \cdots & -a_{in} \\
\vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\
-a_{n1} & -a_{n2} & \cdots & -a_{ni} & \cdots & (1-a_{nn})
\end{bmatrix} \tag{3-5}$$

If there are vectors $\mathbf{X} = [x_1, x_2, x_3, \cdots, x_n]^T$ and $\mathbf{Y} = [y_1, y_2, y_3, \cdots, y_n]^T$, then, Eq.3-5 can be translated in to Eq. 3-6.

$$\begin{aligned}
(1-\mathbf{A})\mathbf{X} &= \mathbf{Y} \\
\mathbf{X} &= (\mathbf{I}-\mathbf{A})^{-1}\mathbf{Y}
\end{aligned} \tag{3-6}$$

In Eq. 3-6, **A** represents the technical coefficient matrix; **X** represents the total output vector, and **Y** represents the final demand vector. The well-known input-output model is carried out straightforwardly. Based on the Eq. 3-6, a small exogenous change in the final demand vector ($\Delta\mathbf{Y}$) can lead to a corresponding change in the output vector ($\Delta\mathbf{X}$) (shown in Eq. 3-7).

$$\begin{aligned}\Delta\mathbf{X} &= (\mathbf{I}-\mathbf{A})^{-1}\Delta\mathbf{Y}\\ \Delta\mathbf{X} &= \mathbf{B}\Delta\mathbf{Y}\end{aligned} \tag{3-7}$$

$(I-A)^{-1}$ (described as **B** with elements b_{ij}) illustrates the Leontief inverse. Each of its elements b_{ij} represents the value of output *i* required directly and indirectly to deliver one additional monetary unit to sector *j*'s demand (Miller & Blair, 2009). In analytical terms, $b_{ij} = \frac{\partial x_i}{\partial y_j}$. Using the information in the inverse matrix, it is possible to calculate Type I and Type II multipliers.

Type I multipliers are defined using direct and indirect effects (Eq. 3-8). Direct effect is the initial change attributable to the exogenous change. Indirect effects are the inter-industry interactions as a result of the initial change. Applying direct effects to the Type I multipliers can calculate the total impacts. Type I multipliers measure the impact over all the economy caused by a change in final demand for output *j*.

$$Type\ I\ multiplier = \frac{Direct\ Effect + Indirect\ Effect}{Direct\ Effect} \tag{3-8}$$

Type II multipliers are defined using direct, indirect, and induced effects (Eq. 3-9). The new term, induced effect, refers to the response of an economy to the direct effect that occurs through re-spending of income received by a component of value added.

$$Type\ II\ \ multiplier = \frac{Direct\ Effect + Indirect\ Effect + Induced\ Effects}{Direct\ Effect} \qquad 3\text{-}9$$

Economic multipliers describe the overall change in total output for a marginal increase in direct input. It is a measure of the scale of impact caused by investment in a particular area. The higher the multiplier, the higher the impacts that result from a marginal increase in spending by an industry. In this study, the IMPLAN SAM (Social Accounting Matrix) multipliers (Type II multipliers) are applied to estimate economic impacts in this study, since the overall impact of a mining industry sector on the regional economy will include all direct, indirect, and induced effects.

3.2.1.2 Regional purchase coefficient and local use ratio. A commodity's regional purchase coefficient, for a particular sector, is the proportion of the total demand for the commodity, by that sector, that is supplied by producers located within the region. This can be represented as Eq.3-10:

$$Regional\ Purchase\ Coefficient\ (RPC) = \frac{Local\ Commodity\ Demand\ (LD)}{Gross\ Commodity\ Demand\ (GD)} \qquad 3\text{-}10$$

Where,

Local commodity demand refers to the amount of local demand met locally; and

Gross commodity demand refers to the amount of local demand.

The local use ratio (LUR) is the proportion of net local supply of a commodity that goes to meet local demands (Eq.3-11).

$$Local\ Use\ Ratio\ (LUR) = \frac{Local\ Use\ of\ Local\ Supply\ (LULS)}{Local\ Net\ Commodity\ Supply\ (LS)} \qquad 3\text{-}11$$

Where,

Local net commodity supply refers to total amount of a commodity produced within the study area less the amount of foreign exports.

In this work, the regional purchase coefficient is the primary variable that is modified in the simulations to model changes in local procurement. The local use ratio is used as a reference to check a commodity's capability for modification of regional purchase coefficient.

3.2.2. Performance Measures.

When input-output analysis, based on multipliers, is used to study the effect of local procurement strategy, it is able to demonstrate the impacts on sales, employment, labor income, and value added. The key performance indicators, in this study, are these four impacts. All four impacts are used because, together, these measures will quantitatively communicate the significance of local procurement strategies by taking into account of direct, indirect, and induced effects of increased local procurement of any particular commodity.

3.3. CASE STUDY: MISSOURI STONE MINING & QUARRYING INDUSTRY

3.3.1. Overview of Mining in Missouri and Approach.

The mining industry is critical contributor to Missouri's economy. Mining activities in Missouri produce raw materials, which are used over all the economy, including natural stone, silver, copper, nickel, lead, zinc and coal. Stone and sand are vital ingredients for construction. Metals such as copper, nickel, lead, and zinc significantly support manufacturing of a broad range of products. The mining industry is supported by the technical and financial services, manufacturing, construction, transportation and other industries.

The impact of the mining industry on Missouri's economy includes direct jobs, and added value (including taxes). There are also induced effects which are generated by employees re-spending salaries at local businesses and further spending on other suppliers by the owners of these businesses.

As shown in Table 3.2, the contribution of mining to Missouri's total value added exceeded $2,685 million in 2012; $1,466 million of this was from non-metallic mining. Labor income, for the same period, is approximately $2,005 million, which is 1.2% of Missouri's total labor income (NMA, 2014). Over 50% Missouri's mining labor income is generated by non-metallic mining, which is over $1 billion. This accounts for around 60% (around 20,360 jobs) of employment associated with mining in Missouri. Limestone is one of the most important non-metallic mineral resources in Missouri. Limestone plays an important role in human life. It is also vital to Missouri's economy by contributing approximately $1 billion to the State's economy, annually (The Geologic Column of Missouri, 2006). The Missouri Limestone Producers Association (MLPA) reports that Missouri ranks first, fourth, and fifth in the nation in the production of lime, crushed limestone, and portland cement, respectively (The Geologic Column of Missouri, 2006). In Missouri, more than one-fourth of the non-metallic mining production is aggregate limestone.

Table 3.2. Economic contribution of the Missouri mining industry (2012) (NMA, 2014; IMPLAN modeling system (2012 database))

Impact ($ millions)	**Coal Mining**	**Metal Mining**	**Non-Metallic**	**All Mining**
Value Added	730	489	1,466	2,685
Labor Income	492	391	1,122	2,005
Tax	168	149	319	636
Impact (No. of Jobs)	**Coal Mining**	**Metal Mining**	**Non-Metallic**	**All Mining**
Employment	7,420	5,600	20,360	33,380

The objective of this case study is to use the stone mining and quarrying industry in Missouri to illustrate the economic impacts of local procurement strategies in supply chain management. The case study illustrates the method outlined in Section 3.2.

The basic principle of regional economic impact analysis using IOA is to apply relevant multipliers to final demand changes through the economy (Eq.3-7). 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 input-output analysis terms, the direct effects stem from the change in final demand of backward commodities while the indirect effects stem from purchases from these backward industry sectors. Induced effects stem from households’ re-spending their salaries and incomes earned as direct and indirect dollars in Missouri. The multipliers in the regional input-output tables can be adjusted to account for feedback effects from other regions due to linkages through trade (though, the initial stimulus is from in the region of interest).

This study uses IMPLAN software and data to model economic impacts of economic activities by the stone mining and quarrying industry in Missouri. IMPLAN is one of the most widely used input-output models. The selected IMPLAN input-output accounts, which are based on the U.S. Department of Commerce Input-Output Tables, are able to facilitate comparison among industrial sectors and, therefore, track the cascading effect through the regional economy. Moreover, economic multipliers can be developed from the accounts and applied to assess economic impacts of the activities of Missouri's stone mining and quarrying industry. All estimates of how the stone mining and quarrying industry's activities impacts the regional economy are in 2012 dollars.

3.3.2. Data and Modeling. In this study, all 89 backward commodities that are purchased by the stone mining and quarrying sector in Missouri were included in the IMPLAN model of the Missouri stone mining and quarrying industry. A backward commodity in this study is a representative term that represents all commodities in one sector. All 89 backward commodities are derived from IMPLAN's 440×440 input-output tables (IMPLAN 2012). The 2012 IMPLAN input and output data, the most recent data, was used for estimating the regional economic impacts of the stone mining and quarrying industry in Missouri.

In order to validate the modeling, the authors used the Analysis-by Parts method (ABP) to cross-check the model results. ABP is a technique by which an analyst can easily create a custom industry based on his or her own budgetary spending pattern. ABP is accomplished using combinations of economic activity types. The total impact estimated by this method is the sum of the direct, indirect, and induced effects, just like the conventional IMPLAN modeling.

In this work, there was no analysis required for the direct effects because the final demand of products did not change based on the spending pattern of the customized industry (i.e. buying more locally does not change the overall supply of mining products). The indirect effects can be evaluated based on the change made by customizing the spending pattern. The induced effects are estimated based on employment compensation and proprietor's income.

3.3.3. Backward Commodities. In this study, ten backward commodities were chosen to evaluate the impact of local procurement by the stone mining and quarrying industry on Missouri's economy (Table 3.3). These ten commodities were chosen based on two guiding principles: (1) generally, these were commodities with high multipliers, since these will have the biggest influence on the economy[3]; and (2) it should be possible to increase the regional purchase coefficient by 10%. The chosen commodities have a broad range of local purchase coefficient (approximately from 16% to 84%) and relatively high multipliers (approximately from 1.88 to 2.02). Whether the regional purchase coefficient can be increased by 10% was determined by assessing the local use ratio. (If the local use ratio was less than 1, then it was possible to increase the regional purchase coefficient by 10%.)

In order to evaluate the effect of a strategy to increase local sourcing of materials as a supply chain management strategy, the local purchase percentage of each of the 10 commodities were increased by 2%, 4%, 6%, 8% and 10%, in separate simulation experiments. The model was re-run each time to estimate the regional economic impacts

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[3] Chapter 4 presents an approach that can be used to select the critical commodities. In this analysis, a more qualitative approach is used to select the commodities.

and the multipliers of Missouri stone mining and quarrying. The results are presented in Section 3.3.4.

