Evaluating the Economic Impact of Improvements in Freight Infrastructure

An Input-Output Approach

BY

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To my wonderful parents

for their commitment to my education

and their love and support.

ECHG

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SUMMARY

This study attempted to create and demonstrate a new approach for examining the broad economic impacts resulting from transportation infrastructure improvements using existing input-output techniques. The tools used in this study are staples of many analysts; however, some of these techniques are seldom used within the field of transportation. The combination of these tools has helped to address some of the short comings of existing tools available to the transportation analyst.

The necessity for this project is documented by the Benefit/Costs estimation tool developed by The Federal Highway Administration. This is a spreadsheet-based tool to capture relationships using cost benefit analysis. However, the tool failed to consider the benefits beyond those realized by the freight industry and their customers. The reorganization of freight logistics could have a profound impact on the structure of the economy, beyond those who participate directly. This shortcoming is acknowledged within the literature published by the Federal Highway Administration, which recognizes that freight benefits typically can be organized into three different categories. Yet, the tool they developed is only able to capture two of the three categories.

Input-output analysis is a common tool used to evaluate the economic impact of various plans, projects and developments. The most common method of analysis is the use of multiplier or impact analyses. Other techniques such as field of influence analysis are less typically used by practitioners, but are accepted by academics. Using input-output analysis and extensions will help to gain a stronger understanding of the many impacts that result from improvement to freight infrastructure by comparative analyses

using a baseline and an updated scenario. In this study this will be accomplished by focusing on the economy of the Chicago metropolitan area. The construction and modification of input-output tables used in this thesis was completed using two widely available computer programs called IMPLAN and PyIO.

The Chicago metro area IMPLAN 2001 input-output matrices were left unaltered for the baseline scenario. A copy of the original input-output matrices was adjusted using the RAS method to create a second economic structure that is called the updated scenario throughout this thesis. This second scenario was created by determining a potential increase in trucking demand. This was accomplished using projected travel times from the Chicago Area Transportation Study's (CATS) 2020 Regional Transportation Plan and the U.S. Central region elasticity rate reported by the Federal Highway Administration. This newly calculated increase in demand was used to calculate an increase in trucking output, which could then be used to mechanically update the direct requirements matrix using the RAS method.

Baseline and updated tables are analyzed using two approaches. Approaches that attempt to quantify a given change, namely impact and multiplier analysis were used toward this end. Additionally, two methods from the broad field of input-output linkage analysis were included to evaluate structural change. These two methods are known as field of influence analysis and key sector analysis.

1. INTRODUCTION

1.1. Background

Freight transportation is a vital service to the economy of the United States. Nationwide employment in transportation sectors accounts for a significant portion of total employment. This is especially true in the Chicago region, which has played the role of freight hub for the entire nation for well over a century. In 2002, 10.5 percent of total employment in the Chicago metropolitan region was in transportation sectors (Chicago The Workforce Boards of Metropolitan 2005). Both nationally and in the Chicago region freight transportation is literally a driving force in the economy because of the reliance of other sectors on moving goods. In 2008, the nationwide transportation sector accounted for just fewer than eight million jobs, approximately 5.8 percent of total employment, a significantly lower percentage than the Chicago area (Kawamura, Sriraj and Lindquist 2009). The transportation network is not only important because it provides an economic base and employment, but also because it is a service that is utilized to some extent by most sectors in the economy (Kawamura, Sriraj and Lindquist 2009). In this sense the transportation sector can act as both an end and a means of economic development. Nationally, freight use has already increased significantly: from 1975 to 1997, total intercity tons increased by 60 percent for all modes. Of this figure, air and truck transportation experienced the fastest growth rates. Additionally, in 2004 the Federal Highway Administration projected freight use to increase by 70 percent by the year 2020 (U.S. Department of Transportation, Federal Highway Administration 2004).

Although it may be taken for granted, research has demonstrated that there are obvious economic implications of the quality of transportation infrastructure (Dev Bhatta and Drennan 2003); however, a causal relationship has not been firmly established in the literature. There is clearly a critical relationship between transportation and the rest of the economy, an appropriate method of quantifying this link is much less obvious.

Much of the available analysis of the economic impact of freight transportation focuses on the direct benefits in terms of cost savings to freight providers and freight users; it does not take a holistic approach by investigating the broader impacts of improvement of freight transportation to the general economy. A common approach to evaluating freight projects is using employment multipliers and impact analysis that focuses largely on the effects of infrastructure construction (Dev Bhatta and Drennan 2003). As an example, Impact analysis for the 2020 Regional Transportation Plan has already been conducted using direct, indirect and induced measures. The analysis estimated that the plan would have an impact of between $668,999,229 and $1,012,789,130 in 1997 dollars (Seetharaman, Kawamura and Dev Bhatta 2003).

1.2. Problem Statement

Even though it has been demonstrated that transportation is a vital piece of the economy in terms of importance and employment, these figures do not capture the entire impact of freight on the wider economy. More advanced econometric techniques should be used to delve more deeply into the broader impacts of freight transportation (Kawamura, Sriraj and Lindquist 2009).

To this effect, the Federal Highway Administration has recently published *The Highway Freight Logistics Reorganization Benefits Estimation Tool,* which divides the economic benefits of freight transportation into three orders. Benefits of freight delivery occur when the quality of freight services improves, which can be the result of lower costs, quicker delivery, better information, and greater connectivity. These benefits can be divided into three orders. First order benefits occur when the cost of transportation services decreases and the new surplus created is treated as profit. When the cost of transportation services decreases and freight customers change their practices to maximize these benefits, in this situation these benefits are called second order benefits. Third order benefits occur when there is a substantial change to the actual product, the quality of the product or the demand for the product (U.S. Department of Transportation, Federal Highway Administration 2004) (Kawamura, Sriraj and Lindquist 2009).

The many ways that improvements in freight services improve can be categorizes into two different types of improvements, performance improvements and cost improvements. Performance improvements are those where delay is reduced by some means. Performance improvements are essentially a reduction in delivery time. The second form of improvement is cost reduction. Cost reduction of freight services can result from several stimuli, such as introduction of new technology to freight providers, an increase in fuel efficiency or lower fuel prices.

A 2008 report published by the Federal Highway Administration found an elasticity of demand of 0.0175 for freight services caused solely by a delay reduction in the central region. In this case, “central region” is defined as 18 transportation corridors dispersed throughout 12 states (HDR|HLB Decision Economics Inc. 2008). A recreated table listing these corridors is included as Table VIII of Appendix A. Delay reduction is a performance measurement of freight. Delay can be reduced in several ways, including improved infrastructure. In application this figure means that if transportation delay in the central region decreased by 10 percent, then demand would increase by a rate of 0.17 percent. Since this figure is based on the longitudinal observations of the relationship between trucking activity and congestion levels along 30 major corridors in the United States, it is considered to capture the long-run responses, i.e. first, second and third order benefits. There is also an increase in demand for freight services as prices decrease. The same report found that elasticity related to price is much greater at 0.92 for the central region; however, this number is based many factors such as the cost of inputs, like gasoline which fluctuate.

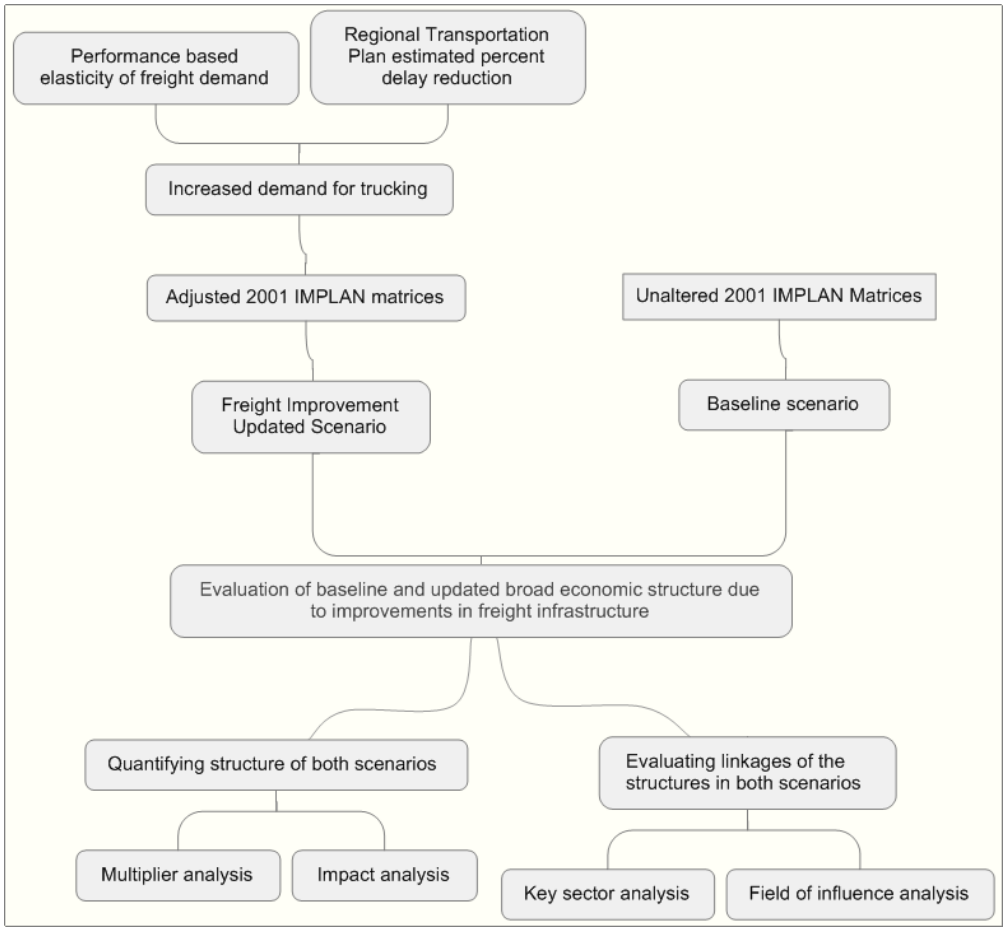
These typologies describing orders of improvement to the freight industry and elasticities of changes to the delivery of freight services are useful only in so far as they are measurable. To this effect, the Federal Highway Administration developed a spreadsheet-based tool that attempts to capture these relationships using cost benefit analysis. The scope of this tool is exceedingly narrow. The benefits considered in the Highway Freight Logistics Reorganization Benefits Estimation Tool are only those benefits realized by the freight industry and their customers. To this extent, the

only costs and benefits weighed are those which are directly related to freight services; in reality, the reorganization of freight logistics could have a profound impact on the structure of the economy, not just those who participate directly as either producer or consumer of freight. Despite the recognition of a third order benefit, the Highway Freight Logistics Reorganization Benefits Tool is unable to capture many third order benefits because it focuses solely on information which pertains only to first and second order benefits (HDR|HLB Decision Economics Inc. 2008).

This project attempts to address the third order benefits that are absent from the Federal Highway Administrations Freight Benefits Tool. In this instance, third order benefits can be described as the change in technology mix of production spurred by delay reduction. For the purposes of this thesis, delay reduction is based on conformity analysis results from the 2020 Regional Transportation Plan that is attributed to capital improvement projects projected to greatly expand expressways. The analysis supposes that there were an increase in demand for trucking services in 2001 due to delay reduction, as projected by the 2020 Regional Transportation Plan. This assumption is necessary for integrating delay reduction into the available 2001 input-output tables. However, this assumption also relegates this research strictly to a theoretical study.

The 2020 Regional Transportation Plan included 20 capital improvement projects with a price tag of $12.4 billion and was scheduled to be implemented over the course of 23 years. Using input-output analysis and extensions will help to gain a stronger understanding of the many impacts that result from improvement to freight

infrastructure. This will be accomplished focusing on the economy of the Chicago metropolitan area and the Chicago Area Transportation Study's 2020 Regional Transportation Plan. The design of this analysis is illustrated below in Figure 1.



Project Design

Figure I

2. LITERATURE REVIEW

2.1. Input-Output Analysis

Input-output analysis is the term for the model developed by Wassily Leontief in the 1930s. Several decades later, Dr. Leontief was awarded the Nobel Prize in Economic Sciences in 1973 for his efforts developing input-output analysis. Leontief was able to articulate and organize concepts about economic structure and analysis that preceded him for decades. Most influential of these works included Francois Quesnays' *Tableau Economique* first published in 1758 and Léon Walras' 1874 theory of general equilibrium published in his work *Elements of Pure Economics* (Stone 1986). A set of Soviet balance sheets created in the 1920s published in *Foundations of Soviet Strategy for Economic Growth* by P. I. Popov were influential when Leontief studied in the U.S.S.R. (Polenske and Skolka 1974). These documents are frequently considered to be precursors to modern input-output analysis (Miller and Blair 1985).

The proliferation of computers has increased the accessibility of input-output tables and tools for analysis. Input-output analysis is used widely within the planning, economics and regional sciences fields. In the decades since the original input-output tables were published by Dr. Leontief, many methods have been developed to update and hone the quality of input-output tables. Meanwhile, other methods, usually called extensions, have been created to add different types of analysis to the input-output model (Dietzenbacher and Lahr 2001).

Input-output tables are attempts to approximate the economy, focusing largely on inter-industry relationships. Input-output analysis has a defined region, usually national,

state or local. The model also has a set duration, which is most typically one year. The foundation of an input-output table is the transactions table. The transactions table is a square matrix in which each sector is included both in a column vertically and a row horizontally. The transactions table can be read two ways: if read horizontally the output row shows the sales made by a given industry to other industries, and if read vertically the input column gives the purchases of a given industry (Miernyk 1965).

Whereas the transactions table is made up of sectors that consume input and produce output, there are typically several rows that depict value added, taxes, imports, wages and total outlay in varying degrees of detail below the transactions table. To the right of the transactions matrix is the final demand section of the input-output table, which includes columns covering exports, government purchases, investments and households. These final demand columns, like the value added rows, also vary in terms of the level of detail shown. The values for all sections of the input-output table are given in some format of dollars, most often millions (Miernyk 1965).

After the input-output table is created it is possible to produce a direct requirements matrix (also referred to as the technical coefficient matrix, the technology matrix, the a-matrix and the direct coefficients). The direct requirements matrix is calculated only for the transactions table portion of the input-output table. The direct requirements matrix represents the amount of additional input from each other sector that a given sector needs to purchase to produce an additional dollar worth of output. The direct requirements matrix can be produced by dividing all entries in each sector column by that column's respective adjusted gross output (Miernyk 1965).

The direct requirements matrix illustrates the additional inputs necessary to fulfill an additional one dollar's worth of output; however, the direct requirements will themselves require increased inputs. These secondary changes can be calculated to produce the total requirements matrix. There are two methods to create the total requirement matrix: the iterative method and the use of matrix algebra. The iterative method is calculated in a number of rounds, where the impact of each round is calculated for each industry (Miernyk 1965). To calculate even a few rounds with relatively few industries can be quite time consuming. To calculate on a large table with many rounds of impact requires a significant investment of time. The second method expedites the process by computing an inverse matrix. The inversion method is usually refered to as the Leontief inverse matrix. The total requirements matrix includes both direct and indirect requirements for a given industry (Miller and Blair 1985).

2.1.1. Regional Input-Output Analysis

Regional input-output analysis operates largely in the same fashion as (national) input-output analysis; however, it is worth noting that they are slightly different. One of the first uses for input-output analysis was the assessment of the sectoral impacts of transitioning out of World War II (Stone 1986). For this purpose national level analysis sufficed. Since its inception, input-output analysis has been adapted to fit many different forms of economic analysis, including regional analysis. Although national level input-output data are necessarily derived from regional data—to the extent that everything occurs somewhere—there is potential for significant deviation between

regional and national level data. These deviations are primarily the result of two factors. First, the necessary inputs may vary widely from one region to another. This is especially true with minimal sectoral aggregation. A second important distinction between regional and national level input-output analysis is the impact of imports. Generally speaking, the larger the area the less reliant it will be on imports, as more demand can be satisfied from supply within the region (Miller and Blair 1985).

2.1.2. Assumptions of the Input-Output Model

Within any modeling system it is necessary to make certain assumptions to simplify the modeling process; input-output modeling is no exception. The input-output model is based on several assumptions, including that the model is a static representation of the economy and technical coefficients are presumed to be fixed. The model assumes that there is a constant return to scale throughout the entire economy (Miernyk 1965).

The input-output model also assumes that output is consistent across industries that often have been highly aggregated and across varying regions because the production functions within the input-output model are fixed. In reality, we know that substitution is used widely throughout the production process. Additionally, the input-output model is based solely on backward linkages (Christ 1955). We also know that supply does not necessary equal demand; however, the equilibrium condition of input-output analysis assumes that this is the case (Schaffer 1980).

