A Multi-Modality Approach to the Regional Economic Impact of Plant Closure in the Mahoning Valley: the General Motors Assembly of Lordstown, OH

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ABSTRACT

This study seeks to explore the expected impact on the Youngstown-Warren regional area of a closure of the General Motors assembly plant in Lordstown, Ohio. Through the course of performing this impact study, the paper has also attempted to expose the true importance of performing such studies as well as comparing methods for evaluating final results of initial shifts. The primary methods for analysis are an economic base model and an input-output model, these methods being both described and then compared in their results.

The construction and implementation of the economic base model shows the benefits of a somewhat faster model in garnering quick numbers from which sound decisions can be made. It also attempts to show some of the pitfalls of such a model; one that lacks the depth of other such models. The input-output model shows through its construction the benefits of a more in-depth model (by comparison to the economic base model), but also the difficulty that lack of adequate information can pose to such models.

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Introduction

Often heard are statements regarding the state of the national economy. The nightly news on any given night will contain information about the housing markets, trade deficits, inflation, or budget concerns. Not much is ever said, however, about regional economies. Sure the local newspapers and television stations might cover stories of a labor dispute, plant closing, or new business moving into the area, but how is the impact of such a thing measured, studied, and analyzed? How can city planners forecast the long-term economic trickle-down effects of a new factory opening up? Though hardly mentioned by the national news, these regional economic situations can indeed have a major importance on the national level economy. After all, what is the nation but a collection of individual regions? A factory closing in any given region of the United States and moving to another region within the country might not show up as a direct change in that company's employment within the United States. Does that mean though that it has had no impact? Perhaps it does yet, as one area might be better suited to turn those factory jobs into jobs in secondary industries, such as health care and transportation. A factory closing in the US and moving to a different country would definitely impact national employment and unemployment figures, but how does it impact said figures beyond just the actual factory jobs? In this paper, we shall seek to answer all these questions (and certainly others) through a careful study of regional economic impacts and shifts due to changes in employment. Two different strategies for computing the effects of a change shall be considered, each calculated and followed through, to give a result that can be compared and examined to show the overall impact of regional economics considerations, and the importance of not ignoring them. Further, we can use the numbers that result from model to compare these models and see which results in a larger predicted impact, why the results might be different, and where the faults of each model lie. This comparison of the two models can be seen as a secondary goal of this study.

The question then becomes what region to study, and where to find a change that might affect this region, specifically one which can be quantified. For the purposes of showing the importance of regional economics, it is relatively unimportant which region we choose. Nearly every region one might define faces a continual series of changes, many of which would certainly be fine for studying secondary impacts and comparing ways of modeling such changes. However, as yet another secondary goal this project is designed to present a future framework for studying changes in the area around Youngstown State University. Therefore, we shall use the Youngstown/Warren region (hereafter referred to simply as "Youngstown" or the "Mahoning Valley" after the area's common name derived from the Mahoning River which flows through it) as the basis for our study. This area has a code of 89566 in the national coding scheme for regions used by the Bureau of Economic Analysis. Having identified a single region for our study, we now would need to identify a shift in employment to input into the models (this in order to generate a secondary effect to quantify). The Mahoning Valley has been for many years dominated by factory jobs and, though the loss of the steel industry has forced the area into a painful transitional process, the area will more than likely continue to define itself as a very blue-collar base, with large scale plant-based production dominating the landscape and psyche of the area's residents. To this end, it would be most appropriate to study the effect of a change in factory/manufacturing employment. With the previously referred to collapse in the steel industry in and around the Mahoning Valley (and, indeed, across the country), the major source of factory jobs in the area has shifted to the auto industry, specifically the General Motors Lordstown assembly. This plant works twenty-four hours a day producing the Cobalt small car for the Chevrolet brand and will soon begin production of the brand new Pontiac G5 small car (having been recently converted over from producing the Chevrolet Cavalier and Pontiac Sunfire small automobiles). It was recently announced that GM would be ceasing operation of a third shift at the plant, which will cost between 1,100 and 1,300 jobs on that shift. However, many of these jobs will be taken in terms of early retirements and buyout options, meaning that there will be very few actual layoffs. This scenario then does not allow for a large number of job losses where those people would be leaving the area to find new jobs (and so cause a secondary impact). More interesting in theoretical terms would be what would happen if the eventual shutdown of the plant takes place (this has been rumored/feared for many years). This would certainly cause a mass exodus from the area as people look to find new employment in the manufacturing field. For our purposes, we will say that the shift in jobs is equal to 6,000 (the approximate current employment of the plant) and that all of these people are forced to leave the area in order to find new jobs in terms of creating a secondary shift. As we examine the removal of these jobs from the Mahoning Valley, we are able to take a slightly different tack that most other published reports, which would mainly concern themselves with the primary loss of jobs in a certain region as opposed to secondary effects across all other industries throughout the region. Through the analysis of this change in employment, we can see some techniques in action that we could further generalized, if desired, so that they could be applied to all manner of regional economic situations across the country. In addition, we will create a set of frameworks that could be used for analyzing changes specific to the Mahoning Valley in the future (of course with an update in the data sets that are used to generate some of the intermediate numbers).