Table 3.3. Selected backward commodities of stone mining and quarrying sector (Data from IMPLAN modeling system (2012 database))

IMPLAN Industry Code	Commodity	RPC	Multipliers
26	Mining and quarrying sand, gravel, clay, and ceramic and refractory minerals	0.4800	1.9163
103	All other miscellaneous wood product	0.2401	1.9453
337	Pipeline transportation services	0.1644	1.9539
338	Scenic and sightseeing transportation services and support activities for transportation	0.5517	1.9146
355	Non-depository credit intermediation and related services	0.7803	2.0255
356	Securities, commodity contracts, investments, and related services	0.7616	1.8908
372	Computer systems design services	0.8397	2.1295
374	Management, scientific, and technical consulting services	0.4754	1.8868
375	Environmental and other technical consulting services	0.3588	1.9003
384	Office administrative services	0.5984	2.0005

3.3.4. Results and Discussions.

3.3.4.1 Economic impact. In 2012, the economic contribution of the stone mining and quarrying industry in Missouri to state’s economy, according to the model developed in this research, is shown in Table 3.4. The estimated economic impacts of stone mining expenditures of $256 million are estimated to be $478 million in total output (total sales). Expressed as a ratio, each dollar that the stone mining and quarrying industry spends generates $1.87 of total impact (direct, indirect, and induced). The multiplier of stone mining and quarrying sector is 1.867. The total value added (depreciation, taxes and profits) by this sector and its direct suppliers through spending is estimated to be $248 million. In 2012, this represented approximately 0.081% of Missouri's regional value added. Total employment is assessed at 2,773 jobs and involves the direct employment of 1,261 people (equivalent full time jobs). Jobs related to the construction and quarrying phase as well as those engaged in the transportation of output from the mine site are all covered by direct employment impacts.

Table 3.4. Economic impact of stone mining and quarrying industry on Missouri (2012)

Impact ($ millions)	**Direct**	**Indirect**	**Induced**	**Total**
Output	$256.2	$130.0	$91.3	$477.5
Value Added	$121.3	$70.5	$55.9	$247.7
Labor Income	$74.5	$45.1	$31.9	$151.5
Impact (No. of Jobs)	**Direct**	**Indirect**	**Induced**	**Total**
Employment	1,261	738	774	2,773

3.3.4.2 Effect of local sourcing on economic impacts. This study tested the role of a local sourcing strategy in SCM in the Missouri stone mining and quarrying industry. An SCM strategy that enables strong local sourcing may result in high local economic impacts. The hypothesis that increasing local purchase percentage of a mining sector's backward commodities will affect regional economic impact is tested by using input-output model. The results of the analysis are shown in Figure 3.1 to Figure 3.4.

Changes in local purchase coefficient of backward commodities have no effect on the direct impacts (direct output), since the total expenditure for the industry is not changing. However, there will be an additional $2.28 million and $0.65 million in indirect and induced impacts with a 10% increase in RPC of all 10 commodities (Table 3.5). That means, when the stone mining and quarrying industry in Missouri increases the proportion of locally sourced product for the chosen 10 backward commodities by 10%, there will be approximately $2.94 million additional total impact on the regional economy. There will be about $1.08 million and $1.59 million additional impact on incomes and value added, respectively. Change in total employment is estimated at 24 jobs for 10% increases in local purchase proportion, and consists of the direct employment of 18 full-time jobs and induced employment of 6 full-time jobs (Figures 3.1-3.4 and Table 3.5).

Table 3.5. Change in impact of labor income, value added, and employment at 10% increase in RPC (2012)

Impact Type	**Change in Employment** (No. of Jobs)	**Change in Labor Income** ($ millions)	**Change in Value added** ($ millions)	**Change in Output** ($ millions)
Direct	0	0	0	0
Indirect	17.9	0.85	1.19	2.28
Induced	5.5	0.23	0.40	0.65
Total	23.4	1.08	1.59	2.94

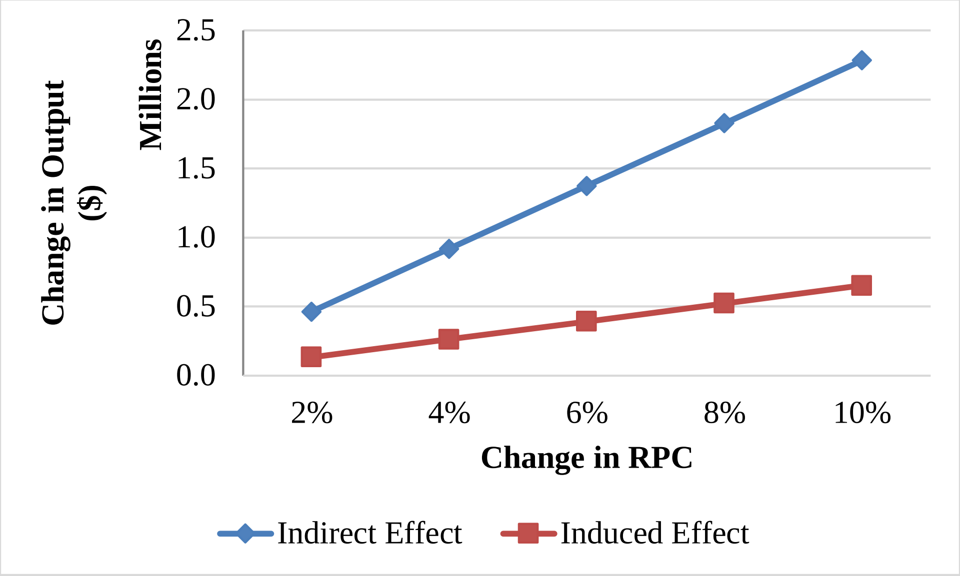

Figure 3.1. Change in output vs. change in RPC

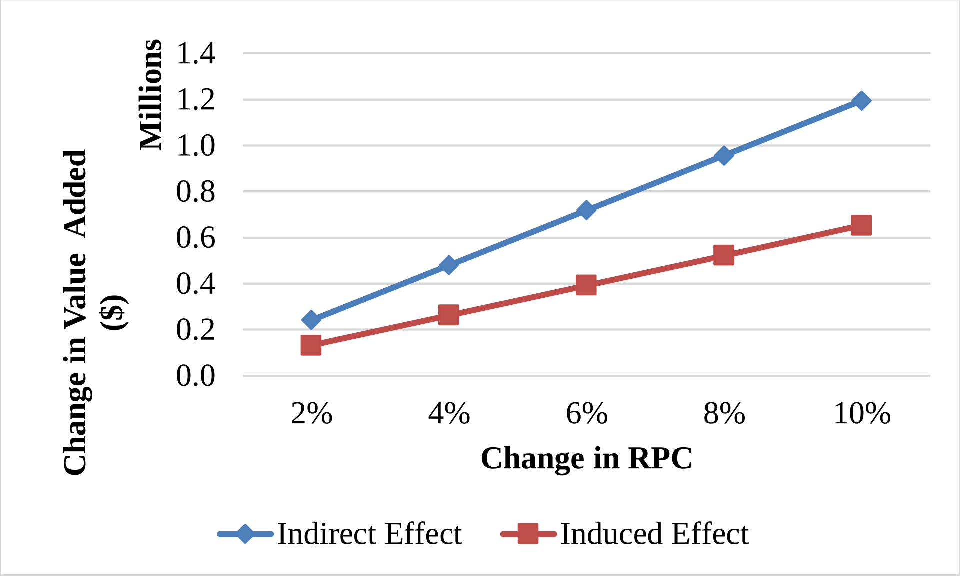

Figure 3.2. Change in value added vs. change in RPC

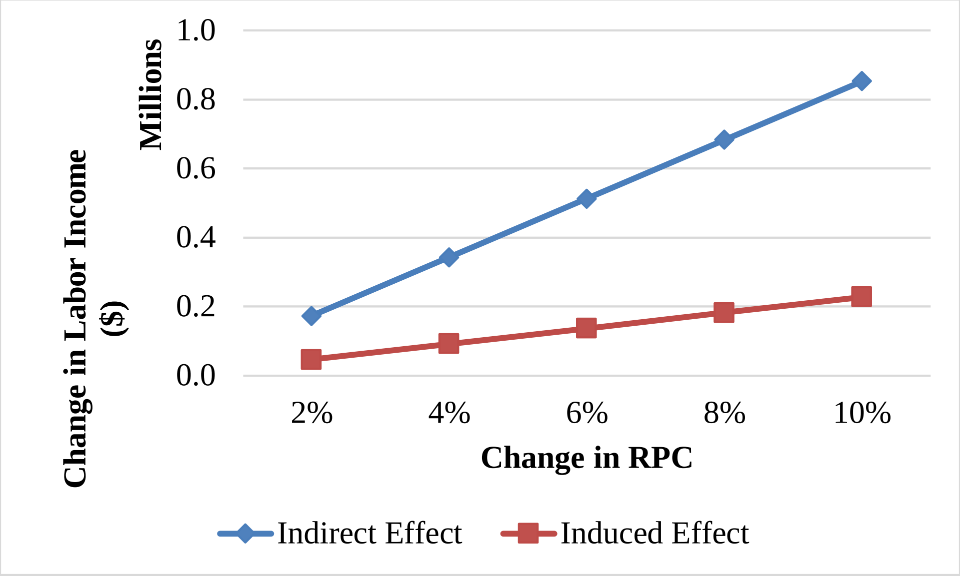

Figure 3.3. Change in labor income vs. change in RPC

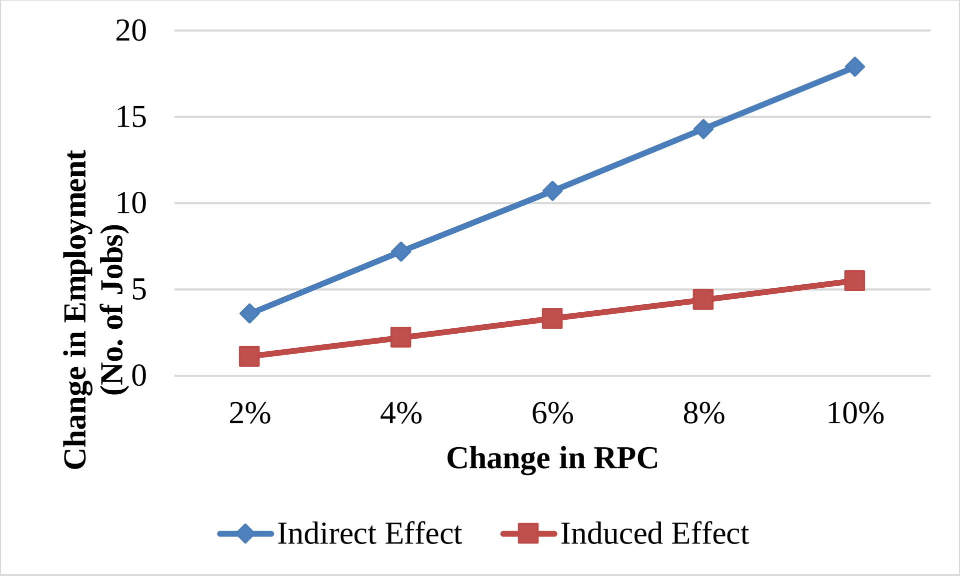

Figure 3.4. Change in employment vs. change in RPC

Figure 3.5 shows the reconstructed output multipliers of the Missouri stone mining and quarrying sector increases from 1.86 to 1.88, with increases in RPC. The sector's multiplier increases approximately 1% for every 2% increase in local purchase coefficient of these ten backward commodities.