2.1.3. Multiplier Analysis

After the construction of input-output tables is complete there are many possible uses. One of the most common uses is multiplier analysis. There are three common multiplier types: output multipliers, income multipliers and employment multipliers. Output multipliers are useful to determine the effects of investment spent on output. The greater the output multiplier the greater the impact of each subsequent dollar spent in that sector. Income multipliers are a measurement of the impact that a change in final demand would have on wages for households. Finally, employment multipliers are an attempt to measure the connection between output value and employment in numbers (not wages) within a sector (Miller and Blair, 1985). Output multipliers are calculated as the column total of the Leontief inverse matrix. The Leontief inverse is given as $B = (b_{ij})$ and the output multiplier is given as O_j and can be found by calculating $O_j = \sum_{i=1}^{n} b_{ij}$ (Miller and Blair 1985).

A common criticism of multiplier reports is that they exaggerate. As Oosterhaven and Stelder have shown, if one were to conduct multiplier analysis for each sector in the economy and include direct, indirect, induced and perhaps other types of multipliers, the result will provide an estimate that is several times larger than the entire economy (Oosterhaven and Stelder 2002). It is problematic that there is significant overlap between various multipliers. However, the use of this tool by many professionals and academics is expansive. Multipliers are most useful when taken with a grain of salt.

2.1.4. Impact Analysis

Impact analysis is a common method for evaluating the effects that a hypothetical change will have on the economy. Impact is measured in terms of final demand. Impact analysis will require an estimate of change in demand for at least one sector. Essentially, impact analysis takes a given change or changes and multiplies the final demand change by its respective cell in the total requirements matrix. The formula to compute impact analysis is included below (Nazara, et al. 2003).

$$X = (I - A)^{-1}F \text{ where } X = \text{output}, (I - A)^{-1} = \text{The Leontief Matrix}, F = \text{Final Demand}$$

Impact analysis is now a commonly used tool by professionals. It is uncommon not to hear about the potential impacts of a proposed project in recent planning documents. One important note about impact analysis is that it is based on output, but often the largest change is due to construction or other short-lived event with a finite time span. Generally speaking, impact analysis is not a tool for long-term projections. Projecting over a short period is one criticism with impact analysis. A second problem with impact analysis is that generally the results are positive, more often than not to illustrate the benefit of a given project. This can be problematic because it may obscure alternative uses for funds or comparisons between different projects. However, impact analysis is a common and useful tool when the implications are understood. These are not fundamental problems of input-output analysis, but rather an example of criticism often made due to the poor use of the model.

2.1.5. Input-Output Criticism

Like all models, the input-output model is imperfect. Two of the most glaring issues with input-output analysis are issues of practicality. The construction of input-output tables is a difficult task. The process requires a significant amount of data which is a challenge to obtain in and of itself. Additionally, the data collection and table creation period usually results in a table that is approximately five years old when it is first published (Planting and Guo 2002). The lag time and generalization of sectors have historically been cited as reasons that input-output analysis has been much more widely accepted for academic work than applied use (Gols 1974). More recently the model has received some criticism for the adoption of applied input-output analysis that overestimates the true impact of a given project (Oosterhaven and Stelder 2002).

Much criticism has been made on several bases. First, the input-output model assumes that technical coefficients are fixed. Second, the model does not allow for substitution within production. Third, aggregation is a convenience that often combines dissimilar establishments that may or may not produce similar items. While there is a significant amount of criticism that has been made about input-output analysis, the input-output transactions table has been less criticized. Several economists, including Milton Friedman, believe that the transactions table does a good job of illustrating the structure of the economy, but that conducting analysis based on these tables would create dubious results given the assumptions that are necessary (Christ 1955).

2.2. Input-Output Extensions

The original constraints of the input-output model have been addressed to some extent by advances in the field. There is now a more diverse set of tools available to the input-output analyst. A broader definition of input-output analysis now includes additional tools of analysis, usually called frontiers or extensions. Although these new additions to input-output analysis include their own limitations, they have addressed some of the initial concerns regarding input-output analysis. In tandem with increased computing capacity these tools have significantly increased interest in input-output analysis since the 1990s (Dietzenbacher and Lahr 2001).

2.2.1. Input-Output Updating Techniques

One solution to issues regarding timeliness or accuracy of regional input-output data availability has been through partial or non-survey methods used to update input-output tables. The two most common methods are the location quotient and the RAS methods (Lahr 2001). Because the location quotient method is primarily used to adapt national tables for regional use it will not be discussed further, as this thesis uses regional data from the onset.

2.2.2. Ratio Allocation System

The RAS method is sometimes referred to as the Ratio Allocation System or the bi-proportional method. It is a widely used method for the updating and balancing of input-output tables (Nazara, et al. 2003) (MIG, Inc. 2004). Although several authors have observed that the RAS name matches the initials of the creator, Richard A. Stone,

the name is actually due to the formula used in the RAS method. The method is an iterative process that attempts to balance a given table, which can be used for many applications. In fact, the same basic procedure was developed independently in the 1930s for traffic planning, in the 1940s for demographics and by the 1960s Stone modified the formula for use with input-output tables (Planting and Guo 2002). The iteration is conducted using the following formula.

$$A^t = [R][A^0][S]$$

Applied to the following

$$\sum_j^n r_i \, x_{ij}^0 s_j = u_i^t \text{ and } \sum_i^n r_i \, x_{ij}^0 s_j = v_j^t$$

[R] and [S] are diagonal matrices from row- and column-oriented multipliers represented by r_i and s_j. A^t is the updated direct requirement matrix and A^0 is the original direct requirement matrix. x_{ij}^0 is intermediate demand for i commodity and j industry. u_i^t is the total intermediate output vector and v_j^t is the total intermediate input vector (Jalili 1998). A modified RAS method exists in which known inter-industry cells may be replaced with a zero before the calculation and replaced with the known value following the procedure. As evident in the formula the RAS method adjusts both rows and columns of data (Miller and Blair 1985).

Because the RAS method is a mechanical tool to update input-output tables, there has been significant discussion of the validity of the technique. The quality of data used to update input-output tables is a determining factor in the validity of results. One example of such is analysis conducted by Lecomber in 1969 and 1975. In the 1969 article *RAS Projections When Two or More Matrices are Known* found significant error;

however, by 1975 Lecomber published *A Critique of Adjusting, Updating and Projecting Matrices*, in which he found that the method was able to produce much more accurate results when expert information had been incorporated using the modified RAS system (Planting and Guo 2002).

One widely accepted notion about the RAS method is that the results are as relevant as other more complex methods such as quadratic or linear programming (Planting and Guo 2002). The RAS technique is used widely to regionalize national input-output tables and update benchmark tables using limited new data. IMPLAN uses the RAS technique several times when creating local level input-output data (MIG, Inc. 2004). Although the accuracy of updating input-output tables varies, RAS and other mechanical updating techniques remain useful tools when input-output tables are out of date and no other method is available. Because input-output tables require a significant investment of time and money and are updated only periodically, the criticisms of the RAS technique are less severe because constructing a new table is likely not feasible and using out of date tables might pose their own problems.

2.2.3. Linkage Analysis

In the 1950s a group of economic linkage analyses began to emerge with publications by Rasmussen (1957) and Hirschman (1958). The intention of linkage analysis is to identify the impact of a given sector on any other given sector (Kawamura, Sriraj and Lindquist 2009). Unlike analysis such as impact analysis, which estimates

the amount of money generated by a change in demand, linkage analysis is focused on the structure of the economy.

2.2.3.1. Field of Influence

Field of influence analysis was developed by Michael Sonis and Geoffery Hewings and first presented in their chapter titled *Fields of Influence and Extended Input-Output Analysis: A Theoretical Account* published in *Regional Input-Output Modeling* by Dewhurst et al. 1989. Field of influence analysis was developed to help evaluate the impact of a change from one sector to the rest of the economy by measuring the impacts of a change in an inter-industry relationship on the remaining sectors, which would be reflected in the Leontief inverse matrix (Sonis and Hewings 1991). It is important to note that the amount of change in field of influence analysis is not important, as it is scalable; the important variable in field of influence analysis is the location of change (Sonis and Hewings 2009).

After calculating the field of influence, the results will be the amount of change to the Leontief inverse matrix caused by a change in the direct requirement matrix. The first order field of influence formula is included on the next page. *F(j, i)* is the first order field of influence.

$A[a_{ij}] = Direct\ requirement\ matrix$
$E[e_{ij}] = A\ Matrix\ containing\ changes\ to\ direct\ requirement\ matrix$
$B[b_{ij}] = Leontief\ inverse\ matrix = (I - A)^{-1}$
$B'[b'_{ij}] = Leontief\ inverse\ matrix\ after\ change\ in\ direct\ requirement\ matrix$
$= (i - A - E)^{-1}$

$$B' = B\ \frac{1}{Q(E)}\left(\sum_{k=1 i\neq is,\ j\neq js}^{n}\sum F_{k^{e_{j_1 i_1}}} \cdots e_{jkik}\right)$$

$Where\ Q(E) = the\ ratio\ of\ the\ determinants\ of\ B, B', F_k.$
$Field\ of\ influence\ first\ order\ is\ given\ as$

$$F[i,j] = \begin{pmatrix} b_{1i} \\ \cdot \\ \cdot \\ \cdot \\ b_{ni} \end{pmatrix} (b_{j1} \quad \cdot \quad \cdot \quad \cdot \quad b_{jn})$$

There is relatively little discussion of the field of influence approach outside of those who employ the method. The lack of discussion in favor or against this method is likely due to the very limited use of the tool. This is especially true outside of academia.

Several authors have pointed out that field of influence analysis is useful as a complement to other linkage analysis techniques, such as key sector analysis (Parré, Alves and Sordi 2002) (Sonis, Guilhoto, et al. 1995). Similar to key sector analysis, the field of influence approach helps to identify specific opportunities for greater than

average potential. However, field of influence analysis provides this linkage for specific relationships rather than the sector generally (Parré, Alves and Sordi 2002).

2.2.3.2. Key Sector Analysis

Key sector analysis identifies the force of a given sector on the rest of the economy. This is achieved analyzing both forward and backward linkages for a given industry, a method first advanced by Rasmussen. The identification of key industries is based on the power of dispersion, which measures backward linkages, and the sensitivity of dispersion, which measures forward linkages. A value greater than one in either forward or backward linkages signifies a change above the average, and if a sector has both forward and backward scores above one it is considered a key industry (Sonis and Hewings 1999). It is important to note that a key sector does not necessarily also have a high multiplier score, as it has sometimes been wrongly assumed (McGilvray 1977).

Initially devised to help identify industries for economic developers to focus on, key sector analysis has received a varied response. The assumption is that if these key sectors are stimulated they will generate more growth than others and through these strong linkages provide significant growth. The use of this approach has been fairly widespread, in part because rarely does input-output analysis examine forward linkages. Like impact and multiplier analysis, the model is straightforward to calculate and the results are reasonably simple to interpret (Suahasil, et al. 2003).

One of the primary criticisms of key sector analysis is that it provides only an idea of what sectors will have the strongest effect on the economy. Because of the static assumptions of input-output analysis, the true effects are unknown until implemented. Additionally, the logic behind key sector analysis may seem counterintuitive because the model assumes both that there is a high degree of mutual dependency between sectors, and yet that some sectors are more important than others (McGilvray 1977). Some criticisms of this model are also shared by the input-output model, such as the ability of supply to meet demand. If we assume that this is the case for input-output analysis then, while it may not be true, it is still appropriate to assume the same for key sector analysis (Hewings 1982). In spite of these criticisms, the model has largely been accepted (Sonis, Guilhoto, et al. 1995).

As previously discussed, key sector identification is based on two calculations. The power of dispersion (backward linkages) identifies sectors that consume above average amounts of inputs. The sensitivity of dispersion (forward linkages) identifies sectors that produce important inputs (McGilvray 1977). Rasmussen's work *Studies in the Inter-sectoral Relations* is no longer available; however, the formulas in it have been reproduced many times. The formulas are included on the following page have been reproduced from Sushasil, et al.

$$Where$$

$$B = (I - A)^{-1} = b_{ij}$$

$$B_j = column\ multiplier, B_i = row\ multiplier$$

$$(BL_j) = Backward\ Linkage, (FL_i) = Forward\ Linkage$$

$$BL_j = \frac{\frac{1}{n}\sum_{i=1}^{n} b_{ij}}{\frac{1}{n^2}\sum_{i,j=1}^{n} b_{ij}} = \frac{\frac{1}{n}B_j}{\frac{1}{n^2}V} = \frac{B_j}{\frac{1}{n}V} \quad And \quad FL_i = \frac{\frac{1}{n}\sum_{j=1}^{n} b_{ij}}{\frac{1}{n^2}\sum_{i,j=1}^{n} b_{ij}} = \frac{\frac{1}{n}B_i}{\frac{1}{n^2}V} = \frac{B_i}{\frac{1}{n}V}$$

$$where\ B_j = \sum_{i=1}^{n} b_{ij}\ and\ B_i = \sum_{j=1}^{n} b_{ij}\ and\ V = \sum_{i=1}^{n}\sum_{j=1}^{n} b_{ij}$$

3. RESOURCES

3.1. Input-Output Data and Software

The proliferation of input-output analysis to widespread use is in part a result of the advances of computer technology and the increased availability of low cost data. Constructing input-output tables is the most time and labor intensive part of the process. However, there are several reconstructed options that make the process considerably more accessible. For this thesis two applications are used toward this end, IMPLAN and PyIO, discussed briefly in respective order.

3.1.1. IMPLAN

One widely used program is IMPLAN (the name derived from Impact Analysis for Planning). IMPLAN is an input-output software package published by the Minnesota IMPLAN Group. IMPLAN markets both the software and a proprietary county level dataset derived from national level input-output tables. IMPLAN version 2.3 was used for this project. Additionally, IMPLAN county level 2001 data were employed in this thesis for Cook, DuPage, Lake, Kane, McHenry and Will counties in Illinois. The most common applications of IMPLAN are impact and multiplier analysis.

3.1.2. PyIO

PyIO, pronounced pai-o, is a free input-output suite developed and published by the Regional Economic Applications Laboratory at the University of Illinois at Urbana Champaign. Version 2 of PyIO is a program built on the Python language and includes a graphic user interface. PyIO results are printed to text or Excel documents. PyIO is

able to perform most analysis types using a tab delimited input-output transactions table, but some analyses such as impact analysis, RAS adjustment, and field of influence analysis require additional information. Currently the maximum number of industries in the *nxn* matrix is 254, which corresponds to the maximum number of columns in Excel 2003. PyIO is capable of many input-output extensions such as updating by RAS and location quotient. PyIO is also capable of creating the Leontief inverse matrix as well as conducting push-pull, key sector, field of influence, multiplier and impact analysis (Suahasil, et al. 2003) (Wu 2009).

3.2. Transportation Data

3.2.1. Chicago Area Transportation Study 2020 Regional Transportation Plan

Until the creation of the Chicago Metropolitan Agency for Planning (CMAP) in 2005, regional transportation planning for the Chicago metropolitan area was conducted by the Chicago Area Transportation Study (CATS). The CATS 2020 Regional Transportation Plan is a six-county planning effort that was completed in 1998 and remained the official long-range transportation plan for the region until 2003. The capital cost of this plan was $12.3 billion (1995 dollars). Improvements in this document included 20 capital improvement plans focusing on highway and rail development (The Chicago Area Transportation Study 1998). These improvements would expand expressway lane miles by 16 percent (Seetharaman, Kawamura and Dev Bhatta 2003).

In addition to capital improvement, this plan projected a 4.9 percent reduction in travel time for commercial vehicles over the baseline scenario if the regional

transportation plan's recommended actions were taken (Seetharaman, Kawamura and Dev Bhatta 2003).

3.2.2. Federal Highway Administration Performance Elasticity

It does not come as a surprise that HLB Decision Economics Inc. working on behalf of the Federal Highway Administration found that in most instances decreases in delay time led to increased demand for trucking services. The central region, which includes Illinois and eleven other centrally located states had an elasticity rate of 0.0175, significantly higher compared to the east and west regions with 0.0076 and 0.0070 respectively. The higher rate of elasticity in the central region is attributed to the relative importance of manufacturing, which is a large consumer of freight services (HDR|HLB Decision Economics Inc. 2008).