Review of Literature

The basic ideas for this project are in some aspect drawn from The Web Book of Regional Science which is published by the Regional Research Institute at West Virginia University. Specifically a book entitled "Computable General Equilibrium Modeling for Regional Analysis" puts forward a number of ideas that form the basis of this paper. From the very outset, the introduction of that paper puts forward the crux of the matter in terms of modeling any economy: the debate between using partial and general equilibrium models.

Partial equilibrium models are, perhaps, the most familiar of all economic models. These are the models that are perhaps the easiest to explain, with a clear starting point, a well-defined change and follow-through to that change. Such models are very useful in some respects. For instance, when creating an econometric model (and looking for some concrete relationship between two or more economic variables), partial equilibrium studies prove invaluable. It is helpful and necessary in this case to be able to hold some of the countless variables in the economy to a constant value; even if this comes at the expense of some realism in the model. Partial equilibrium studies are also very useful in teaching economic principles to students. The much simpler frameworks and shifts of a partial equilibrium approach are ideal for an introduction to economic theory.

The authors of the Web Book, however, are much more drawn to the general equilibrium models for their ability to capture all the "ripple" effects in the economy. They speak of the near constant presence of market feedback and interactions that make the real world a very complex thing to model at all, let alone in simple terms. Complicating things further are the possibility of circular interactions; i.e. those situations in which the continuing effects of the initial change filter back through the economy and cause that beginning market to change yet again. (Vargas, 1999)

The Web Book certainly has much more information worthy of exploration and summary here, but for now we turn to another paper for the description and short history of general equilibrium modeling. This is the "The 1987 Washington State Input-Output Study", published by Philip J. Bourque, Robert A. Chase, and Richard S. Conway Jr. Here, in the preface, they write of the history of general equilibrium models and, more to the point of this paper, the history and development of input-output analysis. Starting with the very beginning, they mention the 1758 *Tableau Economique* of Francois Quesnay, which was one of the first attempts to quantify the interacting flows between various industries and markets. (Chase, 1993) The credit for creating the modern idea of general equilibrium modeling is usually credited not to Quesnay but rather to fellow Frenchman Leon Walras. Walras developed the theory behind what is today called the Direct Requirement Table and the Make and Use tables that are the very center of input-output analysis, though he did not use these names. (Chase, 1993) His ideas of looking at what an industry need to use to produce its outputs would change the way the economy was analyzed.

The main problem with Walras' model lay in the very complexity that made it so accurate. Without the fast computers of today the theoretical framework laid forth in the mid-1800s was rarely used until Wassily Leontief published his input-output tables for the United States in 1936. He was able to construct these tables (for which he would later receive the Nobel Prize in Economics) through the use of two simplifying assumptions. The first is one that we shall indeed make much use of in this paper, the assumption that to each industry/sector there is one output. This is the first step towards having simplified models using aggregate numbers, such as those used in the input-output models found in the later sections of this paper. The second assumption is also of some use here, but in a much more limited way. Leontief dropped the very complex equations from the theory, which makes it much easier to apply here but also comes at the cost of some realism. (Chase, 1993)

An important note in the expanded theory of Leontief is that, in equilibrium, each industry's total output is equal to its total inputs (which are, of course, the outputs of other industries). (Chase, 1993) This leads to the square make/use matrices that are often found in the input-output models of today.

These publications by Leontief lead to the publication of regular US input-output models by the Bureau of Economic Analysis and its predecessor, the Bureau of Labor Statistics. These tables were used to foresee and plan for the boom that occurred in the years immediately following World War II, this marking the first major usages of such tables and modeling in determining economic policy. (Chase, 1993)

The practice of using such techniques on a regional level is an even more recent development, originating only in the past thirty-five to forty years. The Washington State paper continues on in describing how this occurred, all of these developments leading directly to the creation of both that paper and this one. The Washington State paper also draws in the development of the economic base model (a model based on dividing employment into two categories that play on each other) so as to draw parallels. This is somewhat ideal for our purposes as this is the other main model that shall be discussed herein.

The most obvious parallel is in the idea from which the two models stem; namely that growth within a region is generated by its export/base industries. The input-output model, however, unlike the base model, makes a distinction between the different individual industries in the region and how integrated they are into the region as a whole. According to Bourque, Chase, and Conway, the input-output model is effectively an economic base model, albeit a disaggregated one. (Chase, 1993)

They continue on to describe the many applications of the regional input-output model and some of the many places in which it has been used. Among these they name Philadelphia, Utah, and the Pacific Northwest as a whole (they do not distinguish in their definition of region between a single metro area, a part of a state, or even a several state section of the nation). They also mention the states that are notable among those that have produced their own input-output tables (Washington, Kansas, West Virginia, Texas, Colorado, and Nebraska). (Chase, 1993) This paper itself is the input-output study for Washington State, the fifth such survey in a series that started in 1967.