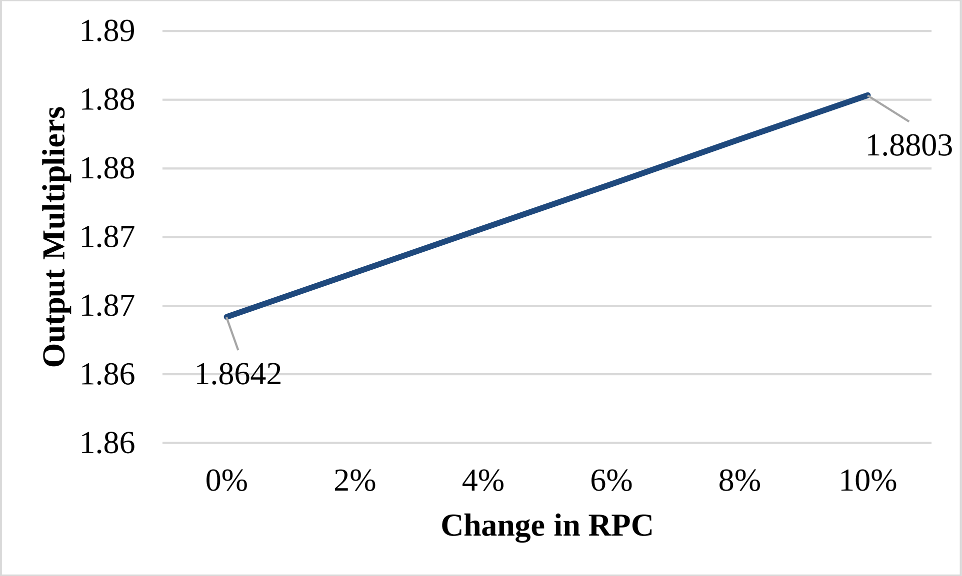

Figure 3.5. Output multiplier changes of mining and quarrying industry

These results illustrate the impact of sourcing local products on the regional economy using the stone mining and quarrying industry in Missouri as an example. In general, the results indicate the significance of mining supply chain management in enhancing local impacts. This is supported by anecdotal evidence that increasing participation of local industries enhances the local and regional impacts of mining (The Africa Mining Vision (AMV), 2014). With the approach outlined by this study, decision makers in the mining industry will be able to use input-output analysis for supply chain management decision making. These results reveal that small increases (10% or less) in local sourcing of the chosen 10 backward commodities will enhance local economic impact significantly. The specific effects on the local community will vary from one economy to the other and depends on the mix of commodities selected for local procurement. For the specific commodities analyzed in this section, a 10% increase in local supply will result in just under $3 million dollars in additional impact on Missouri's economy.

This work shows that it is possible to estimate the return on investment required to increase local supply of specific commodities, assuming there is sufficient local supply. At the sector level, one may be able to decide which commodities to target by comparing their contribution to the local economy and the available local capacity. The approaches of how decision maker chose commodities to target will be discussed in Chapter 4.

3.3.5. Validation Using Analysis-by-Parts. In order to validate the modeling, the Analysis-by-Parts (ABP) method is used to cross-check the model results. The results from both cases will not be identical due to the rounding errors in the simulation. However, such a comparison provides confidence in the model estimates. Figures 3.6-3.9 illustrate the relationship between the deviation (differences between the estimates of the two methods as a percentage of the conventional input-output estimate) and the estimates of impacts (estimated using the conventional input-output approach). In general, all the deviations are very low (less than 0.12%). This level of deviation is negligible.

However, the results show that as the estimated impact increases, the amount of the deviation also increases (bias). The bias appears when the RPCs are modified. This bias is most likely due to the rounding error. When modifying a RPC in ABP analysis, the value of the RPC rounds to two decimal places (the original RPC is displayed in six decimal places) automatically, which lead to an inaccuracy of the reconstructed multiplier. This inaccuracy will cause an error value of the estimated economic impacts; and the error value increases while the final demand increases. Take Figure 3.6 for example. The deviation increases from 0 to 0.08% as the total output increases from a little over $221.3 million to $224.4 million. The percentage deviation for value added, labor income, and employment show a similar relationship (Figures 3.7-3.9).