These estimates are based on data collected by the Federal Highway Administration. Performance data were collected from the Highway Performance Monitoring System. Commodity data came from the Freight Analysis Framework, and regional economic data originated from the Bureau of Economic Analysis. Data were collected for individual corridors and calculated separately for the period between 1992 and 2003. Elasticity of performance was calculated using multiple regression analysis; the steps for calculating elasticity are given in the following formulas that have been recreated from the original document on the following page (HDR|HLB Decision Economics Inc. 2008).

$$Log\left(AADTT_{c,t}\right) = \beta_c + \beta_1 delay_{c,t} + \beta_2 income_{c,t}$$

$Where$
$AADTT = Average\ annual\ daily\ truck\ traffic$
$Delay = Average\ delay\ per\ mile$
$Income = Real\ per\ capita\ income\ growth$
$t = time$
$c = corridor$

Coefficient β_1 can be expressed in calculus notation as

$$\beta_1 = \frac{d\ AADT}{d\ Delay} \times \frac{1}{AADT}$$

Elasticity of demand for highway performance is defined as

$$E = \frac{d\ AADT}{d\ Delay} \times \frac{Delay}{AADT}$$

Therefore,

$$E = \beta_1 \times Delay$$

3.2.3. CMAP Proposed American Recovery and Reinvestment Act Projects

The CMAP Proposed American Recovery and Reinvestment Act Projects document, published in 2009, includes 116 proposed transportation projects throughout the six-county Chicago region. This document has detailed information on each project including the location, type of improvement, the cost and funding source. For demonstration purposes, impact analysis was conducted using a construction improvement for the Kennedy Expressway from East River Road to I-94 as the impact. Of the total $16.07 million dollars for this improvement, $14.22 million are federal funds, and as such are an outside infusion into the economy (Chicago Metropolitan Agency for Planning 2009).

4. METHODS

4.1. Design

Increased demand for trucking services was found using the 2020 Regional Transportation Plan's projection in decreased delays and the elasticity reported by the Federal Highway Administration. This increase in demand is the basis for measurement of the impact of freight infrastructure improvements to the 2001 Chicago region. To that end, the input-output table was adjusted to reflect the increased demand for trucking services using the RAS method. After updating the table, a series of analyses are conducted on both the original table as well as the newly updated table. The analyses will include first order field of influence, multiplier, and impact shock analysis, in which a large scale construction project will be used as the impact.

In addition to the numerous assumptions that are already included in the input-output framework, this project has an addition assumption. It has been assumed that the trucking sector is able to meet the modest increase in demand using existing resources. This means that increased demand does not require additional input to the trucking industry. To this end, the change can be reflected simply by adjusting final demand for trucking.

4.1.1. IMPLAN

4.1.1.1. Geography

Only the six-county Chicago metro area consisting of Cook, DuPage, Kane, Lake, McHenry and Will counties was used for this thesis. Although more counties were available, this geography was selected to correspond to the area of the 2020 Regional

Transportation Plan (The Chicago Area Transportation Study 1998). Although the other available counties, such as Kendall County in Illinois and Porter and Lake Counties in Indiana, are closely linked with the Chicago metropolitan area geographically as well as economically, they are on the fringes. The direct impact of infrastructure change outside of their boundaries is difficult to determine and outside the scope of this project.

4.1.1.2. Aggregation

The 440 sector IMPLAN file has been aggregated to 21 sectors using IMPLAN. The complete aggregation scheme is included in. Table IX, Appendix B. Included on the following page, Table I shows the level of aggregation that has been used throughout analysis of this project. The names are on all tables are exactly as IMPLAN gives them, they have not been modified to ease comparison. It is necessary to isolate trucking from the rest of transportation and warehousing for the purposes of this study.

Aggregating input-output tables can expedite and simplify the input-output process; however, by aggregating an input-output table some concessions are made in terms of quality. The first quality compromise is obvious: although easier to decipher, the detail of the original input-output has been traded for the convenience of a smaller matrix. In addition to losing complexity, the aggregation process can introduce some error (Chakraborty, Mukhopadhya and Thomassin 2010).

IMPLAN Aggregated Sectors
11 Ag, Forestry, Fish and Hunting
21 Mining
22 Utilities
23 Construction
31-33 Manufacturing
42 Wholesale Trade
394 Trucking
48-49 Transportation and Warehousing
44-45 Retail trade
51 Information
52 Finance and insurance
53 Real estate and rental
54 Professional- scientific and tech services
55 Management of companies
56 Administrative and waste services
61 Educational services
62 Health and social services
71 Arts- entertainment and recreation
72 Accommodation and food services
81 Other services
92 Non NAICs

Table I

4.1.1.3. IMPLAN Reports

IMPLAN is capable of exporting many tables and reports; however, the tables are rarely in typical input-output format. For the purposes of this study it is necessary to export multiple documents to construct the necessary tables for further analysis in PyIO. The inter-industry transactions are included in IMPLAN as the Regional Industry X Industry Transactions report, also known as (Text502). This report is shown in millions

of dollars and it does not include any additional information such as total output (MIG, Inc. 2004). The transactions table provides up to six decimals of detail.

For this reason it is necessary to also export Industry Output-Outlay Summary (11050). Like the transactions report, values are given in millions of dollars (MIG, Inc. 2004). This document has many key fields for the construction of PyIO appropriate tables. The Output-Outlay summary includes only one decimal of detail.

4.1.2. PyIO

Prior to conducting analysis using PyIO, tables must be formatted where the number of regions and number of industries are included in the top row separated by a single space, followed by a blank row, followed by the transactions table with no industry identification codes. Following the transactions table are three lines each separated by a blank row, these rows should include in respective order: output values, total final demand and total primary input. All three of these rows are available in the IMPLAN Industry Output-Outlay Summary. This input-output table is called the “datafile” in PyIO; the datafile is the basis of the PyIO model, and an example of this table is included in Table X, Appendix C (Nazara, et al. 2003) (Wu 2009).

PyIO is frequently updated; however, it is not without some problems. One serious issue is the transposing of the RAS updated transactions table, future studies using this methodology should be aware of this problem as of the publishing of this thesis the problem has not been addressed.

4.1.2.1. Ratio Allocation System in PyIO

To conduct the RAS procedure it is also necessary to create the “regionRfile” which includes the number of regions and number of industries separated by a single space. The region and industry numbers should be followed by a blank row and then intermediate output, intermediate outlay and total final demand. Each row should be separated by a single empty row. Because the regionRfile is used for the RAS procedure, any updated values should be included in the regionRfile (Nazara, et al. 2003). The RAS adjustment table used in this thesis is included as Table XI, Appendix C. The full increase in demand, 0.08575 percent of $6,737.7 Million, or $5.78 million, was added to the output. It is assumed that the entire increase in demand is supplied locally. This is consistent with the concentration of transportation services in the region as well as the regional purchase coefficient in IMPLAN of 100% for the trucking industry. RAS adjusted tables are automatically outputted to the same location as the originating transactions matrix, these files can be loaded back into PyIO for further analysis.

It is very important to note that in PyIO version 2.1 the RAS process the direct requirement matrices are properly formatted. However, the transactions table, which is the basis for analysis using PyIO since the direct requirements matrix and Leontief inverse matrix are computed internally is transposed. Before analysis can be conducted the updated transactions matrix must be transposed. This is easily accomplished using a spreadsheet program like Excel.

4.1.2.2. Multiplier Analysis in PyIO

Conducting multiplier analysis using PyIO is a simple process. For this thesis, Type I multipliers, evaluating direct and indirect factors, were created using output for the updated and baseline scenarios. Employment multipliers would have used numbers derived from output, and to that extent would be less accurate. For this reason the decision to use output multipliers was made.

4.1.2.3. Impact Analysis in PyIO

Impact analysis was conducted in PyIO to illustrate a shock to the construction industry in both scenarios using a repaving project included in the American Recovery and Reinvestment Act during a one-year period. This project, which has been described in greater detail in the resources section, does not require an adjustment due to regional purchase coefficients (RPC), as the IMPLAN RPC value for construction was 100 percent.

4.1.2.4. Field of Influence in PyIO

To conduct first order field of influence it is necessary to select the location on the matrix where the change takes place. Given that HLB Decision Economics found the relationship between trucking services and manufacturing was the primary reason for the much stronger correlation between delay reductions and increase for demand in the central region of the country, this relationship was an obvious choice. In the matrix this relationship of the amount of trucking input per unit manufacturing output is

contained in the cell eight rows down and five columns over. Field of influence analysis is conducted on both the original baseline as well as RAS updated direct requirement matrix.

4.1.2.5. Key Sector Analysis in PyIO

Because there is no additional information necessary for the calculation of key sector analysis, running the analysis in PyIO is a very straightforward process. As with the other analysis methods conducted thus far, key sector analysis was conducted for baseline and updated scenarios.

5. DICUSSION

Unlike typical input-output analysis this study updates the structure of direct requirements matrix assuming that existing trucking service providers will be able to meet the increased demand without an increase in inputs. The updated tables are the basis of a comparison between baseline and updated scenarios.

5.1. Ratio Allocation System

As already discussed, the RAS method distributes and balances the contents of a given table based on the introduction of at least one different element. In the case of this thesis, that new element was an increase in output for trucking services of $5.78 million. The baseline matrix is included in Table XII, Appendix D. The updated scenario is included as Table XIII, Appendix D. The resulting direct requirement matrices were used to calculate change by subtracting the updated scenario from the baseline scenario; this is shown on Table XIV, Appendix D. In this table yellow cells represent a negative change, blue cells are positive, grey cells experienced no change and cells that have a black outline represent the top and bottom ten in terms of total change.

Change to the direct requirements matrix is very small. No change is observable until the fifth decimal place in any cell. Much change is too small to be seen with six decimals. It comes as no surprise that the largest increases are concentrated within the trucking sector, with nine of the ten largest increases occurring in the trucking sector. The single cell gain was 0.000047 within the cell located at column eight, row five. This transaction is trucking services purchases by manufacturing. This is consistent with the selection of this relationship being the target cell for field of influence analysis.

A lack of data, specifically alternate best practice direct requirement matrices, expert input or surveys—all of which are instruments that can be used to conduct the more accurate modified RAS procedure—were not available for this research. Although the same technique is used in either instance, the additional data has been shown to greatly improve the quality of a RAS adjusted table. In this respect, the quality of data output is dependent on the data input.

5.2. Impact Analysis

Adjusting the structure of an economy can drastically change the impact of a given project. This is evident when looking at the example impact analysis conducted using the Kennedy Expressway resurfacing project mentioned in section 3.2.3 funded through the American Recovery and Reinvestment Act. In this example there is a only an extremely small amount of change in direct and indirect impact, however, impact analysis results would vary when final demand changes are made to any given sector. The impacts of the Kennedy Expressway resurfacing project in both scenarios are included on Table II on the following page. The total impacts in both scenarios could also be calculated by multiplying the construction project by the construction multiplier provided in section 5.3; this is because both impact and multiplier analysis are conducted using the Leontief inverse. Although the Leontief inverse matrix is not necessary in table format since the computation occurs within PyIO, the baseline and updated matrices are included in as Table XV and Table XVI, Appendix E.

The total impact has declined very slightly in the updated scenario. This could be due to increased efficiency, which would decrease the amount of economic linkages. Over all, the impact was estimated to decrease by $136.6 Dollars. Given the potential issues with the simple RAS method it is entirely possible that this change would not be noticed.

Impact Analysis for the American Recovery and Reinvestment Act Kennedy Expressway Repaving		
All Values in Millions of 2001 Dollars	Baseline Scenario	Updated Scenario
11 Ag, Forestry, Fish & Hunting	0.00450	0.00450
21 Mining	0.09629	0.09629
22 Utilities	0.07715	0.07714
23 Construction	14.25945	14.25945
31-33 Manufacturing	2.97751	2.97747
42 Wholesale Trade	0.73746	0.73744
48-49 Transportation & Warehousing	0.16219	0.16218
394 Trucking	0.23628	0.23626
44-45 Retail trade	0.90894	0.90894
51 Information	0.13308	0.13307
52 Finance & insurance	0.31743	0.31743
53 Real estate & rental	0.35702	0.35701
54 Professional- scientific & tech svcs	0.95015	0.95014
55 Management of companies	0.10945	0.10944
56 Administrative & waste services	0.26687	0.26687
61 Educational svcs	0.01447	0.01447
62 Health & social services	0.00014	0.00014
71 Arts- entertainment & recreation	0.01580	0.01580
72 Accomodation & food services	0.04893	0.04893
81 Other services	0.30593	0.30592
92 Non-NAICS	0.08821	0.08820
Total Impact	22.06724	22.06710

Table II

5.3. Multipliers

As previously discussed, multiplier analysis is calculated based on the Leontief inverse matrix, which is calculated from the direct requirements matrix. It is clear that the structural change will directly impact the multiplier analysis. As seen in Table III, very little change has occurred in multipliers when the baseline and updated scenario are compared. In total, the structural change introduced by using the RAS method accounted for a slight decrease of 0.00062 in total multipliers distributed throughout the sectoral multipliers in the updated scenario. If the updated scenario estimate is correct then the trucking sector will experience the largest single decrease in multipliers, with a total decrease of -0.00052 in the updated scenario.

At the five decimal level the only increases in multipliers in the updated scenario occurred in the management of companies and education services sectors. Both of these sectors had multiplier increases of 0.00001, the lowest detectable change at this decimal level. The only change observable at the four decimal levels is trucking. These changes are quite small, however they do illustrate that the small change introduced through the RAS method is observable.

Baseline and Updated Output Multipliers			
	Baseline Scenario	**Updated Scenario**	**Change**
11 Ag, Forestry, Fish & Hunting	1.34204	1.34198	-0.00007
21 Mining	1.40909	1.40909	-0.00001
22 Utilities	1.39867	1.39867	0.00000
23 Construction	1.55185	1.55184	-0.00001
31-33 Manufacturing	1.61932	1.61931	-0.00001
42 Wholesale Trade	1.33182	1.33182	0.00000
48-49 Transportation & Warehousing	1.49277	1.49276	-0.00001
394 Trucking	1.55422	1.55370	-0.00052
44-45 Retail trade	1.36067	1.36067	0.00000
51 Information	1.31314	1.31314	0.00000
52 Finance & insurance	1.36923	1.36923	0.00000
53 Real estate & rental	1.27965	1.27965	0.00000
54 Professional- scientific & tech svcs	1.19807	1.19807	0.00000
55 Management of companies	1.21849	1.21849	0.00001
56 Administrative & waste services	1.27242	1.27242	0.00000
61 Educational svcs	1.29122	1.29123	0.00001
62 Health & social services	1.47058	1.47058	0.00000
71 Arts- entertainment & recreation	1.36424	1.36424	0.00000
72 Accomodation & food services	1.45757	1.45757	0.00000
81 Other services	1.45327	1.45327	0.00000
92 Non-NAICS	1.14737	1.14737	0.00000

Table III

5.4. Field of Influence

The field of influence analysis, seen on Table IV and Table V on the next two pages, has been shaded so that blue cells are above average, yellow are below average and outlined cells are the top and bottom ten values. The distribution of above and below average cells has not changed when the updated scenario is compared to the baseline. In the baseline scenario, trucking output is above average for every sector and nine out of ten of the largest increases were estimated to occur within the trucking sector. The same is true for the updated scenario, where only minute changes have occurred.

It is not surprising that the most important cell in both instances is contained in column five row eight, the cell containing the transaction of sales of trucking to manufacturing, since this was the cell selected as the point of change. Aside from this cell the most heavily impacted cells in both scenarios, such as manufacturing purchases of trucking, manufacturing purchases of manufacturing, and agriculture, forestry, fishing and hunting purchases of trucking each decrease in terms of the impact a change within the manufacturing purchases of trucking cell of the Leontief inverse matrix in the updated scenario. The overall impact of a change in the relationship of trucking outputs to manufacturing in the updated scenario are overall slightly lower than the baseline scenario, the total for the updated scenario is 4.27650 compared to 4.27810 in the baseline scenario. These changes are perhaps a result of greater efficiency, which would reduce the economic interconnections between sectors.

Baseline Scenario Field of Influence Analysis with Change Occuring in Row 8 Column 5																					
Sector/Sector 2001 Baseline	11 Ag, Forestry, Fish & Hunting	21 Mining	22 Utilities	23 Construction	31-33 Manufacturing	42 Wholesale Trade	48-49 Transportation & Warehousing	394 TRUCKING	44-45 Retail trade	51 Information	52 Finance & insurance	53 Real estate & rental	54 Professional-scientific & tech svcs	55 Management of companies	56 Administrative & waste services	61 Educational svcs	62 Health & social services	71 Arts-entertainment & recreation	72 Accomodation & food services	81 Other services	92 Non-NAICS
11 Ag, Forestry, Fish & Hunting	0.00002	0.00001	0.00001	0.00003	0.00016	0.00001	0.00001	0.00001	0.00000	0.00001	0.00000	0.00000	0.00000	0.00000	0.00001	0.00000	0.00001	0.00001	0.00002	0.00002	0.00000
21 Mining	0.00028	0.00017	0.00012	0.00047	0.00288	0.00011	0.00025	0.00022	0.00009	0.00015	0.00003	0.00005	0.00006	0.00006	0.00009	0.00007	0.00024	0.00010	0.00035	0.00036	0.00006
22 Utilities	0.00046	0.00027	0.00020	0.00077	0.00470	0.00018	0.00041	0.00036	0.00014	0.00024	0.00005	0.00008	0.00010	0.00009	0.00015	0.00011	0.00039	0.00016	0.00058	0.00059	0.00010
23 Construction	0.00042	0.00025	0.00018	0.00070	0.00428	0.00017	0.00037	0.00033	0.00013	0.00022	0.00005	0.00008	0.00009	0.00009	0.00014	0.00010	0.00035	0.00014	0.00053	0.00054	0.00009
31-33 Manufacturing	0.01215	0.00718	0.00533	0.02055	0.12511	0.00493	0.01088	0.00963	0.00376	0.00652	0.00137	0.00222	0.00269	0.00250	0.00397	0.00305	0.01037	0.00420	0.01543	0.01571	0.00261
42 Wholesale Trade	0.00694	0.00410	0.00304	0.01174	0.07147	0.00281	0.00621	0.00550	0.00215	0.00373	0.00078	0.00127	0.00153	0.00143	0.00227	0.00174	0.00592	0.00240	0.00882	0.00898	0.00149
48-49 Transportation	0.00671	0.00396	0.00294	0.01134	0.06905	0.00272	0.00600	0.00532	0.00207	0.00360	0.00076	0.00122	0.00148	0.00138	0.00219	0.00168	0.00572	0.00232	0.00852	0.00867	0.00144
394 TRUCKING	0.13708	0.08103	0.06013	0.23185	1.41157	0.05557	0.12272	0.10867	0.04239	0.07359	0.01544	0.02504	0.03032	0.02815	0.04476	0.03442	0.11698	0.04735	0.17410	0.17727	0.02945
44-45 Retail trade	0.00197	0.00116	0.00086	0.00333	0.02025	0.00080	0.00176	0.00156	0.00061	0.00106	0.00022	0.00036	0.00043	0.00040	0.00064	0.00049	0.00168	0.00068	0.00250	0.00254	0.00042
51 Information	0.00103	0.00061	0.00045	0.00174	0.01056	0.00042	0.00092	0.00081	0.00032	0.00055	0.00012	0.00019	0.00023	0.00021	0.00033	0.00026	0.00088	0.00035	0.00130	0.00133	0.00022
52 Finance & insurance	0.00454	0.00269	0.00199	0.00768	0.04678	0.00184	0.00407	0.00360	0.00140	0.00244	0.00051	0.00083	0.00100	0.00093	0.00148	0.00114	0.00388	0.00157	0.00577	0.00588	0.00098
53 Real estate & rental	0.00399	0.00236	0.00175	0.00674	0.04104	0.00162	0.00357	0.00316	0.00123	0.00214	0.00045	0.00073	0.00088	0.00082	0.00130	0.00100	0.00340	0.00138	0.00506	0.00515	0.00086
54 Professional-scientific & tech	0.00434	0.00256	0.00190	0.00734	0.04468	0.00176	0.00388	0.00344	0.00134	0.00233	0.00049	0.00079	0.00096	0.00089	0.00142	0.00109	0.00370	0.00150	0.00551	0.00561	0.00093
55 Management of companies	0.00147	0.00087	0.00064	0.00248	0.01513	0.00060	0.00132	0.00116	0.00045	0.00079	0.00017	0.00027	0.00032	0.00030	0.00048	0.00037	0.00125	0.00051	0.00187	0.00190	0.00032
56 Administrative & waste services	0.00181	0.00107	0.00079	0.00306	0.01861	0.00073	0.00162	0.00143	0.00056	0.00097	0.00020	0.00033	0.00040	0.00037	0.00059	0.00045	0.00154	0.00062	0.00229	0.00234	0.00039
61 Educational svcs	0.00017	0.00010	0.00008	0.00029	0.00177	0.00007	0.00015	0.00014	0.00005	0.00009	0.00002	0.00003	0.00004	0.00004	0.00006	0.00004	0.00015	0.00006	0.00022	0.00022	0.00004
62 Health & social services	0.00003	0.00002	0.00001	0.00005	0.00029	0.00001	0.00002	0.00002	0.00001	0.00001	0.00000	0.00001	0.00001	0.00001	0.00001	0.00001	0.00002	0.00001	0.00004	0.00004	0.00001
71 Arts-entertainment &	0.00010	0.00006	0.00004	0.00017	0.00102	0.00004	0.00009	0.00008	0.00003	0.00005	0.00001	0.00002	0.00002	0.00002	0.00003	0.00002	0.00008	0.00003	0.00013	0.00013	0.00002
72 Accomodation & food services	0.00041	0.00024	0.00018	0.00070	0.00424	0.00017	0.00037	0.00033	0.00013	0.00022	0.00005	0.00008	0.00009	0.00008	0.00013	0.00010	0.00035	0.00014	0.00052	0.00053	0.00009
81 Other services	0.00748	0.00442	0.00328	0.01266	0.07706	0.00303	0.00670	0.00593	0.00231	0.00402	0.00084	0.00137	0.00165	0.00154	0.00244	0.00188	0.00639	0.00258	0.00950	0.00968	0.00161
92 Non-NAICS	0.00104	0.00061	0.00046	0.00176	0.01070	0.00042	0.00093	0.00082	0.00032	0.00056	0.00012	0.00019	0.00023	0.00021	0.00034	0.00026	0.00089	0.00036	0.00132	0.00134	0.00022

Table IV

Updated Scenario Field of Influence Analysis with Change Occuring in Row 8 Column 5																					
Sector/Sector 2001 RAS Updated	11 Ag, Forestry, Fish & Hunting	21 Mining	22 Utilities	23 Construction	31-33 Manufacturing	42 Wholesale Trade	48-49 Transportation & Warehousing	394 TRUCKING	44-45 Retail trade	51 Information	52 Finance & insurance	53 Real estate & rental	54 Professional-scientific & tech svcs	55 Management of companies	56 Administrative & waste services	61 Educational svcs	62 Health & social services	71 Arts-entertainment & recreation	72 Accomodation & food services	81 Other services	92 Non-NAICS
11 Ag, Forestry, Fish & Hunting	0.00002	0.00001	0.00001	0.00003	0.00016	0.00001	0.00001	0.00001	0.00000	0.00001	0.00000	0.00000	0.00000	0.00000	0.00001	0.00000	0.00001	0.00001	0.00002	0.00002	0.00000
21 Mining	0.00028	0.00016	0.00012	0.00047	0.00287	0.00011	0.00025	0.00022	0.00009	0.00015	0.00003	0.00005	0.00006	0.00006	0.00009	0.00007	0.00024	0.00010	0.00035	0.00036	0.00006
22 Utilities	0.00046	0.00027	0.00020	0.00077	0.00469	0.00018	0.00041	0.00036	0.00014	0.00024	0.00005	0.00008	0.00010	0.00009	0.00015	0.00011	0.00039	0.00016	0.00058	0.00059	0.00010
23 Construction	0.00042	0.00025	0.00018	0.00070	0.00428	0.00017	0.00037	0.00033	0.00013	0.00022	0.00005	0.00008	0.00009	0.00009	0.00014	0.00010	0.00035	0.00014	0.00053	0.00054	0.00009
31-33 Manufacturing	0.01214	0.00717	0.00532	0.02053	0.12499	0.00492	0.01087	0.00961	0.00375	0.00652	0.00137	0.00222	0.00268	0.00249	0.00396	0.00305	0.01036	0.00419	0.01542	0.01570	0.00261
42 Wholesale Trade	0.00693	0.00410	0.00304	0.01173	0.07141	0.00281	0.00621	0.00549	0.00214	0.00372	0.00078	0.00127	0.00153	0.00142	0.00226	0.00174	0.00592	0.00240	0.00881	0.00897	0.00149
48-49 Transportation	0.00670	0.00396	0.00294	0.01133	0.06899	0.00272	0.00600	0.00531	0.00207	0.00360	0.00075	0.00122	0.00148	0.00138	0.00219	0.00168	0.00572	0.00231	0.00851	0.00866	0.00144
394 TRUCKING	0.13704	0.08102	0.06012	0.23183	1.41144	0.05556	0.12271	0.10856	0.04238	0.07358	0.01544	0.02503	0.03031	0.02815	0.04475	0.03442	0.11697	0.04735	0.17408	0.17726	0.02945
44-45 Retail trade	0.00196	0.00116	0.00086	0.00332	0.02023	0.00080	0.00176	0.00156	0.00061	0.00105	0.00022	0.00036	0.00043	0.00040	0.00064	0.00049	0.00168	0.00068	0.00250	0.00254	0.00042
51 Information	0.00102	0.00061	0.00045	0.00173	0.01055	0.00042	0.00092	0.00081	0.00032	0.00055	0.00012	0.00019	0.00023	0.00021	0.00033	0.00026	0.00087	0.00035	0.00130	0.00133	0.00022
52 Finance & insurance	0.00454	0.00268	0.00199	0.00768	0.04674	0.00184	0.00406	0.00359	0.00140	0.00244	0.00051	0.00083	0.00100	0.00093	0.00148	0.00114	0.00387	0.00157	0.00576	0.00587	0.00098
53 Real estate & rental	0.00398	0.00235	0.00175	0.00673	0.04100	0.00161	0.00356	0.00315	0.00123	0.00214	0.00045	0.00073	0.00088	0.00082	0.00130	0.00100	0.00340	0.00138	0.00506	0.00515	0.00086
54 Professional-scientific & tech	0.00433	0.00256	0.00190	0.00733	0.04464	0.00176	0.00388	0.00343	0.00134	0.00233	0.00049	0.00079	0.00096	0.00089	0.00142	0.00109	0.00370	0.00150	0.00551	0.00561	0.00093
55 Management of companies	0.00147	0.00087	0.00064	0.00248	0.01511	0.00059	0.00131	0.00116	0.00045	0.00079	0.00017	0.00027	0.00032	0.00030	0.00048	0.00037	0.00125	0.00051	0.00186	0.00190	0.00032
56 Administrative & waste services	0.00180	0.00107	0.00079	0.00305	0.01859	0.00073	0.00162	0.00143	0.00056	0.00097	0.00020	0.00033	0.00040	0.00037	0.00059	0.00045	0.00154	0.00062	0.00229	0.00233	0.00039
61 Educational svcs	0.00017	0.00010	0.00008	0.00029	0.00177	0.00007	0.00015	0.00014	0.00005	0.00009	0.00002	0.00003	0.00004	0.00004	0.00006	0.00004	0.00015	0.00006	0.00022	0.00022	0.00004
62 Health & social services	0.00003	0.00002	0.00001	0.00005	0.00029	0.00001	0.00002	0.00002	0.00001	0.00001	0.00000	0.00001	0.00001	0.00001	0.00001	0.00001	0.00002	0.00001	0.00004	0.00004	0.00001
71 Arts-entertainment &	0.00010	0.00006	0.00004	0.00017	0.00101	0.00004	0.00009	0.00008	0.00003	0.00005	0.00001	0.00002	0.00002	0.00002	0.00003	0.00002	0.00008	0.00003	0.00013	0.00013	0.00002
72 Accomodation & food services	0.00041	0.00024	0.00018	0.00070	0.00423	0.00017	0.00037	0.00033	0.00013	0.00022	0.00005	0.00008	0.00009	0.00008	0.00013	0.00010	0.00035	0.00014	0.00052	0.00053	0.00009
81 Other services	0.00747	0.00442	0.00328	0.01264	0.07698	0.00303	0.00669	0.00592	0.00231	0.00401	0.00084	0.00137	0.00165	0.00154	0.00244	0.00188	0.00638	0.00258	0.00949	0.00967	0.00161
92 Non-NAICS	0.00104	0.00061	0.00046	0.00176	0.01069	0.00042	0.00093	0.00082	0.00032	0.00056	0.00012	0.00019	0.00023	0.00021	0.00034	0.00026	0.00089	0.00036	0.00132	0.00134	0.00022

Table V

5.5. Key Sector

The results of key sector analysis, shown on Table VI illustrate the relatively few sectors that have above-average forward and backward linkages in both baseline and updated scenarios. There are only two sectors which meet the traditional Rasmussen definition of Key sectors, where both forward and backward linkages are greater than 1. These sectors are manufacturing (31-33), and warehousing (48-49). This is true in both scenarios.

Because key sector analysis is an index there is no absolute change in either scenario. In both cases the total linkages are 21, the same as the number of sectors. However, in the index has slightly shifted. In the updated scenario trucking services had increased forward linkages of 0.0001 and backward linkages of 0.0004. In essence this means that in the updated scenario these services are slightly more in demand, and demand slightly more inputs than the baseline. These changes are countered by slight decreases beyond the fifth decimal in other sectors. A ranked table illustrating the changes in forward and backward linkages in much greater detail is included as Table XVII, Appendix F.

Parré, Alves and Sordi have suggested a relaxing of the key sector assumption that both forward and backward linkages indices should be above one. If the criteria is relaxed, then nine backwards sectors are in the baseline and updated scenarios are considered to be key. Forward linkages there are seven key sectors in both secnarios. Even if the relaxed assumption is imposed there is no change in the order of forward or backward linkages

Table VI

Key Sectors for Baseline and Updated Scenarios

	Baseline Scenario			Updated Scenario			Difference Between Scenarios	
Sector	Forward Linkage	Backward Linkage	Key Sector?	Forward Linkage	Backward Linkage	Key Sector?	Forward Linkage	Backward Linkage
11 Ag, Forestry, Fish & Hunting	0.7358	0.9753	No	0.7358	0.9753	No	0.0000	0.0000
21 Mining	0.9302	1.0241	No	0.9302	1.0241	No	0.0000	0.0000
22 Utilities	0.8362	1.0165	No	0.8362	1.0165	No	0.0000	0.0000
23 Construction	0.8379	1.1278	No	0.8379	1.1278	No	0.0000	0.0000
31-33 Manufacturing	2.0004	1.1768	**Yes**	2.0004	1.1769	**Yes**	0.0000	0.0000
42 Wholesale Trade	1.1405	0.9679	No	1.1405	0.9679	No	0.0000	0.0000
48-49 Transportation & Warehousing	1.0067	1.0849	**Yes**	1.0067	1.0849	**Yes**	0.0000	0.0000
394 Trucking	0.8936	1.1295	No	0.8936	1.1292	No	0.0001	0.0004
44-45 Retail trade	0.8728	0.9889	No	0.8728	0.9889	No	0.0000	0.0000
51 Information	0.8840	0.9543	No	0.8840	0.9543	No	0.0000	0.0000
52 Finance & insurance	1.1783	0.9951	No	1.1783	0.9951	No	0.0000	0.0000
53 Real estate & rental	1.3307	0.9300	No	1.3307	0.9300	No	0.0000	0.0000
54 Professional- scientific & tech svcs	1.4104	0.8707	No	1.4104	0.8707	No	0.0000	0.0000
55 Management of companies	0.8714	0.8855	No	0.8714	0.8856	No	0.0000	0.0000
56 Administrative & waste services	1.0874	0.9247	No	1.0874	0.9248	No	0.0000	0.0000
61 Educational svcs	0.8102	0.9384	No	0.8102	0.9384	No	0.0000	0.0000
62 Health & social services	0.7307	1.0687	No	0.7307	1.0688	No	0.0000	0.0000
71 Arts- entertainment & recreation	0.8040	0.9915	No	0.8040	0.9915	No	0.0000	0.0000
72 Accomodation & food services	0.8108	1.0593	No	0.8108	1.0593	No	0.0000	0.0000
81 Other services	0.9679	1.0562	No	0.9679	1.0562	No	0.0000	0.0000
92 Non-NAICS	0.8602	0.8339	No	0.8602	0.8339	No	0.0000	0.0000

6. CONCLUSIONS

6.1. Results

This study attempted to develop and demonstrate a new approach for examining the broad economic impacts of improvements to transportation infrastructure using existing input-output techniques. The tools used in this study are staples of many analysts; however, these tools are seldom used within the field of transportation. The combination of these tools has helped to address some of the shortcomings of existing tools available to the transportation analyst. Table VII below includes a summary of the key findings of this study.