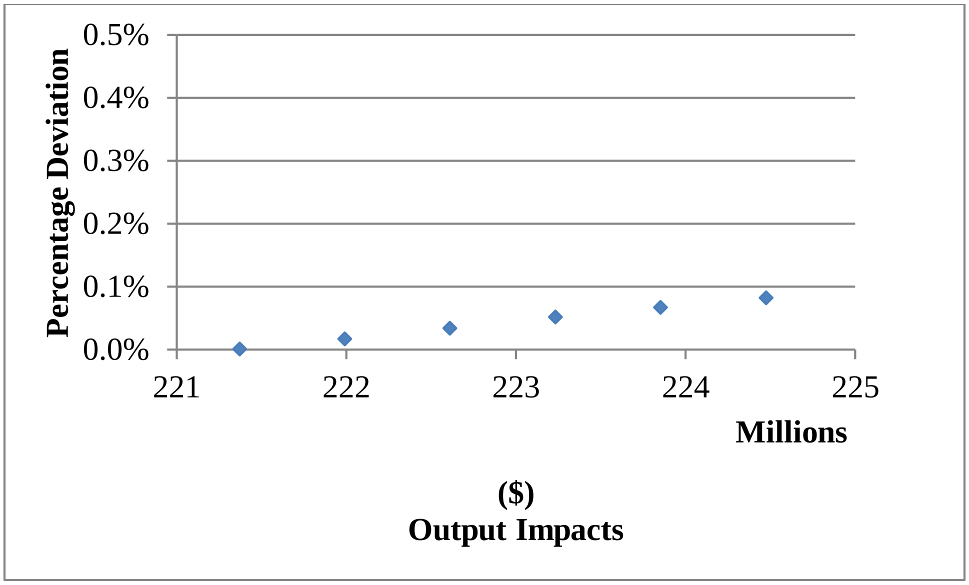

Figure 3.6. Percentage deviation of total output impacts

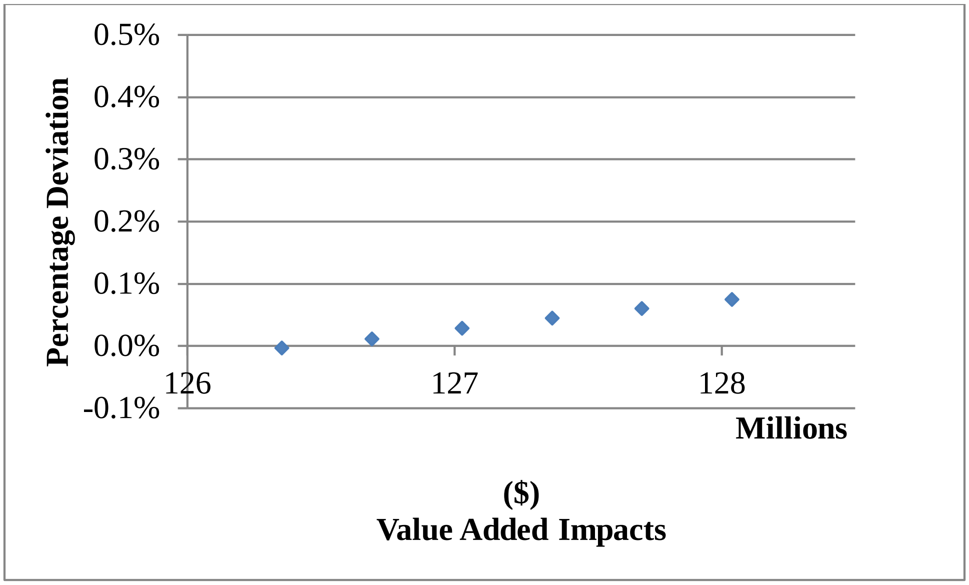

Figure 3.7. Percentage deviation of total value added impacts

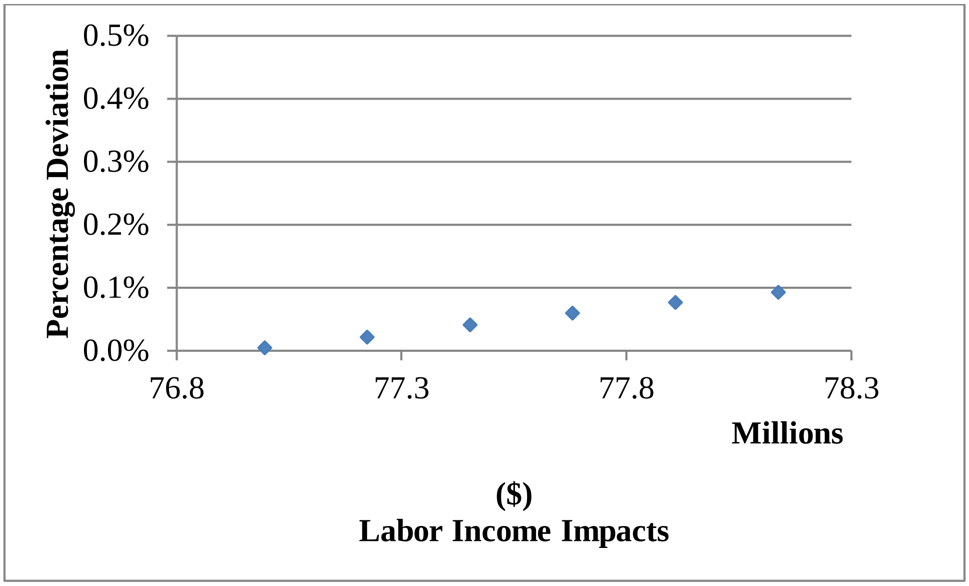

Figure 3.8. Percentage deviation of total labor income impacts

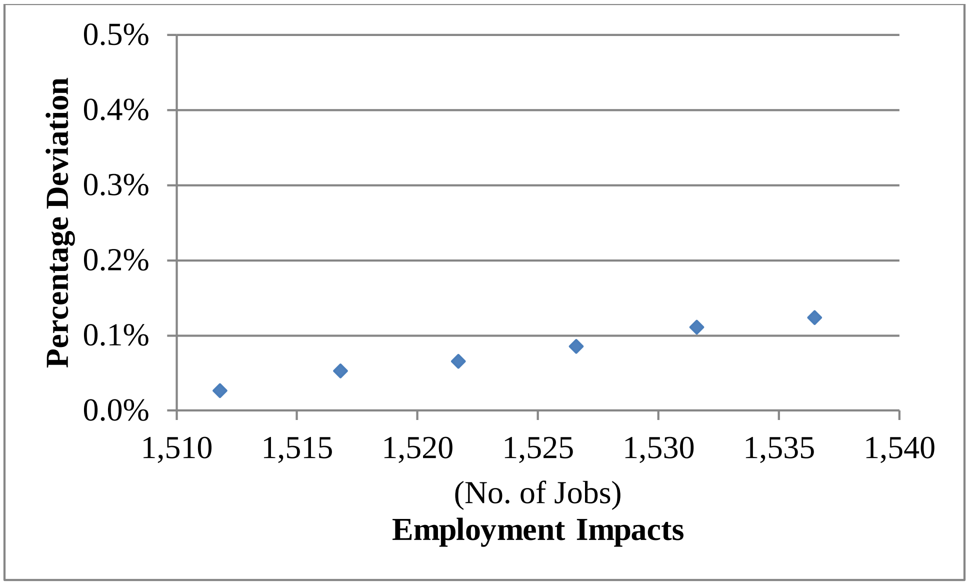

Figure 3.9. Percentage deviation of total employment impacts

3.4. SUMMARY

This chapter illustrates the use of input-output analysis to evaluate the impact of sourcing local products on the regional economy. The stone mining and quarrying industry in Missouri is used as a case study to illustrate the suggested approach. Firstly, ten out of 89 backward commodities are chosen with a broad range of regional purchase coefficients and high multipliers. Local use ratio is used to determine whether the regional purchase coefficient can be increased by 10% or not. Successive scenarios with increasing local sourcing of these 10 commodities are evaluated to determine the impact of increasing local sourcing on regional economic impact. The model results are compared to results using the Analysis-By-Parts (ABP) method to ensure confidence in the model estimates. All scenarios resulting in differences less than 0.12% of the estimated impacts. This is considered acceptable for this kind of analysis.

The simulation results show that, ten percent increase in regional purchase coefficient of all ten chosen commodities results in $2.94 million additional impact on the regional economy: $1.08 million and $1.59 million increase in incomes and value added, respectively. It can be concluded that small increases in local sourcing of backward commodities will enhance local economic impact significantly.

4. A METHOD TO IDENTIFY CRITICAL BACKWARD COMMODITIES OF MINING

4.1. INTRODUCTION

This chapter addresses the second objective of this research, which is to develop a methodology to identify critical backward commodities[4] of a regional mining sector. This chapter proposes two alternative methods for identifying the linkages of a mineral sector that lead to high economic impacts on a regional economy. As in Chapter 3, the stone mining and quarrying industry in Missouri is used as a case study to illustrate the proposed methods.

The degree of local sourcing (which can be estimated, in input-output models, using the regional purchase coefficient) of mining's backward commodities will vary from different regions and depends on the mix of commodities required by different mining sectors. The degree of local sourcing for a commodity varies for sectors or companies located in different regions. It is not possible to provide a universal list of the critical commodities that will have the most effect on the economic impacts in every mining project. For example, a change in the degree of local sourcing of a commodity used by a mining sector may not have the same potential economic impact on Oklahoma's economy as it may have on Missouri's. Companies extracting different mineral resources or operating in different conditions (surface or underground) may require different commodities as well. Evaluating the impacts of each backward commodity (in Chapter 3, a backward commodity was defined as a representative term that represents all commodities, in one industry sector, supplied to the sector under study)

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[4] As used in this thesis, the term "critical backward commodities" means those commodities that are deemed to have the most impact on the regional economy.

of a mining sector or company in a complicated supply chain can be challenging. Input-output analysis (IOA) can help to better understand the effect of a local sourcing supply chain management strategy on regional economies. This chapter presents two methods—based on input-output analysis—which can help in such analysis.

In the first method, IMPLAN simulation is used to evaluate the impacts of each complete local sourcing of backward commodities of a mining sector on a regional economy using input-output analysis. It is assumed that the regional purchase coefficient of all backward commodities equals 1. The impacts of the changes are then used to produce a ranking of the backward commodities, which is used to determine the critical commodities. In the second method, an analytical approach—again based on input-output analysis—is used to estimate the impact of increasing local sourcing of each commodity based on the extra capacity in the regional economy. Similar to the first method, the impacts are used to produce a ranking which is used to determine critical backward commodities. The proposed methods are illustrated with a case study of the Missouri stone mining and quarrying industry.

4.2. IDENTIFYING CRITICAL BACKWARD COMMODITIES

4.2.1. Determining Critical Backward Commodities Using IMPLAN Simulation. To study a supply chain, an analyst first identifies key components or major players, in the chain. Simulation experiments involving changes to the proportion of local supply of backward commodities can be used to evaluate the potential effects of these changes on the local economy. Such analysis can be used to identify the critical backward commodities. Such experiments can be conducted by several widely used input-output models, such as Regional Economic Models, Inc. (REMI) and Impact Analysis for

Planning (IMPLAN). This study uses IMPLAN software and data to model economic impacts of such simulation experiments. This can be done by changing the regional purchase coefficient in each simulation experiment.

The regional purchase coefficient can take values from zero to one. A value of zero means that there is no local supply of the commodity towards the local demand, while a value of one indicates that all local demand for the commodity is purchased locally. The analyst can customize the economic activities and edit a commodity's regional purchase coefficient to create a customized economy (this is synonymous with building a model in IMPLAN or any input-output software). To evaluate the potential impacts of the assumption that all the demand for a particular backward commodity of the customized sector can be purchased locally, the regional purchase coefficients of that commodity is changed to one. This can be done for each backward commodity in turn and the economic impacts estimated with each change. Based on the estimated regional economic impacts after these changes, an analyst will be able to produce a ranked list of the backward commodities. Decision-makers can then decide which backward commodities to target to achieve shared value goals.

Input-output models can be built based on user-defined regions and economies. For example, it is possible for an analyst to define the region to include one or more states when building a model. In the situation of multiple states as one reconfigured study region, the specific mining sector of interest is also a reconfigured sector based on the data among these states. Any activities of this mining sector will impact the economy in the overall study region. The other situation is that it is possible to build multi-region input-output analysis (MRIOA) with unlimited number of linked regions. In this situation, the study region is still the specific state and the linked regions are not considered to be the part of the study region. However, by running the MRIOA, any feedback effects (from the linked regions) that may exist are accounted for in the economic impact estimates. The model captures how the impacts of an activity in one state disperse into the surrounding multi-state area and allows the analyst to see how these stimuli in these surrounding regions create additional effects in the study region.

The proposed method is based on comparison of estimated regional economic impacts of a mining sector after modifying each backward commodity's regional purchase coefficient. After building the input-output model, *n* backward commodities are identified, which means there are *n* modifications of RPC. Each time the RPC is modified, the input-output model should be updated, and the mining sector's multiplier is reconstructed. The change in multiplier can be calculated using the mining sector's original multiplier and its reconstructed multiplier. The algorithm for using input-output analysis to estimate the change in impacts can be found in Eq. 4-1. The increased in the multiplier ($\Delta\mathbf{B}$) will be applied to estimate the change in impacts. Since customizing the mining sector's spending pattern does not change the overall supply of mining products, the final demand (**Y**) is not changed.

$$\Delta\mathbf{X} = \Delta\mathbf{B} \cdot \mathbf{Y} \qquad 4\text{-}1$$

In the algorithm, the process of evaluating economic impacts is repeated for each backward commodity of the mining sector. From the comparison of the impacts, the ranking of all commodities can be produced. The case study in section 4.3.1 is used to illustrate the suggested approach.

4.2.2. Identifying Critical Backward Commodities Using Analytical Estimates. Alternatively, the impact of changes to the local sourcing can be estimated analytically. For someone interested only in estimating the contribution to the regional economy by increased local sourcing that occurs by considering only the available commodity capacity, the process of identifying critical backward commodities will be different from the IMPLAN simulation.

Conceptually, assuming local sourcing is constrained by the existing capacity, there are three terms to consider when identifying critical backward commodities: multiplier, regional purchase coefficient, and local use ratio. As explained in Chapter 3, the multiplier demonstrates the relationship between the initial effect of a final demand change and the total effects resulting from that change. Regional purchase coefficient refers to the proportion of the total demand for the commodity that is supplied by producers located within the region. Local use ratio refers to the proportion of the total local supply of a commodity that is used to meet local demand.