Summary of Results		
Top Three Values	**Baseline Scenario**	**Updated Scenario**
Multiplier	Manufacturing (33-34) Trucking (394) Construction (22)	Manufacturing (33-34) Trucking (394) Construction (22)
Field of Influence	Trucking (394) to Manufacturing (33-34) Trucking (394) to Construction (22) Trucking (394) to Other Services (81)	Trucking (394) to Manufacturing (33-34) Trucking (394) to Construction (22) Trucking (394) to Other Services (81)
Key Sector	Manufacturing (33-34) Transportation & Warehousing (48-49) N/A	Manufacturing (33-34) Transportation & Warehousing (48-49) N/A
Relaxed Key Sector Forward	Manufacturing (33-34) Professional & Scientific Services (54) Real Estate & Rental (53)	Manufacturing (33-34) Professional & Scientific Services (54) Real Estate & Rental (53)
Relaxed Key Sector Backward	Manufacturing (33-34) Trucking (394) Construction (22)	Manufacturing (33-34) Trucking (394) Construction (22)

Table VII

Based on the RAS updated direct requirements matrix, there are several small trends. Increased output is largely above average for agriculture (11), mining (21), and trucking (394). There were significant decreases for the outputs of utilities (22), wholesale trade (42), and management of companies (55). Increased inputs are heavily concentrated to agriculture (11), utilities (22), trucking (394), and other services (81).

Obviously the changes that occurred during the RAS process had an effect through the entire process. Despite the changes induced in the RAS process the changes in the multiplier reports were very small. When ranked, no multipliers gained or lost rank in the updated scenario. The change was very small, but the sensitivity of multiplier and impact analysis were able to detect the changes made during the RAS process at the forth decimal.

As previously discussed in section 5.2, impact analysis has been conducted using a repaving project of the Kennedy Expressway. Although only a fragment of the change included in the American Recovery and Reinvestment Act, this impact analysis is an example of the detail that can be added beyond simple multiplier analysis. Multiplier analysis already has demonstrated a small decrease estimated at $136 in total impact when the two scenarios are compared. The greater level of detail included in impact analysis illustrates that the largest portion of direct impact was due to the decreasing of linkages between trucking and other sectors of the economy. This could be a result of increased efficiency.

The field of influence analysis found that when a change to the trucking inputs to manufacturing occurred in the baseline scenario that trucking output and manufacturing

input would be most affected. There was also some effect on manufacturing output. The results of the updated scenario were slightly decreased. Using the field of influence technique has shown to be sensitive to structural change; however in this example the results are quite small due to the relatively low change between the updated and baseline scenario.

Key sector analysis, using both the relaxed and traditional frameworks was sensitive to structural change; however, there was no reorganization of key sectors using either framework for classifying of key sectors. Because key sector analysis provides only a cursory understanding of the linkages of a given sector this change is not especially significant. According to this measure the structural change does not have a large influence on the overall economy.

6.2. Technique Evaluation

The techniques utilized for this project were selected in an effort to create a tool that was specific enough for the task at hand and general enough to detect third order benefits. The RAS method was successful in changing the structure of the economy, given the data constraints of this project. The accuracy could be improved as previously mentioned; however even with limited data it is clear that the goal of examining third order goods resulting from structural change is possible using the method set forth. Previous attempts to use smaller increases of output with the RAS method were unsuccessful because the change was too small. Although the $5.7 million dollar increase was successful in so far as there was detectable change in the direct

requirements matrix, none of the techniques employed measured significant change when comparing the baseline and updated scenarios.

Impact and multiplier analysis, as already discussed are highly related. These measures are useful for illustrating the how structural change would affect the way new demand for products would be met in both scenarios. Multiplier analysis is easy to calculate and provides a good understanding of the local level of industrial relationships. In the case of this study impact analysis did not provide significantly more useful detail than multiplier analysis. Although it is easy to calculate impact analysis should be used on a project by project basis as it may in some instances not be necessary if a thorough understanding of structural change is the end goal.

Field of influence analysis was useful and does not require significant amounts of data. In this project only the first order field of influence was calculated. This method is useful; however it is easy to be misled. The calculation is based on a given change, in this case the output of trucking to manufacturing so it is expected that the largest impact of a given change will occur within these rows and columns. Similar to impact analysis the usefulness of this tool depends on the needs of future studies. In this study which focuses more on a general analysis of the impact of structural change the results were too specific for much practical use, aside from the observation that little change occurred in the direct requirements matrix. This is in part a result of the very slight changes in the direct requirements matrix. However future studies identifying a specific relationship would benefit greatly from the first order field of influence analysis.

Key sector analysis proved to be useful, specifically when the relaxation of key sector designation is employed. Whereas both multiplier analysis and backward linkage analysis ranked the top three industries as manufacturing, trucking, and construction in both scenarios forward linkages analysis provided some new insight. Although there was no change between the two scenarios forward linkage analysis identified manufacturing, professional and scientific services, and real estate and rental as especially important sectors. This distinction is important to identify and analyze the results of structural change. In fact, backward linkages and multipliers were directly correlated in terms of the rank and order of each sector. For this reason the key sector and forward linkages were most useful. Backward linkages are necessary in order to compute key sector analysis; however, their results did not provide new insight.

6.3. Weaknesses, Further Work, and Contributions

One appealing aspect of the Federal Highway Administration's tool is that it is relatively easy to understand the results. Introducing techniques such as the linkage analyses will likely decrease accessibility of freight benefit analysis. The results are much clearer using the Federal Highway Administrations tool, whereas the approach taken in this thesis requires more analysis. Additionally, first and second order benefits of transportation infrastructure improvement are somewhat more clear as there are two parties involved; third order goods are likely to change the structure of the economy, and thus some sectors may benefit at the expense of other sectors. In this more dynamic system the term benefit is somewhat less obvious.

This study provides a useful framework for future analysis; however, several elements can be addressed to improve new work following this example. Although the RAS method has been shown to vary in accuracy, using the modified RAS method that uses known data points would significantly improve the validity of future analysis. Using the modified RAS method would require implementation of survey or expert input into the model and by doing so would account for substitution, rather than strictly the mechanical redistribution process employed in this study. Using some known data points may also increase the ability of some tools to estimate the impact of those changes because it may be known that some sectors will increase their use of freight more than others. This will decrease the general distribution process used in the simple RAS method. Additionally, he second and third order field of influence analysis should also be conducted.

Because of the theoretical nature of this study a high level of aggregation was used to help create an easily comprehensible method of analysis. However, significantly more detailed tables are available and modern computing enables the use of these tables for future studies. The initial restriction of 256 columns in PyIO is being addressed and a new version should be available for download soon, enabling the use of the entire detailed IMPLAN transactions table for these procedures.

For the purposes of this study, elasticity has been applied across the entire regional economy at the same rate. Updated sectoral rates should be used in the future to account for sectoral relationships in regard to trucking services.

Another area for future consideration is the spatial arrangement of firms. One benefit often discussed in regards to improvement in freight services is the ability of firms to locate in more peripheral cites. This phenomenon could also have a strong impact on the structure of a regional economy, but it is not accounted for in this study. This may be accomplished to some extent by using a wider geography. This analysis could also benefit from regional comparisons.

Creating the updated scenario table is a useful method for evaluating structural change; however, it is problematic to update tables based solely on changes regarding one sector, as we have previously mentioned the almost inherent obsolescence of input-output tables. We do know that certainly freight demand is not the only structural change to occur.

The imperfections caused by the assumptions of this model are not significantly greater than many other models. The margin of error should be acceptable given that these tools, especially key sector and field of influence analysis that provide an estimation of linkages rather than an estimation of economic impact.

These concerns aside this study should be used in conjunction with other methods such as the Federal Highway Cost/Benefit tool discussed to create a better estimation of the dynamic relationships between the trucking sector and the rest of the economy.

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9. APPENDICES

9.1. Appendix A

Central Fright Corridors
Cleveland-Columbus
Dayton-Detroit
Indianapolis-Chicago
Indianapolis-Columbus
Kansas City-St Louis
Knoxville-Dayton
Louisville-Columbus
Louisville-Indianapolis
Nashville-Louisville
Nashville-St Louis
St Louis-Indianapolis
Omaha-Chicago
Chicago-Cleveland
Billings-Sioux Falls
Amarillo-Oklahoma City
Memphis-Dallas
Memphis-Oklahoma City
St Louis-Oklahoma City
Source: (HLB Decision Economics Inc. 2008)

Table VIII

10. Appendix B

IMPLAN Aggregation Output		
Aggregated Sector	**Sector Detail**	**IMPLAN Code**
11 Ag, Forestry, Fish & Hunting	Oilseed farming	1
	Grain farming	2
	Vegetable and melon farming	3
	Tree nut farming	4
	Fruit farming	5
	Greenhouse and nursery production	6
	Tobacco farming	7
	Cotton farming	8
	Sugarcane and sugar beet farming	9
	All other crop farming	10
	Cattle ranching and farming	11
	Poultry and egg production	12
	Animal production, except cattle and poultry and e	13
	Logging	14
	Forest nurseries, forest products, and timber trac	15
	Fishing	16
	Hunting and trapping	17
	Agriculture and forestry support activities	18
21 Mining	Oil and gas extraction	19
	Coal mining	20
	Iron ore mining	21
	Copper, nickel, lead, and zinc mining	22
	Gold, silver, and other metal ore mining	23
	Stone mining and quarrying	24
	Sand, gravel, clay, and refractory mining	25
	Other nonmetallic mineral mining	26
	Drilling oil and gas wells	27
	Support activities for oil and gas operations	28
	Support activities for other mining	29

IMPLAN Aggregation Output (continued)		
Aggregated Sector	**Sector Detail**	**IMPLAN Code**
22 Utilities	Power generation and supply	30
	Natural gas distribution	31
	Water, sewage and other systems	32
23 Construction	New residential 1-unit structures, nonfarm	33
	New multifamily housing structures, nonfarm	34
	New residential additions and alterations, nonfarm	35
	New farm housing units and additions and alteratio	36
	Manufacturing and industrial buildings	37
	Commercial and institutional buildings	38
	Highway, street, bridge, and tunnel construction	39
	Water, sewer, and pipeline construction	40
	Other new construction	41
	Maintenance and repair of farm and nonfarm residen	42
	Maintenance and repair of nonresidential buildings	43
	Maintenance and repair of highways, streets, bridg	44
	Other maintenance and repair construction	45
31-33 Manufacturing	Dog and cat food manufacturing	46
	Other animal food manufacturing	47
	Flour milling	48
	Rice milling	49
	Malt manufacturing	50
	Wet corn milling	51
	Soybean processing	52
	Other oilseed processing	53
	Fats and oils refining and blending	54
	Breakfast cereal manufacturing	55
	Sugar manufacturing	56
	Confectionery manufacturing from cacao beans	57
	Confectionery manufacturing from purchased chocola	58

IMPLAN Aggregation Output (continued)		
Aggregated Sector	**Sector Detail**	**IMPLAN Code**
	Nonchocolate confectionery manufacturing	59
	Frozen food manufacturing	60
	Fruit and vegetable canning and drying	61
	Fluid milk manufacturing	62
	Creamery butter manufacturing	63
	Cheese manufacturing	64
	Dry, condensed, and evaporated dairy products	65
	Ice cream and frozen dessert manufacturing	66
	Animal, except poultry, slaughtering	67
	Meat processed from carcasses	68
	Rendering and meat byproduct processing	69
	Poultry processing	70
	Seafood product preparation and packaging	71
	Frozen cakes and other pastries manufacturing	72
	Bread and bakery product, except frozen, manufactu	73
	Cookie and cracker manufacturing	74
	Mixes and dough made from purchased flour	75
	Dry pasta manufacturing	76
	Tortilla manufacturing	77
	Roasted nuts and peanut butter manufacturing	78
	Other snack food manufacturing	79
	Coffee and tea manufacturing	80
	Flavoring syrup and concentrate manufacturing	81
	Mayonnaise, dressing, and sauce manufacturing	82
	Spice and extract manufacturing	83
	All other food manufacturing	84
	Soft drink and ice manufacturing	85
	Breweries	86
	Wineries	87
	Distilleries	88
	Tobacco stemming and redrying	89

IMPLAN Aggregation Output (continued)		
Aggregated Sector	**Sector Detail**	**IMPLAN Code**
	Cigarette manufacturing	90
	Other tobacco product manufacturing	91
	Fiber, yarn, and thread mills	92
	Broadwoven fabric mills	93
	Narrow fabric mills and schiffli embroidery	94
	Nonwoven fabric mills	95
	Knit fabric mills	96
	Textile and fabric finishing mills	97
	Fabric coating mills	98
	Carpet and rug mills	99
	Curtain and linen mills	100
	Textile bag and canvas mills	101
	Tire cord and tire fabric mills	102
	Other miscellaneous textile product mills	103
	Sheer hosiery mills	104
	Other hosiery and sock mills	105
	Other apparel knitting mills	106
	Cut and sew apparel manufacturing	107
	Accessories and other apparel manufacturing	108
	Leather and hide tanning and finishing	109
	Footwear manufacturing	110
	Other leather product manufacturing	111
	Sawmills	112
	#N/A	113
	Reconstituted wood product manufacturing	114
	Veneer and plywood manufacturing	115
	Engineered wood member and truss manufacturing	116
	#N/A	117
	Cut stock, resawing lumber, and planing	118
	Other millwork, including flooring	119
	#N/A	120
	Manufactured home, mobile home, manufacturing	121

IMPLAN Aggregation Output (continued)		
Aggregated Sector	**Sector Detail**	**IMPLAN Code**
	Prefabricated wood building manufacturing	122
	Miscellaneous wood product manufacturing	123
	Pulp mills	124
	Paper and paperboard mills	125
	Paperboard container manufacturing	126
	Flexible packaging foil manufacturing	127
	Surface-coated paperboard manufactuing	128
	Coated and laminated paper and packaging materials	129
	Coated and uncoated paper bag manufacturing	130
	Die-cut paper office supplies manufacturing	131
	Envelope manufacturing	132
	Stationery and related product manufacturing	133
	Sanitary paper product manufacturing	134
	All other converted paper product manufacturing	135
	Manifold business forms printing	136
	Books printing	137
	Blankbook and looseleaf binder manufacturing	138
	Commercial printing	139
	Tradebinding and related work	140
	Prepress services	141
	Petroleum refineries	142
	Asphalt paving mixture and block manufacturing	143
	Asphalt shingle and coating materials manufacturin	144
	Petroleum lubricating oil and grease manufacturing	145
	All other petroleum and coal products manufacturin	146
	Petrochemical manufacturing	147
	Industrial gas manufacturing	148
	Synthetic dye and pigment manufacturing	149
	Other basic inorganic chemical manufacturing	150

IMPLAN Aggregation Output (continued)		
Aggregated Sector	**Sector Detail**	**IMPLAN Code**
	Other basic organic chemical manufacturing	151
	Plastics material and resin manufacturing	152
	Synthetic rubber manufacturing	153
	Cellulosic organic fiber manufacturing	154
	Noncellulosic organic fiber manufacturing	155
	Nitrogenous fertilizer manufacturing	156
	Phosphatic fertilizer manufacturing	157
	Fertilizer, mixing only, manufacturing	158
	Pesticide and other agricultural chemical manufact	159
	Pharmaceutical and medicine manufacturing	160
	Paint and coating manufacturing	161
	Adhesive manufacturing	162
	Soap and other detergent manufacturing	163
	Polish and other sanitation good manufacturing	164
	Surface active agent manufacturing	165
	Toilet preparation manufacturing	166
	Printing ink manufacturing	167
	Explosives manufacturing	168
	Custom compounding of purchased resins	169
	Photographic film and chemical manufacturing	170
	Other miscellaneous chemical product manufacturing	171
	Plastics packaging materials, film and sheet	172
	Plastics pipe, fittings, and profile shapes	173
	Laminated plastics plate, sheet, and shapes	174
	Plastics bottle manufacturing	175
	Resilient floor covering manufacturing	176
	Plastics plumbing fixtures and all other plastics	177
	Foam product manufacturing	178
	Tire manufacturing	179
	Rubber and plastics hose and belting manufacturing	180
	Other rubber product manufacturing	181

IMPLAN Aggregation Output (continued)		
Aggregated Sector	**Sector Detail**	**IMPLAN Code**
	Vitreous china plumbing fixture manufacturing	182
	Vitreous china and earthenware articles manufactur	183
	Porcelain electrical supply manufacturing	184
	Brick and structural clay tile manufacturing	185
	Ceramic wall and floor tile manufacturing	186
	Nonclay refractory manufacturing	187
	Clay refractory and other structural clay products	188
	Glass container manufacturing	189
	Glass and glass products, except glass containers	190
	Cement manufacturing	191
	Ready-mix concrete manufacturing	192
	Concrete block and brick manufacturing	193
	Concrete pipe manufacturing	194
	Other concrete product manufacturing	195
	Lime manufacturing	196
	Gypsum product manufacturing	197
	Abrasive product manufacturing	198
	Cut stone and stone product manufacturing	199
	Ground or treated minerals and earths manufacturin	200
	Mineral wool manufacturing	201
	Miscellaneous nonmetallic mineral products	202
	Iron and steel mills	203
	Ferroalloy and related product manufacturing	204
	Iron, steel pipe and tube from purchased steel	205
	Rolled steel shape manufacturing	206
	Steel wire drawing	207
	Alumina refining	208
	Primary aluminum production	209
	Secondary smelting and alloying of aluminum	210
	Aluminum sheet, plate, and foil manufacturing	211
	Aluminum extruded product manufacturing	212
	Other aluminum rolling and drawing	213

IMPLAN Aggregation Output (continued)		
Aggregated Sector	**Sector Detail**	**IMPLAN Code**
	Primary smelting and refining of copper	214
	Primary nonferrous metal, except copper and alumin	215
	Copper rolling, drawing, and extruding	216
	Copper wire, except mechanical, drawing	217
	Secondary processing of copper	218
	Nonferrous metal, except copper and aluminum, shap	219
	Secondary processing of other nonferrous	220
	Ferrous metal foundaries	221
	Aluminum foundries	222
	Nonferrous foundries, except aluminum	223
	Iron and steel forging	224
	Nonferrous forging	225
	Custom roll forming	226
	All other forging and stamping	227
	Cutlery and flatware, except precious, manufacturi	228
	Hand and edge tool manufacturing	229
	Saw blade and handsaw manufacturing	230
	Kitchen utensil, pot, and pan manufacturing	231
	Prefabricated metal buildings and components	232
	Fabricated structural metal manufacturing	233
	Plate work manufacturing	234
	Metal window and door manufacturing	235
	Sheet metal work manufacturing	236
	Ornamental and architectural metal work manufactur	237
	Power boiler and heat exchanger manufacturing	238
	Metal tank, heavy gauge, manufacturing	239
	Metal can, box, and other container manufacturing	240
	Hardware manufacturing	241
	Spring and wire product manufacturing	242
	Machine shops	243

IMPLAN Aggregation Output (continued)		
Aggregated Sector	**Sector Detail**	**IMPLAN Code**
	Turned product and screw, nut, and bolt manufactur	244
	Metal heat treating	245
	Metal coating and nonprecious engraving	246
	Electroplating, anodizing, and coloring metal	247
	Metal valve manufacturing	248
	Ball and roller bearing manufacturing	249
	Small arms manufacturing	250
	Other ordnance and accessories manufacturing	251
	Fabricated pipe and pipe fitting manufacturing	252
	Industrial pattern manufacturing	253
	Enameled iron and metal sanitary ware manufacturin	254
	Miscellaneous fabricated metal product manufacturi	255
	Ammunition manufacturing	256
	Farm machinery and equipment manufacturing	257
	Lawn and garden equipment manufacturing	258
	Construction machinery manufacturing	259
	Mining machinery and equipment manufacturing	260
	Oil and gas field machinery and equipment	261
	Sawmill and woodworking machinery	262
	Plastics and rubber industry machinery	263
	Paper industry machinery manufacturing	264
	Textile machinery manufacturing	265
	Printing machinery and equipment manufacturing	266
	Food product machinery manufacturing	267
	Semiconductor machinery manufacturing	268
	All other industrial machinery manufacturing	269
	Office machinery manufacturing	270
	Optical instrument and lens manufacturing	271
	Photographic and photocopying equipment manufactur	272

IMPLAN Aggregation Output (continued)		
Aggregated Sector	**Sector Detail**	**IMPLAN Code**
	Other commercial and service industry machinery ma	273
	Automatic vending, commercial laundry and dryclean	274
	Air purification equipment manufacturing	275
	Industrial and commercial fan and blower manufactu	276
	Heating equipment, except warm air furnaces	277
	AC, refrigeration, and forced air heating	278
	Industrial mold manufacturing	279
	Metal cutting machine tool manufacturing	280
	Metal forming machine tool manufacturing	281
	Special tool, die, jig, and fixture manufacturing	282
	Cutting tool and machine tool accessory manufactur	283
	Rolling mill and other metalworking machinery	284
	Turbine and turbine generator set units manufactur	285
	Other engine equipment manufacturing	286
	Speed changers and mechanical power transmission e	287
	Pump and pumping equipment manufacturing	288
	Air and gas compressor manufacturing	289
	Measuring and dispensing pump manufacturing	290
	Elevator and moving stairway manufacturing	291
	Conveyor and conveying equipment manufacturing	292
	Overhead cranes, hoists, and monorail systems	293
	Industrial truck, trailer, and stacker manufacturi	294
	Power-driven handtool manufacturing	295
	Welding and soldering equipment manufacturing	296
	Packaging machinery manufacturing	297
	Industrial process furnace and oven manufacturing	298
	Fluid power cylinder and actuator manufacturing	299

IMPLAN Aggregation Output (continued)		
Aggregated Sector	**Sector Detail**	**IMPLAN Code**
	Fluid power pump and motor manufacturing	300
	Scales, balances, and miscellaneous general purpos	301
	Electronic computer manufacturing	302
	Computer storage device manufacturing	303
	Computer terminal manufacturing	304
	Other computer peripheral equipment manufacturing	305
	Telephone apparatus manufacturing	306
	Broadcast and wireless communications equipment	307
	Other communications equipment manufacturing	308
	Audio and video equipment manufacturing	309
	Electron tube manufacturing	310
	Semiconductors and related device manufacturing	311
	All other electronic component manufacturing	312
	Electromedical apparatus manufacturing	313
	Search, detection, and navigation instruments	314
	Automatic environmental control manufacturing	315
	Industrial process variable instruments	316
	Totalizing fluid meters and counting devices	317
	Electricity and signal testing instruments	318
	Analytical laboratory instrument manufacturing	319
	Irradiation apparatus manufacturing	320
	Watch, clock, and other measuring and controlling	321
	Software reproducing	322
	Audio and video media reproduction	323
	Magnetic and optical recording media manufacturing	324
	Electric lamp bulb and part manufacturing	325
	Lighting fixture manufacturing	326
	Electric housewares and household fan manufacturin	327
	Household vacuum cleaner manufacturing	328
	Household cooking appliance manufacturing	329

IMPLAN Aggregation Output (continued)		
Aggregated Sector	**Sector Detail**	**IMPLAN Code**
	Household refrigerator and home freezer manufactur	330
	Household laundry equipment manufacturing	331
	Other major household appliance manufacturing	332
	Electric power and specialty transformer manufactu	333
	Motor and generator manufacturing	334
	Switchgear and switchboard apparatus manufacturing	335
	Relay and industrial control manufacturing	336
	Storage battery manufacturing	337
	Primary battery manufacturing	338
	Fiber optic cable manufacturing	339
	Other communication and energy wire manufacturing	340
	Wiring device manufacturing	341
	Carbon and graphite product manufacturing	342
	Miscellaneous electrical equipment manufacturing	343
	Automobile and light truck manufacturing	344
	Heavy duty truck manufacturing	345
	Motor vehicle body manufacturing	346
	Truck trailer manufacturing	347
	Motor home manufacturing	348
	Travel trailer and camper manufacturing	349
	Motor vehicle parts manufacturing	350
	Aircraft manufacturing	351
	Aircraft engine and engine parts manufacturing	352
	Other aircraft parts and equipment	353
	Guided missile and space vehicle manufacturing	354
	Propulsion units and parts for space vehicles and	355
	Railroad rolling stock manufacturing	356
	Ship building and repairing	357
	Boat building	358
	Motorcycle, bicycle, and parts manufacturing	359

IMPLAN Aggregation Output (continued)		
Aggregated Sector	**Sector Detail**	**IMPLAN Code**
	Military armored vehicles and tank parts manufactu	360
	All other transportation equipment manufacturing	361
	#N/A	362
	Upholstered household furniture manufacturing	363
	Nonupholstered wood household furniture manufactur	364
	Metal household furniture manufacturing	365
	Institutional furniture manufacturing	366
	Other household and institutional furniture	367
	#N/A	368
	Custom architectural woodwork and millwork	369
	Office furniture, except wood, manufacturing	370
	Showcases, partitions, shelving, and lockers	371
	Mattress manufacturing	372
	Blind and shade manufacturing	373
	Laboratory apparatus and furniture manufacturing	374
	Surgical and medical instrument manufacturing	375
	Surgical appliance and supplies manufacturing	376
	Dental equipment and supplies manufacturing	377
	Ophthalmic goods manufacturing	378
	Dental laboratories	379
	Jewelry and silverware manufacturing	380
	Sporting and athletic goods manufacturing	381
	Doll, toy, and game manufacturing	382
	Office supplies, except paper, manufacturing	383
	Sign manufacturing	384
	Gasket, packing, and sealing device manufacturing	385
	Musical instrument manufacturing	386
	Broom, brush, and mop manufacturing	387
	Burial casket manufacturing	388
	Buttons, pins, and all other miscellaneous manufac	389

IMPLAN Aggregation Output (continued)		
Aggregated Sector	**Sector Detail**	**IMPLAN Code**
42 Wholesale Trade	Wholesale trade	390
394 TRUCKING	Truck transportation	394
48-49 Transportation & Warehousing	Air transportation	391
	Rail transportation	392
	Water transportation	393
	Transit and ground passenger transportation	395
	Pipeline transportation	396
	Scenic and sightseeing transportation and support	397
	Postal service	398
	Couriers and messengers	399
	Warehousing and storage	400
44-45 Retail trade	Motor vehicle and parts dealers	401
	Furniture and home furnishings stores	402
	Electronics and appliance stores	403
	Building material and garden supply stores	404
	Food and beverage stores	405
	Health and personal care stores	406
	Gasoline stations	407
	Clothing and clothing accessories stores	408
	Sporting goods, hobby, book and music stores	409
	General merchandise stores	410
	Miscellaneous store retailers	411
	Nonstore retailers	412
51 Information	Newpaper publishers	413
	Periodical publishers	414
	Book publishers	415
	Database, directory, and other publishers	416
	Software publishers	417
	Motion picture and video industries	418
	Sound recording industries	419
	Radio and television broadcasting	420
	Cable networks and program distribution	421

IMPLAN Aggregation Output (continued)		
Aggregated Sector	**Sector Detail**	**IMPLAN Code**
	Telecommunications	422
	Information services	423
	Data processing services	424
52 Finance & insurance	Nondepository credit intermediation and related a	425
	Securities, commodity contracts, investments	426
	Insurance carriers	427
	Insurance agencies, brokerages, and related	428
	Funds, trusts, and other financial vehicles	429
	Monetary authorities and depository credit interme	430
53 Real estate & rental	Real estate	431
	Automotive equipment rental and leasing	432
	Video tape and disc rental	433
	Machinery and equipment rental and leasing	434
	General and consumer goods rental except video tap	435
	Lessors of nonfinancial intangible assets	436
54 Professional-scientific & tech svcs	Legal services	437
	Accounting and bookkeeping services	438
	Architectural and engineering services	439
	Specialized design services	440
	Custom computer programming services	441
	Computer systems design services	442
	Other computer related services, including facilit	443
	Management consulting services	444
	Environmental and other technical consulting servi	445
	Scientific research and development services	446
	Advertising and related services	447
	Photographic services	448
	Veterinary services	449
	All other miscellaneous professional and technical	450
55 Management of companies	Management of companies and enterprises	451
56 Administrative & waste services	Office administrative services	452

IMPLAN Aggregation Output (continued)		
Aggregated Sector	**Sector Detail**	**IMPLAN Code**
	Facilities support services	453
	Employment services	454
	Business support services	455
	Travel arrangement and reservation services	456
	Investigation and security services	457
	Services to buildings and dwellings	458
	Other support services	459
	Waste management and remediation services	460
61 Educational services	Elementary and secondary schools	461
	Colleges, universities, and junior colleges	462
	Other educational services	463
62 Health & social services	Home health care services	464
	Offices of physicians, dentists, and other health	465
	Other ambulatory health care services	466
	Hospitals	467
	Nursing and residential care facilities	468
	Child day care services	469
	Social assistance, except child day care services	470
71 Arts-entertainment & recreation	Museums, historical sites, zoos, and parks	475
	Performing arts companies	471
	Spectator sports	472
	Independent artists, writers, and performers	473
	Promoters of performing arts and sports and agents	474
	Museums, historical sites, zoos, and parks	475
	Fitness and recreational sports centers	476
	Bowling centers	477
	Other amusement, gambling, and recreation industri	478
72 Accommodation & food services	Hotels and motels, including casino hotels	479
	Other accommodations	480
	Food services and drinking places	481
81 Other services	Car washes	482

IMPLAN Aggregation Output (continued)		
Aggregated Sector	**Sector Detail**	**IMPLAN Code**
	Automotive repair and maintenance, except car wash	483
	Electronic equipment repair and maintenance	484
	Commercial machinery repair and maintenance	485
	Household goods repair and maintenance	486
	Personal care services	487
	Death care services	488
	Drycleaning and laundry services	489
	Other personal services	490
	Religious organizations	491
	Grantmaking and giving and social advocacy organiz	492
	Civic, social, professional and similar organization	493
	Private households	494
92 Government & non NAICs	Federal electric utilities	495
	Other Federal Government enterprises	496
	State and local government passenger transit	497
	State and local government electric utilities	498
	Other State and local government enterprises	499
	Noncomparable imports	500
	Scrap	501
	Used and secondhand goods	502
	State & Local Education	503
	State & Local Non-Education	504
	Federal Military	505
	Federal Non-Military	506
	Rest of the world adjustment to final uses	507
	Inventory valuation adjustment	508
	Owner-occupied dwellings	509

9.3. Appendix C

PyIO formatted Transactions Table

1 21																				
7.962832	0.016197	0.00325	2.032397	216.381	0.069751	0.027499	0.001095	0.052985	0.096333	0.028612	1.971807	0.112951	0.000138	4.797515	0.007691	0.897333	0.656166	9.903549	0.238955	0.46865
0.414463	256.4939	881.5785	74.69337	1937.585	1.893541	22.78105	0.575426	0.799255	1.758798	0.39403	2.897001	1.571348	0.17288	0.629915	0.112782	3.880733	0.233296	2.638296	3.908944	103.6964
6.539174	22.23303	12.44251	74.5944	1255.3	227.1007	82.01318	8.458653	287.0915	63.27103	83.73174	606.957	79.17189	67.35213	84.96957	14.98031	257.8765	56.33802	205.6642	175.5437	117.951
2.671866	0.847857	146.3301	31.7737	267.8838	119.5952	83.02278	9.95437	136.4478	80.07316	171.0308	495.4349	80.02633	67.00138	29.9411	95.73305	201.6927	54.17556	107.0078	144.5908	673.6771
72.52739	167.594	219.6288	5042.256	28603.29	1362.033	1565.494	404.0851	590.1999	1254.012	307.4961	395.5124	855.683	134.7134	451.6202	80.32195	2679.939	168.6651	1715.7	2577.751	945.4537
31.47422	42.60651	63.36621	1141.337	8919.093	1407.303	386.4193	300.3461	181.4149	310.8528	74.1685	99.87659	183.6846	22.87787	173.9584	32.56051	860.5381	51.32575	628.5795	568.0378	291.9057
5.897647	22.64403	466.1258	158.4418	1227.096	766.2428	1206.539	319.3279	476.9717	168.956	510.1508	237.9614	391.4346	6.1318	169.4895	23.04539	532.1283	48.62675	90.86316	181.0839	104.6746
7.043872	18.42871	23.23075	383.397	2006.238	59.78716	168.5576	705.1059	49.67596	43.00948	12.19163	27.78998	27.98515	5.247935	39.22188	6.230556	108.9179	11.02602	99.1575	93.64787	69.51364
0.741291	4.51667	5.873404	2039.171	264.5186	273.9255	59.79065	89.22552	307.8095	35.18658	44.66685	241.698	105.6879	0.137185	204.0109	3.635697	188.2963	21.87765	107.7352	391.5302	425.564
1.155886	5.850936	20.64405	195.1742	524.1325	339.9964	168.8841	35.13068	241.1514	1285.208	336.2572	199.9117	433.7508	137.9604	135.0059	38.42359	331.8972	52.65253	87.94718	167.6387	62.40759
10.4371	38.3121	77.61108	413.7124	1321.445	594.9156	399.4357	172.1661	508.3113	234.1242	10544.29	893.807	387.523	14.93933	192.6089	44.65704	896.1355	98.28012	206.5037	206.5321	1374.151
27.08587	266.7903	41.54039	406.196	2107.395	980.7139	586.654	141.1483	1261.168	627.9636	1279.913	1786.302	1047.432	263.2877	371.6618	259.8858	2120.281	260.0943	659.2413	829.0655	529.8143
7.607409	52.19084	201.0763	1623.431	3079.683	1979.746	955.9202	133.5158	1581.911	1283.969	2169.868	1260.594	2050.338	774.9699	577.808	82.48572	1488.458	287.5171	384.628	549.223	671.7779
0.13444	75.48064	3.946284	26.85411	2110.513	675.9456	54.35995	54.43412	986.2134	64.32574	281.1411	40.14236	69.94862	0	180.0902	3.830864	311.4421	38.91853	30.67456	124.2357	1.377587
1.197918	8.58708	54.4898	337.8613	710.7429	1199.159	919.351	37.61938	662.2256	293.5652	536.1892	1565.244	1307.395	8.515995	696.6949	82.62784	1653.036	150.8574	147.7246	443.9661	346.4957
0.001974	1.039619	25.27949	7.740205	78.66861	110.1632	28.86738	2.986344	47.6927	33.55552	82.0131	26.49438	49.91678	0.036	51.59077	293.5455	83.76147	90.70802	6.220853	139.3857	13.23806
0	0	0	0	0	0	0.308141	1.457035	0.102116	0	0.036635	0	3.232332	0	0.925386	0.766639	177.4784	0.708746	0.061322	0.792195	0
0.579392	21.53061	2.481767	14.92452	92.17271	48.50237	7.073044	1.720179	24.8848	219.4426	67.28561	37.00866	115.3636	1.462125	27.81139	6.548874	40.63618	420.3664	60.26748	37.84822	2.9879
0.382556	2.93182	36.84222	40.8809	453.5807	197.6239	255.8957	7.7528	139.1609	65.07954	386.018	197.2176	345.9152	0.441843	123.5928	9.007678	484.8357	16.89189	87.61539	92.16814	9.224946
8.089275	4.13515	15.22004	468.0128	2591.898	483.7773	249.4765	371.8663	272.5043	276.6622	201.1261	294.321	286.5269	147.6639	322.7903	30.6169	424.3702	90.74587	148.0714	258.2669	313.0382
2.315561	16.77744	15.21666	70.55746	1376.725	359.5287	521.2407	29.33306	137.2544	305.0087	676.2386	471.483	174.7697	29.68279	65.92214	9.570621	147.5528	27.86011	93.68054	100.1445	97.30428
794.2	3513.5	8791.3	33029.2	138719.5	45316.7	21940	7422.5	28635.6	28771.5	64322	41805.2	53492.3	9979.6	19263.9	5126.2	38147.1	7148.2	15168	22362.7	58660.9
548.5	214.8	5001.7	30030.3	89125.6	29545	14826.2	3457.1	23820	23970.3	45692.1	25951.5	32295.6	4845.6	8100.4	3953.3	37961.2	5897.3	12214.9	15103.5	53932.7
367	1813.7	4599	16072.1	50820.6	30608.9	11383.6	3880.5	18180.1	17249.8	39557	30198.5	42470.2	7693.1	13927.7	3527.6	20388.2	4560.2	8325.4	12482.6	50531.3