The proposed method uses input-output techniques to estimate the impacts of changes in regional purchase coefficients on the regional economy. Let us assume a backward commodity demanded by a mining sector in the study region can be purchased at the highest regional purchase coefficient. First of all, it is necessary to identify the remaining capacity of the local sources that can contribute to the mining sector. Eq.4-2 shows the portion of final demand (local demand by mining sector) that was imported in the base case.

$$Final\ Demand\ Left\ (FDL) = GD - LD \tag{4-2}$$

Where,

GD is gross commodity demand;

LD is local commodity demand;

FDL refers to the amount of final demand for a commodity that is imported from outside of the study region in the base case. Applying Eq. 3-10, Eq. 4-2 can be written as Eq.4-3.

$$Final\ Demand\ Left\ (FDL) = \frac{1 - RPC}{RPC} \cdot LD \tag{4-3}$$

The amount of local net supply that was for export can be written as Eq.4-4.

$$Capatcity\ Left\ (CL) = LS - LD \tag{4-4}$$

Where,

LS is local net commodity supply;

LD is local commodity demand;

CL can be viewed as the amount of the local supply of a commodity that can be used to supply the portion of the demand that used to be imported (i.e. no more exports or exports are done with additional new capacity). Apply Eq.3-11 to Eq.4-4 and it can be written as Eq.4-5

$$Capatcity\ Left\ (CL) = \frac{LULS}{LUR} - LD \qquad 4\text{-}5$$

When local supply can meet all local demand of a commodity towards the mining industry (i.e. $CL - FDL > 0$), the potential impact increased by this commodity then can be rewritten as Eq. 4-6.

$$Impact\ Increased = FDL \cdot Multiplier(M) = \frac{1 - RPC}{RPC} \cdot LD \cdot M \qquad 4\text{-}6$$

When local supply can only meet part of the local demand of a commodity (i.e. $CL - FDL < 0$), the potential impact can be rewritten as Eq.4-7.

$$Impact\ Increased = CL \cdot Multiplier(M) = (\frac{LULS}{LUR} - LD) \cdot M \qquad 4\text{-}7$$

The notion of multiplier rests on the amount of change in final demand and the total impact of that change. Economic impacts can be estimated using the product of final demand and the multiplier of the commodity, according to input-output theory. Eqs. 4-6 and 4-7 were developed based on input-output theory. The effect of local sourcing of all backward commodities on the regional economy can be estimated using these equations. It is necessary to first determine the demand from the mining sector before deciding whether to apply Eq. 4-6 or 4-7. When there is enough local capacity, the final demand for that commodity equals *FDL*. When the local capacity is not sufficient, the final demand will be equal to the rest of the available local capacity (*CL*) for that commodity.

Based on the analytical method proposed in this section, the potential economic impacts of increased local sourcing of a mining sector's backward commodities can be estimated, analytically.

4.3. CASE STUDY OF MISSOURI STONE MINING & QUARRYING

4.3.1. Using IMPLAN Simulation. To illustrate the proposed approach, Missouri economic data was used, and the input-output model based on Missouri data was built using IMPLAN V3 software. In IMPLAN, there are 89 backward commodities of the stone mining and quarrying sector in Missouri. The regional purchase coefficients of the 89 commodities were generated from the model. Each commodity's RPC was modified to 1 and then the input-output model was updated to reconstruct the multiplier of the stone mining sector based on this modification. Given the reconstructed multiplier, the change in multiplier was calculated. Input-output analysis was used to estimate the increased impacts that stemmed from the stone mining and quarrying sector. The process of this approach was repeated for each backward commodity, as discussed in section 4.2.1.

Table 4.1 shows the change in multipliers and impacts for the 20 commodities with the highest impacts. The full results are contained in Appendix A. The change in multiplier used for the evaluation is the increased stone mining industry multiplier.

Table 4.1. The potential impacts of the top 20 backward commodities of Missouri stone mining and quarrying industry (2012) (IMPLAN modeling system (2012 database))

Code	**Commodity Description**	**Change in Multiplier**[1]	**Impact on Output**[2]
150	Tires	0.0226	$10,768,907
356	Securities, commodity contracts, investments, and related services	0.0180	$8,585,136
25	Natural stone	0.0164	$7,854,507
338	Scenic and sightseeing transportation services and support activities for transportation	0.0163	$7,765,685
170	Iron and steel and ferroalloy products	0.0153	$7,287,672
283	Motor vehicle parts	0.0136	$6,500,693
115	Refined petroleum products	0.0132	$6,286,757
365	Commercial and industrial machinery and equipment rental and leasing services	0.0126	$6,000,713
205	Construction machinery	0.0106	$5,065,698
228	Material handling equipment	0.0104	$4,960,641
31	Electricity, and distribution services	0.0101	$4,825,020
335	Truck transportation services	0.0099	$4,732,856
369	Architectural, engineering, and related services	0.0073	$3,486,010
354	Monetary authorities and depository credit intermediation services	0.0072	$3,433,004
149	Other plastics products	0.0059	$2,808,387
32	Natural gas, and distribution services	0.0053	$2,537,625
21	Coal	0.0053	$2,507,062
206	Mining and oil and gas field machinery	0.0035	$1,685,701
357	Insurance	0.0035	$1,675,195
10	All other crop farming products	0.0035	$1,661,942

[1] The Missouri stone mining and quarrying sector’s base case multiplier is 1.8642.

[2] The Missouri stone mining and quarrying sector’s base case total output is $478 million

It can be concluded from Table 4.1 that changes in local purchase percentage of backward commodities have an effect on the multiplier of the mining sector. This is consistent with the results in Chapter 3, where similar results conclusions were drawn for 10 backward commodities. A ranking of backward commodities can be easily produced based on their effects on the Missouri stone mining sector's multiplier. From Table 4.1, the change in multiplier of the assumption that all the demand for tires (150) can be purchase locally is 0.0226, which is the highest among all commodities. The greater the multiplier increases, the higher the potential impacts the mining sector may create. The 2nd to 11th commodities increase the mining sector's multiplier in the range of 0.010 to 0.018. The rest of the commodities increase the multiplier by less than 0.01, which means those commodities have less impact on the mining sector's multiplier; therefore, they will be less of an impact on the regional economy.

4.3.2. Using Analytical Method. The proposed analytical method presented in Section 4.2.2 and summarized in Table 4.2 (below) was applied to the Missouri stone mining and quarrying sector. Each of the 89 backward commodities was assessed to determine the relationship between *CL* and *FDL*. If both *FDL* and *CL* are nonzero, then there exist potential impacts. Those impacts are estimated using the appropriate model (Table 4.2). If either *FDL* or *CL* equals to zero, there will be no impacts from changing local sourcing of that commodity (either because all the demand is already being met locally or there is no excess capacity locally). The results for the 20 commodities with the highest impacts can be found in Table 4.3. The full results are contained in Appendix B. The multipliers used for the evaluation are industry multipliers corresponding to the commodities based on IMPLAN 2012 data.

Table 4.2. Method of evaluating economic potential impacts of an industry's backward commodities

Local Capacity	**Final Demand**	**Multiplier**	**Impact**
$CL>FDL\neq 0$	FDL	M	$FDL \cdot M = \frac{1-RPC}{RPC} \cdot LD \cdot M$
$FDL>CL\neq 0$	CL	M	$CL \cdot M = (\frac{LULS}{LUR} - LD) \cdot M$
$FDL=0/CL=0$	0	M	$0 \cdot M = 0$

Table 4.3 shows the top 20 commodities' estimated potential impacts and a ranking of the commodities based on their impact. It shows the changes in final demand and the influence it will have on total potential impacts. For instance, tires (150) that were associated with a relatively low multiplier (1.50) can create high potential impacts due to the large amount of change in final demand ($6,824,449). It also can be concluded that commodities such as transportation (i.e. 335 &338) and operational equipment (i.e. 205, 228 & 365), and parts along with them (i.e. 150, 170 & 283) have greater potential impacts than other commodities. Eight out of the first twelve backward commodities belong to the category of transportation and operational equipment.

Table 4.3. The potential impacts of the top 20 backward commodities of Missouri stone mining and quarrying industry (2012) (IMPLAN modeling system (2012 database))

Code	**Commodity Description**	**Change in Final Demand**	**Multiplier**	**Impact on Output**
150	Tires	$6,824,449	1.5048	$10,269,173
356	Securities, commodity contracts, investments, and related services	$4,422,760	1.8908	$8,362,616
338	Scenic and sightseeing transportation services and support activities for transportation	$3,870,340	1.9146	$7,410,203
170	Iron and steel and ferroalloy products	$4,642,193	1.5932	$7,395,801
25	Natural stone	$3,957,490	1.8642	$7,377,469
283	Motor vehicle parts	$4,184,496	1.4773	$6,181,593
365	Commercial and industrial machinery and equipment rental and leasing services	$3,022,343	1.8695	$5,650,121
115	Refined petroleum products	$4,513,072	1.2153	$5,484,723
205	Construction machinery	$3,384,815	1.4140	$4,786,086
228	Material handling equipment	$3,187,939	1.4946	$4,764,540
31	Electricity, and distribution services	$3,415,060	1.3341	$4,555,916
335	Truck transportation services	$2,576,740	1.7303	$4,458,656
369	Architectural, engineering, and related services	$1,753,640	1.8812	$3,298,902
354	Monetary authorities and depository credit intermediation services	$2,093,607	1.5470	$3,238,762
149	Other plastics products	$1,818,731	1.4672	$2,668,416
21	Coal	$1,416,511	1.7100	$2,422,196
32	Natural gas, and distribution services	$1,821,153	1.2704	$2,313,674
206	Mining and oil and gas field machinery	$1,070,821	1.4932	$1,598,965
357	Insurance	$859,997	1.8384	$1,581,002
10	All other crop farming products	$880,936	1.7802	$1,568,213

4.3.3. Discussion. The IMPLAN simulation estimated the impacts assuming that the local capacity is sufficient to supply the mining sector's demand. An analyst is able use this information to develop strategies to build local capacity to meet the demand and estimate the return on investment of the strategies. However, it is not possible to provide a universal list of the ranking of commodities. The critical commodities and their potential impacts will vary from one economy to another. Each mining company should apply the methodology in order to produce a list based on their own situation. The ability of any given mine in any given region to use this methodology in producing their own list of critical backward commodities gives this approach great flexibility and range in its application. One drawback to this method, however, is that the process of reconstructing the multiplier for a given sector in a given region can be time consuming.

The analytical method estimates the impact of increasing local sourcing of each commodity based on the actual capacity in the regional economy. It has some of the same advantages and disadvantages of the simulation approach, as discussed above. For example, the results provide a ranked list of the backward commodities, and decision-makers are able to develop their procurement strategy without exceeding the local capacity to achieve shared value goals. However, compared to the IMPLAN simulation, the analytical method is less time consuming. This is because it is not necessary to reconstruct the entire model for each commodity. Table 4.4 compares the ranking of the top 20 commodities' impacts evaluated by both methods.

Table 4.4. Comparison of top 20 rankings

Rank	**Simulation**	**Analytical Method**
1	Tires (150)	Tires (150)
2	Securities, commodity contracts, investments, and related services (356)	Securities, commodity contracts, investments, and related services (356)
3	Natural stone (25)	Scenic and sightseeing transportation services and support activities for transportation (338)
4	Scenic and sightseeing transportation services and support activities for transportation (338)	Iron and steel and ferroalloy products (170)
5	Iron and steel and ferroalloy products (170)	Natural stone (25)
6	Motor vehicle parts (283)	Motor vehicle parts (283)
7	Refined petroleum products (115)	Commercial and industrial machinery and equipment rental and leasing services (365)
8	Commercial and industrial machinery and equipment rental and leasing services (365)	Refined petroleum products (115)
9	Construction machinery (205)	Construction machinery (205)
10	Material handling equipment (228)	Material handling equipment (228)
11	Electricity, and distribution services (31)	Electricity, and distribution services (31)
12	Truck transportation services (335)	Truck transportation services (335)
13	Architectural, engineering, and related services (369)	Architectural, engineering, and related services (369)
14	Monetary authorities and depository credit intermediation services (354)	Monetary authorities and depository credit intermediation services (354)
15	Other plastics products (149)	Other plastics products (149)
16	Natural gas, and distribution services (32)	Coal (21)
17	Coal (21)	Natural gas, and distribution services (32)
18	Mining and oil and gas field machinery (206)	Mining and oil and gas field machinery (206)
19	Insurance (357)	Insurance (357)
20	All other crop farming products (10)	All other crop farming products (10)

Tires (commodity 150) has the highest potential impacts in both cases, and securities, commodity contracts, investments, and related services (commodity 356) has the second highest potential impacts. In this case (Missouri stone mining and quarrying case study), there are no differences among the first ten commodities, but the ranking order is different. One can choose the mix of commodities selected for local procurement based on their objectives. It can be concluded from the fact that the top 10 linkages are the same for both methodologies that a supply chain management strategy for Missouri stone mining sector that concentrates on these linkages would create the most shared value. However, the commodities identified will vary from one economy to the other.

The stone mining and quarrying industry is vital to Missouri's economy. It contributes approximately $477 million output, annually (Table 3.4). Tire manufacturers, one of the mining sector's backward commodity manufacturing industries, not only are making tires for passenger vehicles but more lucratively for massive earth-moving machinery and vehicles in the mining industry (Retna, 2013); and they are expanding their production due to the demand for mining equipment (Bennett, 2012). For instance, Michelin's heavy tires, which can have rim diameters of more than five feet, are deployed in a variety of equipment, including dump trucks, and can sell for as much as $250,000 each (Bennett, 2012). From the results of this study, tire manufacturing in Missouri can create a change in impact of more than $10 million on Missouri's economy (Table 4.3). Security and related activities deals with finance within an organization. An organization use financial management to oversee and govern its income, expenses, and assets with the objectives of maximizing profits and ensuring sustainability. With a high demand of such financial services by Missouri stone mining sector, there is an estimated $8 million additional impact on Missouri's economy, if Missouri's financial sector can provide all the services. Based on the results of the analytical method, the top ten critical backward commodities of Missouri stone mining and quarrying industry represent approximately $67 million in additional potential impacts, which is a 15% increase in total output of this mining sector, which will occur if local sourcing strategies are successful. This could represent significant gains in shared value for all.

In this work, two methods for identifying critical backward commodities, using two different assumptions, are used to identify critical backward commodities. Figure 4.1 shows that, in most cases, the rankings are similar. However, there are a few notable differences: Computer terminals and other computer peripheral equipment (236), automotive equipment rental and leasing services (362), other computer related services, including facilities management (373), and waste management and remediation services (390). These differences are due to the different assumptions under which the two methods operate. For example, the RPC of automotive equipment rental and leasing services (362) is 81.98%. Assuming the RPC equals one, the impact estimated in the IMPLAN simulation is $296,072 (Appendix A). The multiplier of this commodity is 1.7044. It can be calculated that the increased final demand for this commodity is $173,711. However, applying the analytical method, the final demand (without exceeding local capacity) is $155,569 (Appendix B). The deviation (difference between the estimates of the two methods as a percentage of the analytical method estimate) is 10%. Similarly, the deviations for commodity 373 and 390 are 14% and 17%, respectively. Due to the limited local capacity, the deviations for these commodities are relatively high, which is an important reason of the difference in the rankings.

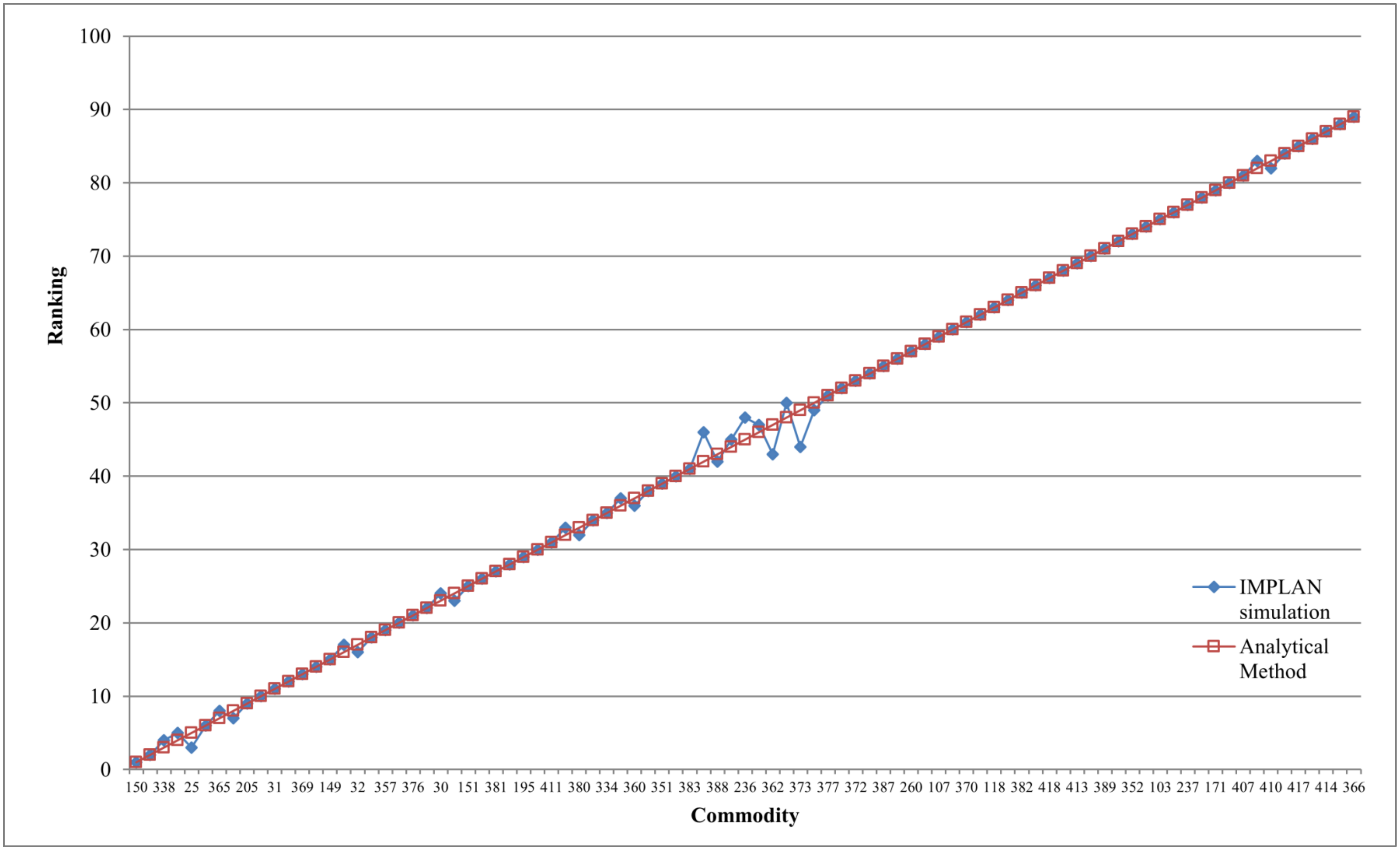

Figure 4.1. Ranking of commodities' impacts in both simulation analyses

An analyst can determine the mix of backward commodities to target for increased local sourcing in order to create shared value by referring to the ranking that best suits the market situation and the supply chain management objectives. For example, in this case study themes relating to equipment (including tires and parts) and transportation are revealed to be important. An industry wide approach to build more local capacity and purchase more locally in these areas could significantly increase the impact of stone mining and quarrying in Missouri. With the approach outlined by this study, industry can be more targeted in developing strategies to build local capacity to meet the demand of the sector and create shared value. When an industry increases its production, the demand for inputs from its supplying industries will increase as well. The return on investment of a specific strategy can also be easily evaluated. This ensures that mines can build strong partnerships with the local community, help and encourage local businesses to meet the mines’ procurement standards in order to develop their businesses and become long term suppliers to the mines, and, therefore, create shared value for all local stakeholders.

4.4. SUMMARY

Identifying backward commodities that can have significant impacts on the regional economy, if a supply chain strategy is implemented to increase local sourcing, is crucial to creating the most shared value with supply chain management for sustainability. This chapter presents two alternative methods to evaluate local capacity of commodities and identify critical backward commodities of a mineral sector that lead to high economic impacts on the regional economy. The stone mining and quarrying industry in Missouri is used as a case study to illustrate the proposed methods. The methods proposed in this chapter are robust. They can be used to evaluate supply chain management strategies in mining. The first method evaluates potential impacts by using IMPLAN simulation. In this method, it is assumed that 100% of the demand for each commodity can be purchased locally (RPC=1). In the second method, critical backward commodities are identified analytically using multipliers and an estimate of excess capacity that can be used to supply the mining sector under study. A case study of the Missouri stone mining and quarrying sector applies both methods to provide a ranking of all 89 backward commodities. These rankings can be used to guide the choice of businesses to partner with to build local capacity to meet sustainable supply chain management objectives.

The results show that the top ten backward commodities are the same for both methods, although the exact rankings differ slightly. The top ten backward commodities are tires, securities and related services, natural stone, scenic and sightseeing transportation services and support activities for transportation, iron and steel and ferroalloy products, motor vehicle parts, refined petroleum products, commercial and industrial machinery and equipment rental and leasing services, construction machinery, and material handling equipment. The two methods differ in cases where the specific commodity’s local capacity is relatively low.