Table IX

Updated Data Used for the RAS Method in PyIO

1 21																				
170.3	3193.9	3142.3	2815.6	45037.4	14026.3	6617.5	3515.8	4458.6	4518.5	17871.7	14840.8	19946.8	4646.7	10588.9	1111.4	172.3	1076.2	2692.1	6611.8	4347.8
152.9	1008.2	2219.5	11651.8	50851.9	10804.3	7548.9	2568.8	7270.2	6537.9	17412.8	8619.1	7859.6	1648.7	3763.3	1070.9	12076.3	1394.4	4548.2	6581.9	5813.1
649.6	3399.6	7935.4	30571.7	121334	43799.5	21342.6	6743.4	26657.8	28353.3	63153.9	40898.9	52765.7	9836.7	18658	4939.7	35467.9	5159.2	14259.3	20827.3	55213.8

Table X

9.4. Appendix D

Baseline Total Requirements Matrix

Sector/Sector 2001	11 Ag, Forestry, Fish & Hunting	21 Mining	22 Utilities	23 Construction	31-33 Manufacturing	42 Wholesale Trade	48-49 Transportation & Warehousing	394 TRUCKING	44-45 Retail trade	51 Information	52 Finance & insurance	53 Real estate & rental	54 Professional-scientific & tech svcs	55 Management of companies	56 Administrative & waste services	61 Educational svcs	62 Health & social services	71 Arts- entertainment & recreation	72 Accomodation & food services	81 Other services	92 Non-NAICS
11 Ag, Forestry, Fish & Hunting	0.0078	0.0000	0.0000	0.0000	0.0012	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000	0.0001	0.0005	0.0000	0.0000
21 Mining	0.0006	0.0789	0.1125	0.0025	0.0149	0.0000	0.0011	0.0001	0.0000	0.0001	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0002	0.0002	0.0019
22 Utilities	0.0072	0.0057	0.0014	0.0020	0.0080	0.0045	0.0034	0.0010	0.0090	0.0020	0.0012	0.0131	0.0013	0.0061	0.0040	0.0026	0.0061	0.0071	0.0121	0.0070	0.0018
23 Construction	0.0032	0.0002	0.0171	0.0010	0.0019	0.0026	0.0038	0.0013	0.0047	0.0028	0.0027	0.0118	0.0015	0.0067	0.0015	0.0184	0.0053	0.0075	0.0070	0.0064	0.0115
31-33 Manufacturing	0.0903	0.0482	0.0262	0.1553	0.2052	0.0307	0.0732	0.0557	0.0208	0.0444	0.0048	0.0096	0.0162	0.0136	0.0238	0.0158	0.0718	0.0239	0.1145	0.1171	0.0165
42 Wholesale Trade	0.0382	0.0120	0.0074	0.0343	0.0625	0.0310	0.0177	0.0404	0.0063	0.0108	0.0012	0.0024	0.0034	0.0023	0.0090	0.0063	0.0225	0.0071	0.0410	0.0252	0.0050
48-49 Transportation	0.0071	0.0063	0.0541	0.0048	0.0086	0.0168	0.0549	0.0429	0.0164	0.0058	0.0079	0.0057	0.0073	0.0006	0.0087	0.0044	0.0139	0.0067	0.0059	0.0080	0.0018
394 TRUCKING	0.0085	0.0052	0.0027	0.0115	0.0140	0.0013	0.0077	0.0948	0.0017	0.0015	0.0002	0.0007	0.0005	0.0005	0.0020	0.0012	0.0028	0.0015	0.0065	0.0041	0.0012
44-45 Retail trade	0.0009	0.0013	0.0007	0.0612	0.0018	0.0060	0.0027	0.0120	0.0106	0.0012	0.0007	0.0058	0.0020	0.0000	0.0105	0.0007	0.0049	0.0030	0.0070	0.0173	0.0072
51 Information	0.0014	0.0016	0.0024	0.0059	0.0037	0.0074	0.0077	0.0047	0.0083	0.0440	0.0052	0.0047	0.0080	0.0137	0.0069	0.0074	0.0086	0.0073	0.0057	0.0074	0.0011
52 Finance & insurance	0.0127	0.0108	0.0091	0.0125	0.0093	0.0131	0.0183	0.0232	0.0176	0.0081	0.1639	0.0214	0.0072	0.0015	0.0100	0.0086	0.0235	0.0137	0.0135	0.0092	0.0234
53 Real estate & rental	0.0329	0.0750	0.0048	0.0122	0.0148	0.0216	0.0268	0.0190	0.0437	0.0218	0.0199	0.0427	0.0195	0.0263	0.0192	0.0501	0.0555	0.0361	0.0430	0.0368	0.0090
54 Professional-scientific & tech	0.0093	0.0147	0.0235	0.0490	0.0216	0.0438	0.0438	0.0180	0.0550	0.0446	0.0338	0.0302	0.0383	0.0776	0.0299	0.0160	0.0390	0.0400	0.0251	0.0244	0.0115
55 Management of companies	0.0002	0.0212	0.0005	0.0008	0.0148	0.0149	0.0025	0.0073	0.0342	0.0022	0.0044	0.0010	0.0013	0.0000	0.0093	0.0007	0.0081	0.0054	0.0020	0.0055	0.0000
56 Administrative & waste services	0.0015	0.0025	0.0064	0.0102	0.0050	0.0265	0.0420	0.0051	0.0230	0.0102	0.0083	0.0374	0.0244	0.0008	0.0360	0.0159	0.0433	0.0210	0.0096	0.0197	0.0059
61 Educational svcs	0.0000	0.0003	0.0030	0.0002	0.0006	0.0025	0.0013	0.0004	0.0017	0.0012	0.0013	0.0006	0.0010	0.0000	0.0027	0.0578	0.0022	0.0129	0.0004	0.0063	0.0002
62 Health & social services	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0001	0.0046	0.0001	0.0000	0.0000	0.0000
71 Arts-entertainment &	0.0007	0.0060	0.0003	0.0004	0.0006	0.0010	0.0003	0.0002	0.0008	0.0075	0.0010	0.0009	0.0021	0.0001	0.0014	0.0012	0.0010	0.0580	0.0039	0.0017	0.0000
72 Accomodation & food services	0.0004	0.0008	0.0042	0.0012	0.0031	0.0042	0.0113	0.0010	0.0047	0.0022	0.0058	0.0046	0.0062	0.0000	0.0062	0.0017	0.0123	0.0023	0.0055	0.0040	0.0002
81 Other services	0.0098	0.0012	0.0018	0.0141	0.0182	0.0107	0.0114	0.0501	0.0094	0.0096	0.0031	0.0070	0.0053	0.0148	0.0167	0.0059	0.0111	0.0126	0.0097	0.0115	0.0053
92 Non-NAICS	0.0027	0.0046	0.0017	0.0021	0.0095	0.0078	0.0238	0.0039	0.0046	0.0106	0.0105	0.0111	0.0032	0.0029	0.0033	0.0018	0.0037	0.0038	0.0059	0.0043	0.0016

Table XI

2001 RAS Updated Total Requirements Matrix

Sector/Sector	11 Ag, Forestry, Fish & Hunting	21 Mining	22 Utilities	23 Construction	31-33 Manufacturing	42 Wholesale Trade	48-49 Transportation & Warehousing	394 Trucking	44-45 Retail trade	51 Information	52 Finance & insurance	53 Real estate & rental	54 Professional-scientific & tech svcs	55 Management of companies	56 Administrative & waste services	61 Educational svcs	62 Health & social services	71 Arts- entertainment & recreation	72 Accomodation & food services	81 Other services	92 Non-NAICS
11 Ag, Forestry, Fish & Hunting	0.0078	0.0000	0.0000	0.0000	0.0012	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000	0.0001	0.0005	0.0000	0.0000
21 Mining	0.0006	0.0789	0.1125	0.0025	0.0149	0.0000	0.0011	0.0001	0.0000	0.0001	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0002	0.0002	0.0019
22 Utilities	0.0072	0.0057	0.0014	0.0020	0.0080	0.0045	0.0034	0.0010	0.0090	0.0020	0.0012	0.0131	0.0013	0.0061	0.0040	0.0026	0.0061	0.0071	0.0121	0.0070	0.0018
23 Construction	0.0032	0.0002	0.0171	0.0010	0.0019	0.0026	0.0038	0.0013	0.0047	0.0028	0.0027	0.0118	0.0015	0.0067	0.0015	0.0184	0.0053	0.0075	0.0070	0.0064	0.0115
31-33 Manufacturing	0.0902	0.0482	0.0262	0.1553	0.2052	0.0307	0.0732	0.0556	0.0208	0.0444	0.0048	0.0096	0.0162	0.0136	0.0238	0.0158	0.0718	0.0239	0.1145	0.1171	0.0165
42 Wholesale Trade	0.0382	0.0120	0.0074	0.0343	0.0625	0.0310	0.0177	0.0404	0.0063	0.0108	0.0012	0.0024	0.0034	0.0023	0.0090	0.0063	0.0225	0.0071	0.0410	0.0252	0.0050
48-49 Transportation	0.0071	0.0063	0.0541	0.0048	0.0086	0.0168	0.0549	0.0428	0.0164	0.0058	0.0079	0.0057	0.0073	0.0006	0.0087	0.0044	0.0139	0.0067	0.0059	0.0080	0.0018
394 Trucking	0.0085	0.0052	0.0027	0.0115	0.0140	0.0013	0.0077	0.0947	0.0017	0.0015	0.0002	0.0007	0.0005	0.0005	0.0020	0.0012	0.0028	0.0015	0.0065	0.0041	0.0012
44-45 Retail trade	0.0009	0.0013	0.0007	0.0612	0.0018	0.0060	0.0027	0.0120	0.0106	0.0012	0.0007	0.0058	0.0020	0.0000	0.0105	0.0007	0.0049	0.0030	0.0070	0.0173	0.0072
51 Information	0.0014	0.0016	0.0024	0.0059	0.0037	0.0074	0.0077	0.0047	0.0083	0.0440	0.0052	0.0047	0.0080	0.0137	0.0069	0.0074	0.0086	0.0073	0.0057	0.0074	0.0011
52 Finance & insurance	0.0127	0.0108	0.0091	0.0125	0.0093	0.0131	0.0183	0.0232	0.0176	0.0081	0.1639	0.0214	0.0072	0.0015	0.0100	0.0086	0.0235	0.0137	0.0135	0.0092	0.0234
53 Real estate & rental	0.0329	0.0750	0.0048	0.0122	0.0148	0.0216	0.0268	0.0190	0.0437	0.0218	0.0199	0.0427	0.0195	0.0263	0.0192	0.0501	0.0555	0.0361	0.0430	0.0368	0.0090
54 Professional-scientific & tech	0.0093	0.0147	0.0235	0.0490	0.0216	0.0438	0.0438	0.0180	0.0550	0.0446	0.0338	0.0302	0.0383	0.0776	0.0299	0.0160	0.0390	0.0400	0.0251	0.0244	0.0115
55 Management of companies	0.0002	0.0212	0.0005	0.0008	0.0148	0.0149	0.0025	0.0073	0.0342	0.0022	0.0044	0.0010	0.0013	0.0000	0.0093	0.0007	0.0081	0.0054	0.0020	0.0055	0.0000
56 Administrative & waste services	0.0015	0.0025	0.0064	0.0102	0.0050	0.0265	0.0420	0.0051	0.0230	0.0102	0.0083	0.0374	0.0244	0.0008	0.0360	0.0159	0.0433	0.0210	0.0096	0.0197	0.0059
61 Educational svcs	0.0000	0.0003	0.0030	0.0002	0.0006	0.0025	0.0013	0.0004	0.0017	0.0012	0.0013	0.0006	0.0010	0.0000	0.0027	0.0578	0.0022	0.0129	0.0004	0.0063	0.0002
62 Health & social services	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0001	0.0046	0.0001	0.0000	0.0000	0.0000
71 Arts- entertainment &	0.0007	0.0060	0.0003	0.0004	0.0006	0.0010	0.0003	0.0002	0.0008	0.0075	0.0010	0.0009	0.0021	0.0001	0.0014	0.0012	0.0010	0.0580	0.0039	0.0017	0.0000
72 Accomodation & food services	0.0004	0.0008	0.0042	0.0012	0.0031	0.0042	0.0113	0.0010	0.0047	0.0022	0.0058	0.0046	0.0062	0.0000	0.0062	0.0017	0.0123	0.0023	0.0055	0.0040	0.0002
81 Other services	0.0098	0.0012	0.0018	0.0141	0.0182	0.0107	0.0114	0.0500	0.0094	0.0096	0.0031	0.0070	0.0053	0.0148	0.0167	0.0059	0.0111	0.0126	0.0097	0.0115	0.0053
92 Non-NAICS	0.0027	0.0046	0.0017	0.0021	0.0095	0.0078	0.0238	0.0039	0.0046	0.0106	0.0105	0.0111	0.0032	0.0029	0.0033	0.0018	0.0037	0.0038	0.0059	0.0043	0.0016