5. CONCULSIONS AND RECOMMENDATIONS FOR FUTURE WORK

5.1. OVERVIEW

The mining industry is dynamic and diverse, and is of critical importance to economic development on many scales including locally, regionally, and domestically. However, there have been claims that mining corporations are operating in ways that place them in positions of short-term economic gain, while ignoring or exacerbating social and environmental concerns around their operations. The phenomenon is a potential liability for mine decision makers. Economic activities that rely on the use of local supply chains will have significant impacts on creating shared value to stakeholders, which can be an efficient approach to help mining companies sustain their social license to operate. However, a review of the literature reveals that limited work has been done to evaluate the potential of supply chains and to effectively identify the key components of the chains in order to create shared value in a sustainable manner. One limited study (Kusi-Sarpong et al, 2014) identifies strategic supplier partnership (SSP) as an influential strategic factor using multi-attribute evaluation tools, but no work has attempted to confirm this approach.

The goal of this research work was to foster understanding of the effect of a strong local supply chain on regional economic impacts of mining. The study has specifically sought to provide unique baseline information, which could be used by the mining industry and public policy makers in devising supply chain management strategies and policies to curb the social and economic impacts associated with the mine. The specific objectives were to:

1. Test the hypothesis that a local procurement strategy by mines in a region, significantly affects regional economy; and
2. Develop a methodology to identify critical backward commodities of a regional mining sector.

To achieve the first objective, an economic analysis was conducted based on input-output analysis (IOA) to evaluate the impacts of local a procurement strategy for a mine's backward commodities on a regional economy. This was conducted to help analysts draw the right inferences about the effect of local sourcing strategy on local economy. Two alternate methods were suggested to achieve the second objective of this study and to identify critical backward commodities that lead to significant impacts. The methods are illustrated with Missouri stone mining and quarrying industry data extracted from IMPLAN databases.

5.2. CONCLUSIONS

The following conclusions are drawn from this work:

- The critical backward commodities of mining sectors can be identified using regional input-output tables. Mining sector's backward commodities significantly affect the mining sector's ability to contribute to a regional economy. The multiplier of a mining sector will increase when its backward commodities' local purchase percentage increases. For the Missouri stone mining and quarrying sector, the multiplier increases 1% for every 2% increase in local purchase percentage of the ten backward commodities chosen in this study.

- The local procurement strategy is found to impact regional economy (regional output, labor income, value added, and employment impacts). There is no effect on the direct impacts because the final demand of mining products does not change based on the spending pattern of the customized industry. For the Missouri stone mining and quarrying sector, however, a 10% increase in the regional purchase coefficient of the ten chosen commodities will cause an additional $2.94 million in total output impacts (indirect and induced impacts). Also, such a change will cause an additional$1.08 million and $1.59 million, respectively, in total impacts for labor income and value added.

- Two valid methods have been proposed in this work to evaluate the potential impacts of all backward commodities under two assumptions. The methods are based on input-output analysis of economic performance. They were illustrated with a case study. The case study gives results of two sets of rankings of backward commodities', which provides directions for mine decision makers in developing their strategies.

- For the Missouri stone mining and quarrying industry, tires (commodity code 150), securities, commodity contracts, investments, and related services (356), and transportation services and support activities for transportation (338) have the highest potential output impacts on Missouri's economy. Commodities related to transportation and operational equipment have the greatest potential impacts.

5.3. RECOMMENDATIONS FOR FUTURE WORK

The following recommendations are made for future work to improve on the present work:

- The theoretical basis for supply chain management needs to be revisited in order to further understand how shared value is created for all stakeholders and how it can be made more socio-economically sustainable.

- This work would be enhanced by creating an input-output model that is dynamic. In future, the dynamic model should be investigated to examine the dynamic relationship between commodity input and economic benefit (e.g. by the customized economic pattern in year *t*, an analyst can estimate the economic pattern in year (*t*-1), which can be useful to understand what needs to be done in year (*t*-1) if you desire a particular outcome in year *t*).

- The proposed method for identifying critical backward commodities can be improved by incorporating rankings by the impacts on labor income, value added, and employment, in addition to the local economic value used in this work. This will provide more information for decision makers.

- Further research is required to enlarge the scale of the study area. To generate achievable policy strategies and development targets with regards to regional supply chains, there is a need for more case studies at the broader regional level to allow further assessment of national dimensions of the subject.

APPENDIX A.

THE POTENTIAL IMPACTS OF THE BACKWARD COMMODITIES OF MISSOURI STONE MINING AND QUARRYING INDUSTRY (2012 IMPLAN SIMULATION)

Code	**Commodity Description**	**Change in Multiplier**	**Impact on Output**
150	Tires	0.0226	$10,768,907
356	Securities, commodity contracts, investments, and related services	0.0180	$8,585,136
25	Natural stone	0.0164	$7,854,507
338	Scenic and sightseeing transportation services and support activities for transportation	0.0163	$7,765,685
170	Iron and steel and ferroalloy products	0.0153	$7,287,672
283	Motor vehicle parts	0.0136	$6,500,693
115	Refined petroleum products	0.0132	$6,286,757
365	Commercial and industrial machinery and equipment rental and leasing services	0.0126	$6,000,713
205	Construction machinery	0.0106	$5,065,698
228	Material handling equipment	0.0104	$4,960,641
31	Electricity, and distribution services	0.0101	$4,825,020
335	Truck transportation services	0.0099	$4,732,856
369	Architectural, engineering, and related services	0.0073	$3,486,010
354	Monetary authorities and depository credit intermediation services	0.0072	$3,433,004
149	Other plastics products	0.0059	$2,808,387
32	Natural gas, and distribution services	0.0053	$2,537,625
21	Coal	0.0053	$2,507,062
206	Mining and oil and gas field machinery	0.0035	$1,685,701
357	Insurance	0.0035	$1,675,195
10	All other crop farming products	0.0035	$1,661,942
376	Scientific research and development services	0.0033	$1,595,447
319	Wholesale trade distribution services	0.0025	$1,212,941
368	Accounting, tax preparation, bookkeeping, and payroll services	0.0024	$1,149,906
30	Support services for other mining	0.0023	$1,098,332
151	Rubber and plastics hoses and belts	0.0019	$906,840
197	Coated, engraved, heat treated products	0.0019	$886,784
381	Management of companies and enterprises	0.0018	$879,621
333	Rail transportation services	0.0018	$858,132
195	Machined products	0.0016	$786,979
367	Legal services	0.0016	$778,861
411	Hotels and motel services, including casino hotels	0.0015	$697,202
380	All other miscellaneous professional, scientific, and technical services	0.0014	$661,387
152	Other rubber products	0.0014	$653,746

Code	**Commodity Description**	**Change in Multiplier**	**Impact on Output**
106	Paperboard from pulp	0.0013	$613,156
334	Water transportation services	0.0013	$610,291
360	Real estate buying and selling, leasing, managing, and related services	0.0012	$592,622
374	Management, scientific, and technical consulting services	0.0012	$586,891
26	Sand, gravel, clay, and ceramic and refractory minerals	0.0011	$529,110
351	Telecommunications	0.0011	$504,755
332	Air transportation services	0.0010	$459,389
383	Travel arrangement and reservation services	0.0008	$367,702
388	Services to buildings and dwellings	0.0007	$325,679
362	Automotive equipment rental and leasing services	0.0006	$296,072
373	Other computer related services, including facilities management	0.0006	$291,774
141	All other chemical products and preparations	0.0006	$291,297
390	Waste management and remediation services	0.0006	$287,954
196	Turned products and screws, nuts, and bolts	0.0006	$282,701
236	Computer terminals and other computer peripheral equipment	0.0006	$272,673
375	Environmental and other technical consulting services	0.0006	$267,898
386	Business support services	0.0006	$265,032
377	Advertising and related services	0.0004	$197,222
315	Gaskets, packing and sealing devices	0.0004	$181,464
372	Computer systems design services	0.0003	$160,452
384	Office administrative services	0.0003	$159,019
387	Investigation and security services	0.0003	$156,632
108	Coated and laminated paper, packaging paper and plastics film	0.0003	$148,514
260	Lighting fixtures	0.0003	$147,081
193	Hardware	0.0003	$138,963
107	Paperboard containers	0.0003	$122,249
355	Nondepository credit intermediation and related services	0.0002	$105,058
370	Specialized design services	0.0002	$81,181
202	Other fabricated metals	0.0002	$76,883
118	Petroleum lubricating oils and greases	0.0002	$76,406
220	Cutting tools and machine tool accessories	0.0001	$66,855
382	Employment services	0.0001	$54,917
337	Pipeline transportation services	0.0001	$54,439
418	Personal and household goods repairs and maintenance	0.0001	$50,141
239	Other communications equipment	0.0001	$46,321

Code	Commodity Description	Change in Multiplier	Impact on Output
413	Restaurant, bar, and drinking place services	0.000096	$45,843
238	Broadcast and wireless communications equipment	0.000085	$40,591
389	Other support services	0.000080	$38,203
20	Oil and natural gas	0.000078	$37,248
352	Data processing- hosting- ISP- web search portals	0.000072	$34,383
425	Civic, social, and professional services	0.000068	$32,590
103	All other miscellaneous wood products	0.000065	$31,040
33	Water, sewage treatment, and other utility services	0.000060	$28,652
237	Telephone apparatus	0.000046	$21,967
416	Electronic and precision equipment repairs and maintenance	0.000041	$19,579
171	Steel products from purchased steel	0.000035	$16,714
247	Other electronic components	0.000026	$12,416
407	Fitness and recreational sports center services	0.000020	$9,551
410	Other amusements and recreation	0.000017	$8,118
313	Office supplies (except paper)	0.000014	$6,685
403	Spectator sports	0.000005	$2,388
417	Commercial and industrial machinery and equipment repairs and maintenance	0.000005	$2,388
39	Maintained and repaired nonresidential structures	0.000002	$955
336	Transit and ground passenger transportation services	0	$0
366	Leasing of nonfinancial intangible assets	0	$0
414	Automotive repair and maintenance services, except car washes	0	$0

APPENDIX B.

THE POTENTIAL IMPACTS OF THE BACKWARD COMMODITIES OF MISSOURI STONE MINING AND QUARRYING INDUSTRY USING ANALYTICAL METHOD (2012)

Code	Commodity Description	Change in Final Demand	Multiplier	Impact on Output
150	Tires	$6,824,449	1.5048	$10,269,173
356	Securities, commodity contracts, investments, and related services	$4,422,760	1.8908	$8,362,616
338	Scenic and sightseeing transportation services and support activities for transportation	$3,870,340	1.9146	$7,410,203
170	Iron and steel and ferroalloy products	$4,642,193	1.5932	$7,395,801
25	Natural stone	$3,957,490	1.8642	$7,377,469
283	Motor vehicle parts	$4,184,496	1.4773	$6,181,593
365	Commercial and industrial machinery and equipment rental and leasing services	$3,022,343	1.8695	$5,650,121
115	Refined petroleum products	$4,513,072	1.2153	$5,484,723
205	Construction machinery	$3,384,815	1.4140	$4,786,086
228	Material handling equipment	$3,187,939	1.4946	$4,764,540
31	Electricity, and distribution services	$3,415,060	1.3341	$4,555,916
335	Truck transportation services	$2,576,740	1.7303	$4,458,656
369	Architectural, engineering, and related services	$1,753,640	1.8812	$3,298,902
354	Monetary authorities and depository credit intermediation services	$2,093,607	1.5470	$3,238,762
149	Other plastics products	$1,818,731	1.4672	$2,668,416
21	Coal	$1,416,511	1.7100	$2,422,196
32	Natural gas, and distribution services	$1,821,153	1.2704	$2,313,674
206	Mining and oil and gas field machinery	$1,070,821	1.4932	$1,598,965
357	Insurance	$859,997	1.8384	$1,581,002
10	All other crop farming products	$880,936	1.7802	$1,568,213
376	Scientific research and development services	$806,050	1.8680	$1,505,709
319	Wholesale trade distribution services	$691,797	1.6536	$1,143,951
30	Support services for other mining	$568,246	1.9183	$1,090,050
368	Accounting, tax preparation, bookkeeping, and payroll services	$633,030	1.7120	$1,083,719
151	Rubber and plastics hoses and belts	$601,430	1.4299	$860,008
197	Coated, engraved, heat treated products	$551,218	1.5427	$850,366
381	Management of companies and enterprises	$441,430	1.8806	$830,146
333	Rail transportation services	$475,372	1.7074	$811,638
195	Machined products	$453,275	1.6663	$755,283
367	Legal services	$433,434	1.6949	$734,644
411	Hotels and motel services, including casino hotels	$398,235	1.6518	$657,820
152	Other rubber products	$417,716	1.4992	$626,241
380	All other miscellaneous professional, scientific, and technical services	$379,229	1.6455	$624,037

Code	Commodity Description	Change in Final Demand	Multiplier	Impact on Output
106	Paperboard from pulp	$344,370	1.7087	$588,413
334	Water transportation services	$355,228	1.6088	$571,483
374	Management, scientific, and technical consulting services	$294,410	1.8868	$555,489
360	Real estate buying and selling, leasing, managing, and related services	$415,745	1.3335	$554,413
26	Sand, gravel, clay, and ceramic and refractory minerals	$249,996	1.9163	$479,072
351	Telecommunications	$298,056	1.5965	$475,843
332	Air transportation services	$292,569	1.4669	$429,180
383	Travel arrangement and reservation services	$196,706	1.7622	$346,634
390	Waste management and remediation services	$201,232	1.6742	$336,902
388	Services to buildings and dwellings	$187,560	1.6392	$307,452
141	All other chemical products and preparations	$177,001	1.5678	$277,501
236	Computer terminals and other computer peripheral equipment	$163,397	1.6790	$274,338
196	Turned products and screws, nuts, and bolts	$177,711	1.5336	$272,540
362	Automotive equipment rental and leasing services	$155,569	1.7044	$265,151
386	Business support services	$134,851	1.8616	$251,043
373	Other computer related services, including facilities management	$153,520	1.6341	$250,871
375	Environmental and other technical consulting services	$120,634	1.9003	$229,239
377	Advertising and related services	$106,427	1.6816	$178,967
315	Gaskets, packing and sealing devices	$111,013	1.5690	$174,176
372	Computer systems design services	$72,006	2.1295	$153,339
384	Office administrative services	$74,912	2.0005	$149,865
387	Investigation and security services	$81,135	1.8207	$147,724
108	Coated and laminated paper, packaging paper and plastics film	$96,632	1.4701	$142,058
260	Lighting fixtures	$91,003	1.5423	$140,355
193	Hardware	$88,449	1.5029	$132,929
107	Paperboard containers	$76,413	1.5156	$115,813
355	Nondepository credit intermediation and related services	$50,751	2.0255	$102,797
370	Specialized design services	$45,084	1.6877	$76,088
202	Other fabricated metals	$50,685	1.4680	$74,406
118	Petroleum lubricating oils and greases	$57,167	1.2709	$72,655
220	Cutting tools and machine tool accessories	$39,644	1.6260	$64,461
382	Employment services	$28,942	1.7884	$51,761
337	Pipeline transportation services	$26,400	1.9539	$51,583

Code	Commodity Description	Change in Final Demand	Multiplier	Impact on Output
418	Personal and household goods repairs and maintenance	$28,345	1.6771	$47,537
239	Other communications equipment	$26,179	1.7289	$45,261
413	Restaurant, bar, and drinking place services	$24,878	1.7411	$43,316
238	Broadcast and wireless communications equipment	$24,990	1.5276	$38,174
389	Other support services	$22,560	1.6815	$37,935
20	Oil and natural gas	$20,434	1.7724	$36,218
352	Data processing- hosting- ISP- web search portals	$21,176	1.5134	$32,048
425	Civic, social, and professional services	$13,700	2.2441	$30,744
103	All other miscellaneous wood products	$15,691	1.9453	$30,523
33	Water, sewage treatment, and other utility services	$15,313	1.6718	$25,600
237	Telephone apparatus	$14,997	1.4178	$21,263
416	Electronic and precision equipment repairs and maintenance	$10,991	1.6891	$18,565
171	Steel products from purchased steel	$10,812	1.4809	$16,012
247	Other electronic components	$6,821	1.7268	$11,778
407	Fitness and recreational sports center services	$4,819	1.8637	$8,981
313	Office supplies (except paper)	$5,327	1.5000	$7,991
410	Other amusements and recreation	$4,482	1.7545	$7,864
403	Spectator sports	$1,260	2.0242	$2,551
417	Commercial and industrial machinery and equipment repairs and maintenance	$1,383	1.6889	$2,336
39	Maintained and repaired nonresidential structures	$753	1.3538	$1,019
414	Automotive repair and maintenance services, except car washes	$0	1.7897	$0
336	Transit and ground passenger transportation services	$0	1.2077	$0
366	Leasing of nonfinancial intangible assets	$0	1.7364	$0

APPENDIX C.

DEFINITIONS OF INPUT-OUTPUT RELATED TERMS (IMPLAN GLOSSARY)

Activity	A grouping of one or more events that represent a related spending change within the study area. Six types of activities are available. These fall into three main categories: production by industry (industry, construction, retail), production of goods and services (commodity), and institutional spending (household, labor income).
Commodity	A commodity is a product or service. It may be produced by one or by many industries. Commodity output represents the total output of the product or service, regardless of the industry that produced it.
Consumption	Consumption is an activity in which institutional units use up goods or services. Consumption can be either intermediate or final.
Direct effects	The set of expenditures applied to the predictive model (i.e., I/O multipliers) for impact analysis. It is a series of (or single) production changes or expenditures made by producers/consumers as a result of an activity or policy. These initial changes are determined by an analyst to be a result of this activity or policy. Applying these initial changes to the multipliers in an IMPLAN model will then display how the region will respond, economically to these initial changes.
Employee	An employee is a person who enters an agreement, which may be formal or informal, with an enterprise to work for the enterprise in return for remuneration in cash or in kind.
Employment multipliers	I-O multipliers used to estimate the total number of jobs (both full-time and part-time) throughout the economy that are needed, directly and indirectly, to deliver $1 million of final demand for a specific commodity.
Exports	A component of final uses that measures goods and services that are produced in the United States and sold to the foreign sector. They are valued at f.a.s. (free alongside ship), which is equivalent to purchasers' value at the U.S. port of export. The definition of exports in the U.S. international transactions accounts differs slightly from that in the National income and product accounts (NIPAs) and I-O accounts, primarily in the treatment of trade in nonmonetary gold and of trade involving U.S. territories.
Final demand	The value of goods & services produced and sold to final users (institutions) during the calendar year. This value is also equivalent to the direct effect of the impact.
Gross	The term gross is a common means of referring to values before deducting consumption of fixed capital; all the major balancing items in the accounts from value added through to saving may be recorded

	gross or net.
Gross domestic product (GDP)	The market value of the goods and services produced by labor and property located within the borders of the United States.
Households	Residents of the study area. Final users of non-durable goods and services.
Indirect effects	The impact of local industries buying goods and services from other local industries. The cycle of spending works its way backward through the supply chain until all money leaks from the local economy, either through imports or by payments to value added. The impacts are calculated by applying direct effects to the Type I multipliers.
Induced effects	The response by an economy to an initial change (direct effect) that occurs through re-spending of income received by a component of value added. IMPLAN's default multiplier recognizes that labor income (employee compensation and proprietor income components of value added) is not a leakage to the regional economy. This money is recirculated through the household spending patterns causing further local economic activity.
Industry	A group of establishments engaged in the same or similar types of economic activity.
Labor income	All forms of employment income, including employee compensation (wages and benefits) and proprietor income.
Local use ratio (LUR)	The proportion of local net supply of a commodity that goes to meet local demands. It is calculated by dividing local use of local supply by local net commodity supply. Local net commodity supply is the amount of total local commodity supply that is used domestically (i.e., total local commodity supply less foreign exports).
Multipliers	Total production requirements within the study area for every unit of production sold to final demand. Total production will vary depending on whether induced effects are included and the method of inclusion. Multipliers may be constructed for output, employment, and every component of value added.
Output	The value of industry production. In IMPLAN, these are annual production estimates for the year of the data set and are in producer prices. For manufacturers this would be sales plus or minus change in inventory. For service sectors production is equal to sales. For retail and wholesale trade, output is equal to gross margin not gross sales.

Regional purchase coefficient (RPC)	The proportion of the total demand for a commodity by all users in the study area that is supplied by producers located within the study area.
Value added	The difference between an industry's or an establishment's total output and the cost of its intermediate inputs. This is equal to the gross output minus intermediate inputs.

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