Table XII

2001 Difference between Baseline and RAS Updated Total Requirements Matrices

Sector/Sector 2001	11 Ag, Forestry, Fish & Hunting	21 Mining	22 Utilities	23 Construction	31-33 Manufacturing	42 Wholesale Trade	48-49 Transportation & Warehousing	394 TRUCKING	44-45 Retail trade	51 Information	52 Finance & insurance	53 Real estate & rental	54 Professional-scientific & tech svcs	55 Management of companies	56 Administrative & waste services	61 Educational svcs	62 Health & social services	71 Arts-entertainment & recreation	72 Accomodation & food services	81 Other services	92 Non-NAICS
11 Ag, Forestry, Fish & Hunting	0.000002	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
21 Mining	0.000000	0.000001	-0.000002	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
22 Utilities	0.000002	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000001	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
23 Construction	0.000001	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000001	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	-0.000001	0.000000	0.000000	0.000000	0.000000	0.000000
31-33 Manufacturing	0.000018	0.000001	0.000000	0.000001	0.000000	0.000000	0.000000	0.000047	0.000000	0.000000	0.000000	0.000000	0.000000	-0.000001	0.000000	0.000000	0.000000	0.000000	0.000000	-0.000001	0.000000
42 Wholesale Trade	0.000007	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000034	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
48-49 Transportatior	0.000001	0.000000	-0.000001	0.000000	0.000000	0.000000	0.000000	0.000036	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
394 TRUCKING	0.000002	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000080	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
44-45 Retail trade	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000010	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
51 Information	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000004	0.000000	0.000000	0.000000	0.000000	0.000000	-0.000001	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
52 Finance & insurance	0.000002	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000020	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
53 Real estate & rental	0.000006	0.000002	0.000000	0.000000	0.000000	0.000000	0.000000	0.000016	0.000000	0.000000	0.000000	0.000000	0.000000	-0.000001	0.000000	-0.000001	0.000000	-0.000001	0.000000	0.000000	0.000000
54 Professional-scientific & tech	0.000002	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000015	0.000001	0.000000	0.000000	0.000000	0.000000	-0.000003	0.000000	0.000000	0.000000	-0.000001	0.000000	0.000000	0.000000
55 Management of companies	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000006	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
56 Administrative & waste services	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000004	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	-0.000001	0.000000	0.000000	0.000000
61 Educational svcs	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	-0.000002	0.000000	0.000000	0.000000	0.000000	0.000000
62 Health & social services	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000001	0.000000	0.000000	0.000000	0.000000
71 Arts-entertainment &	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	-0.000004	0.000000	0.000000	0.000000
72 Accomodation & food services	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000001	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
81 Other services	0.000002	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000043	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
92 Non-NAICS	0.000001	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000003	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

Table XIII

9.5. Appendix E

2001 Baseline Leontief Inverse Matrix

Sector/Sector	11 Ag, Forestry, Fish & Hunting	21 Mining	22 Utilities	23 Construction	31-33 Manufacturing	42 Wholesale Trade	48-49 Transportation & Warehousing	394 TRUCKING	44-45 Retail trade	51 Information	52 Finance & insurance	53 Real estate & rental	54 Professional-scientific & tech svcs	55 Management of companies	56 Administrative & waste services	61 Educational svcs	62 Health & social services	71 Arts- entertainment & recreation	72 Accomodation & food services	81 Other services	92 Non-NAICS
11 Ag, Forestry, Fish & Hunting	1.0081	0.0001	0.0001	0.0003	0.0016	0.0001	0.0002	0.0001	0.0001	0.0001	0.0000	0.0001	0.0000	0.0000	0.0003	0.0000	0.0002	0.0002	0.0007	0.0002	0.0000
21 Mining	0.0038	1.0879	0.1236	0.0068	0.0221	0.0017	0.0039	0.0023	0.0021	0.0016	0.0006	0.0023	0.0008	0.0013	0.0014	0.0011	0.0030	0.0019	0.0047	0.0041	0.0029
22 Utilities	0.0094	0.0085	1.0034	0.0054	0.0118	0.0062	0.0060	0.0037	0.0110	0.0036	0.0023	0.0146	0.0024	0.0071	0.0055	0.0042	0.0089	0.0092	0.0150	0.0099	0.0025
23 Construction	0.0047	0.0022	0.0182	1.0028	0.0040	0.0041	0.0058	0.0034	0.0065	0.0041	0.0041	0.0133	0.0023	0.0077	0.0028	0.0208	0.0074	0.0096	0.0089	0.0083	0.0120
31-33 Manufacturing	0.1238	0.0732	0.0543	0.2094	1.2748	0.0502	0.1108	0.0981	0.0383	0.0665	0.0139	0.0226	0.0274	0.0254	0.0404	0.0311	0.1057	0.0428	0.1572	0.1601	0.0266
42 Wholesale Trade	0.0495	0.0197	0.0155	0.0519	0.0854	1.0375	0.0295	0.0561	0.0115	0.0175	0.0038	0.0062	0.0068	0.0056	0.0141	0.0109	0.0333	0.0128	0.0550	0.0389	0.0080
48-49 Transportation	0.0116	0.0104	0.0602	0.0114	0.0161	0.0209	1.0624	0.0542	0.0206	0.0089	0.0113	0.0089	0.0094	0.0027	0.0118	0.0070	0.0192	0.0104	0.0115	0.0132	0.0033
394 TRUCKING	0.0119	0.0077	0.0055	0.0166	0.0205	0.0028	0.0113	1.1073	0.0031	0.0031	0.0008	0.0017	0.0014	0.0013	0.0034	0.0024	0.0056	0.0030	0.0102	0.0077	0.0020
44-45 Retail trade	0.0026	0.0028	0.0029	0.0639	0.0045	0.0078	0.0054	0.0159	1.0125	0.0027	0.0019	0.0080	0.0030	0.0014	0.0122	0.0031	0.0075	0.0052	0.0094	0.0198	0.0086
51 Information	0.0033	0.0038	0.0045	0.0094	0.0072	0.0100	0.0109	0.0083	0.0112	1.0476	0.0076	0.0066	0.0096	0.0157	0.0090	0.0095	0.0118	0.0099	0.0084	0.0103	0.0020
52 Finance & insurance	0.0200	0.0189	0.0165	0.0223	0.0191	0.0201	0.0290	0.0367	0.0257	0.0138	1.1986	0.0295	0.0113	0.0046	0.0155	0.0145	0.0345	0.0214	0.0225	0.0172	0.0298
53 Real estate & rental	0.0406	0.0901	0.0204	0.0251	0.0283	0.0295	0.0380	0.0322	0.0529	0.0289	0.0281	1.0495	0.0243	0.0315	0.0260	0.0591	0.0670	0.0461	0.0533	0.0473	0.0125
54 Professional-scientific & tech	0.0193	0.0268	0.0350	0.0668	0.0399	0.0554	0.0593	0.0350	0.0685	0.0550	0.0462	0.0392	1.0448	0.0850	0.0392	0.0246	0.0542	0.0523	0.0391	0.0385	0.0164
55 Management of companies	0.0033	0.0250	0.0047	0.0077	0.0214	0.0172	0.0060	0.0119	0.0361	0.0042	0.0059	0.0025	0.0025	1.0009	0.0113	0.0020	0.0116	0.0074	0.0062	0.0099	0.0012
56 Administrative & waste services	0.0069	0.0091	0.0128	0.0188	0.0132	0.0333	0.0521	0.0146	0.0303	0.0157	0.0138	0.0436	0.0288	0.0054	1.0417	0.0221	0.0528	0.0285	0.0172	0.0273	0.0084
61 Educational svcs	0.0005	0.0008	0.0036	0.0010	0.0014	0.0032	0.0021	0.0014	0.0023	0.0018	0.0019	0.0011	0.0013	0.0003	0.0034	1.0617	0.0031	0.0150	0.0011	0.0073	0.0005
62 Health & social services	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001	0.0002	1.0047	0.0001	0.0000	0.0000	0.0000
71 Arts-entertainment &	0.0011	0.0073	0.0014	0.0011	0.0014	0.0016	0.0009	0.0008	0.0014	0.0087	0.0016	0.0013	0.0026	0.0005	0.0019	0.0017	0.0017	1.0621	0.0047	0.0023	0.0002
72 Accomodation & food services	0.0018	0.0022	0.0058	0.0034	0.0053	0.0058	0.0138	0.0033	0.0063	0.0035	0.0078	0.0059	0.0072	0.0011	0.0075	0.0028	0.0145	0.0038	1.0074	0.0058	0.0008
81 Other services	0.0144	0.0050	0.0052	0.0215	0.0270	0.0143	0.0174	0.0604	0.0131	0.0130	0.0054	0.0097	0.0074	0.0167	0.0198	0.0087	0.0166	0.0165	0.0155	1.0173	0.0069
92 Non-NAICS	0.0055	0.0077	0.0051	0.0062	0.0144	0.0103	0.0281	0.0084	0.0072	0.0129	0.0137	0.0129	0.0046	0.0042	0.0052	0.0036	0.0074	0.0061	0.0095	0.0078	1.0027

Table XIV

2001 Updated Leontief Inverse Matrix

Sector/Sector	11 Ag, Forestry, Fish & Hunting	21 Mining	22 Utilities	23 Construction	31-33 Manufacturing	42 Wholesale Trade	48-49 Transportation & Warehousing	394 TRUCKING	44-45 Retail trade	51 Information	52 Finance & insurance	53 Real estate & rental	54 Professional-scientific & tech svcs	55 Management of companies	56 Administrative & waste services	61 Educational svcs	62 Health & social services	71 Arts- entertainment & recreation	72 Accomodation & food services	81 Other services	92 Non-NAICS
11 Ag, Forestry, Fish & Hunting	1.0080	0.0001	0.0001	0.0003	0.0016	0.0001	0.0002	0.0001	0.0001	0.0001	0.0000	0.0001	0.0000	0.0000	0.0003	0.0000	0.0002	0.0002	0.0007	0.0002	0.0000
21 Mining	0.0038	1.0879	0.1236	0.0068	0.0221	0.0017	0.0039	0.0023	0.0021	0.0016	0.0006	0.0023	0.0008	0.0013	0.0014	0.0011	0.0030	0.0019	0.0047	0.0041	0.0029
22 Utilities	0.0094	0.0085	1.0034	0.0054	0.0118	0.0062	0.0060	0.0037	0.0110	0.0036	0.0023	0.0146	0.0024	0.0071	0.0055	0.0042	0.0089	0.0092	0.0150	0.0099	0.0025
23 Construction	0.0047	0.0022	0.0182	1.0028	0.0040	0.0041	0.0058	0.0034	0.0065	0.0041	0.0041	0.0133	0.0023	0.0077	0.0028	0.0208	0.0074	0.0096	0.0089	0.0083	0.0120
31-33 Manufacturing	0.1238	0.0732	0.0543	0.2094	1.2748	0.0502	0.1108	0.0980	0.0383	0.0665	0.0139	0.0226	0.0274	0.0254	0.0404	0.0311	0.1056	0.0428	0.1572	0.1601	0.0266
42 Wholesale Trade	0.0495	0.0197	0.0155	0.0519	0.0854	1.0375	0.0295	0.0560	0.0115	0.0175	0.0038	0.0062	0.0068	0.0056	0.0141	0.0109	0.0333	0.0128	0.0550	0.0389	0.0080
48-49 Transportation & Warehousing	0.0116	0.0104	0.0602	0.0114	0.0161	0.0209	1.0624	0.0541	0.0206	0.0089	0.0113	0.0089	0.0094	0.0027	0.0118	0.0070	0.0192	0.0104	0.0115	0.0132	0.0033
394 TRUCKING	0.0119	0.0077	0.0055	0.0166	0.0205	0.0028	0.0113	1.1072	0.0031	0.0031	0.0008	0.0017	0.0014	0.0013	0.0034	0.0024	0.0056	0.0030	0.0102	0.0077	0.0020
44-45 Retail trade	0.0026	0.0028	0.0029	0.0639	0.0045	0.0078	0.0054	0.0159	1.0125	0.0027	0.0019	0.0080	0.0030	0.0014	0.0122	0.0031	0.0075	0.0052	0.0094	0.0198	0.0086
51 Information	0.0033	0.0038	0.0045	0.0094	0.0072	0.0100	0.0109	0.0083	0.0112	1.0476	0.0076	0.0066	0.0096	0.0157	0.0090	0.0095	0.0118	0.0099	0.0084	0.0103	0.0020
52 Finance & insurance	0.0200	0.0189	0.0165	0.0223	0.0191	0.0201	0.0290	0.0367	0.0257	0.0138	1.1986	0.0295	0.0113	0.0046	0.0155	0.0145	0.0345	0.0214	0.0225	0.0172	0.0298
53 Real estate & rental	0.0406	0.0901	0.0204	0.0251	0.0283	0.0295	0.0380	0.0322	0.0529	0.0289	0.0281	1.0495	0.0243	0.0315	0.0260	0.0591	0.0670	0.0461	0.0533	0.0473	0.0125
54 Professional-scientific & tech	0.0193	0.0268	0.0350	0.0668	0.0399	0.0554	0.0593	0.0350	0.0685	0.0550	0.0462	0.0392	1.0448	0.0850	0.0392	0.0246	0.0542	0.0523	0.0391	0.0385	0.0164
55 Management of companies	0.0033	0.0250	0.0047	0.0077	0.0214	0.0172	0.0060	0.0119	0.0361	0.0042	0.0059	0.0025	0.0025	1.0009	0.0113	0.0020	0.0116	0.0074	0.0062	0.0099	0.0012
56 Administrative & waste services	0.0069	0.0091	0.0128	0.0188	0.0132	0.0333	0.0521	0.0146	0.0303	0.0157	0.0138	0.0436	0.0288	0.0054	1.0417	0.0221	0.0528	0.0285	0.0172	0.0273	0.0084
61 Educational svcs	0.0005	0.0008	0.0036	0.0010	0.0014	0.0032	0.0021	0.0014	0.0023	0.0018	0.0019	0.0011	0.0013	0.0003	0.0034	1.0617	0.0031	0.0150	0.0011	0.0073	0.0005
62 Health & social services	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001	0.0002	1.0047	0.0001	0.0000	0.0000	0.0000
71 Arts-entertainment &	0.0011	0.0073	0.0014	0.0011	0.0014	0.0016	0.0009	0.0008	0.0014	0.0087	0.0016	0.0013	0.0026	0.0005	0.0019	0.0017	0.0017	1.0621	0.0047	0.0023	0.0002
72 Accomodation & food services	0.0018	0.0022	0.0058	0.0034	0.0053	0.0058	0.0138	0.0033	0.0063	0.0035	0.0078	0.0059	0.0072	0.0011	0.0075	0.0028	0.0145	0.0038	1.0074	0.0058	0.0008
81 Other services	0.0144	0.0050	0.0052	0.0215	0.0270	0.0143	0.0174	0.0604	0.0131	0.0130	0.0054	0.0097	0.0074	0.0167	0.0198	0.0087	0.0166	0.0165	0.0155	1.0173	0.0069
92 Non-NAICS	0.0055	0.0077	0.0051	0.0062	0.0144	0.0103	0.0281	0.0084	0.0072	0.0129	0.0137	0.0129	0.0046	0.0042	0.0052	0.0036	0.0074	0.0061	0.0095	0.0078	1.0027

Table XV

9.6. Appendix F

Ranked Baseline and Updated Linkages					
Sector	Baseline Forward Linkages	Updated Forward Linkages	Sector	Baseline Backward Linkages	Updated Backward Linkages
31-33 Manufacturing	2.0004	2.0004	31-33 Manufacturing	1.1768	1.1769
54 Professional- scientific & tech svcs	1.4104	1.4104	394 Trucking	1.1295	1.1292
53 Real estate & rental	1.3307	1.3307	23 Construction	1.1278	1.1278
52 Finance & insurance	1.1783	1.1783	48-49 Transportation & Warehousin	1.0849	1.0849
42 Wholesale Trade	1.1405	1.1405	62 Health & social services	1.0687	1.0688
56 Administrative & waste services	1.0874	1.0874	72 Accomodation & food services	1.0593	1.0593
48-49 Transportation & Warehousing	1.0067	1.0067	81 Other services	1.0562	1.0562
81 Other services	0.9679	0.9679	21 Mining	1.0241	1.0241
21 Mining	0.9302	0.9302	22 Utilities	1.0165	1.0165
394 Trucking	0.8936	0.8936	52 Finance & insurance	0.9951	0.9951
51 Information	0.8840	0.8840	71 Arts- entertainment & recreation	0.9915	0.9915
44-45 Retail trade	0.8728	0.8728	44-45 Retail trade	0.9889	0.9889
55 Management of companies	0.8714	0.8714	11 Ag, Forestry, Fish & Hunting	0.9753	0.9753
92 Non-NAICS	0.8602	0.8602	42 Wholesale Trade	0.9679	0.9679
23 Construction	0.8379	0.8379	51 Information	0.9543	0.9543
22 Utilities	0.8362	0.8362	61 Educational svcs	0.9384	0.9384
72 Accomodation & food services	0.8108	0.8108	53 Real estate & rental	0.9300	0.9300
61 Educational svcs	0.8102	0.8102	56 Administrative & waste services	0.9247	0.9248
71 Arts- entertainment & recreation	0.8040	0.8040	55 Management of companies	0.8855	0.8856
11 Ag, Forestry, Fish & Hunting	0.7358	0.7358	54 Professional- scientific & tech sv	0.8707	0.8707
62 Health & social services	0.7307	0.7307	92 Non-NAICS	0.8339	0.8339

Table XVI

10. VITA

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