As the paper moves on into its content sections, its purpose becomes clearer. They mean to present an overall picture of the entire state economy as opposed to studying as single change (as is the aim of this paper). As such, the paper is much more a list of numbers and description of said numbers than a studying in using those numbers. Even still, it has some value in terms of our purposes here and perhaps in being able to predict what the numbers for the Youngstown area say should happen.

The content of the paper itself is broken down into three sections. The first section describes the transaction table along with some definitions and general conventions for the use of input-output tables. After a fairly low level description of what an input-output model is, it moves on into how to read the tables and gives an example showing the use of a simplified version of the tables.

Moving into the definitions section, the paper tackles a tough issue in this arena, that of the definition of region. Earlier on in the paper, the authors refused to nail down a definition of region, for the points they were making were applicable to all such definitions. At this point, however, it is important to define a region so that they can quantify what they will include and what they will exclude. They decide on a "place-of-performance" approach wherein they will include any output that is produced within the state and nothing that is produced outside (regardless of if it is a Washington based business or not). (Chase, 1993) For the purposes of this paper, we shall take nearly the same tact, as we care mainly about output for the purposes of the employment that it creates. Therefore, we shall concern ourselves with all production that generates employment in the Youngstown area, a very small and fairly insignificant modification to the "place-of-performance" approach (or at least to the wording that they use).

The next several pages go into great detail on first the determination of the base year and then the separating of the output into the various sectors that they will be using in their table. It is of little bearing the base year that we choose, since we are looking at a future projection, so this does not factor into any of the data. In terms of deciding how and why to split up the sectors, the data we have is already split up as it will be. This data limitation both hurts and helps our model (it helps the simplicity of the model but potentially hurts the realism) yet this is a limitation of the available data and so is something that we must live with. As we cannot make any choices of our own, we skip on the next relevant part of the Washington State paper, this being the second section.

The second section is related to how the tables have been constructed. The authors at length discuss the various methods for creating a table. The three main methods are the survey, non-survey, or hybrid approaches, each of which has their own good and bad points. For the Washington State paper, they have decided to use a survey, albeit a selective one. A total, exhaustive survey of all employers/producers within the region would be the ideal method for constructing an accurate input-output table. However, such an approach would be prohibitively expensive and even at that would likely be impossible, as some producers would likely refuse to return the surveys due to their possibly being seen as asking for privileged information. Due to its limited budget, the state of Washington generally sends surveys to only some companies and augments that data from other sources in the region and at the national level. (Chase, 1993)

In this paper, owing primarily to money and time restraints, the non-survey method will be used. This entails getting all data that can be gathered at the national level (mainly tables and data sheets from the Bureau for Economic Analysis) and regionalizing it. Methods for doing this shall be explored in greater depth in the individual models later on in the paper.

The third and final main section of the Washington State paper actually gets into the main portion of what we will be discussing as a part of this study. It begins to look at uses for an input-output model at the regional (here state) level. Beginning with a brief overview of the descriptive uses for the table (which are mainly to the effect of being able to dissect which intermediate outputs go to which consumers), it gets into a fairly low level discussion of using the charts for impact analysis and growth modeling within the region. This discussion includes some of the mathematics that will be used in deriving outcomes later on in this paper, and so a discussion of these shall be left to that point.

Getting back to the Web Book of Regional Science article entitled "Computable General Equilibrium models for Regional Analysis", we are able to see a different method of attempting to achieve the same goals. They also focus on general equilibrium models, but here they speak in more generic terms than in the Washington State paper, as this is entirely more theoretical in nature. Marcouiler and the co-authors do discuss input-output modeling briefly before giving up on it in favor as a somewhat modified version of a general equilibrium approach, which is known as a supply-determined Social Accounting Matrix. (SAM) (Vargas, 1999) Such matrices are able to overcome many of the limitations of the input-output models (which are introduced into the model by the assumptions that it makes; more of this shall be discussed when the input-output model is computed later on in this paper). These models though, do still have some features that make them unenviable for reliance upon for accurate forecasting. Therefore the authors turn to the Computable General Equilibrium (CGE) analysis techniques in an attempt to find some sound theoretical footing for their own theories. (Vargas, 1999)

These CGE models actually encompass features of both the I-O model and the SAM framework. They focus on price as a way to accommodate both demand and supply changes into a single model, allowing prices and quantities to clear markets as is the case in most neoclassical models. (Vargas, 1999) Most current work with CGE models has come at the national level where data is much easier to obtain than it would be at the regional or sub-regional level (advanced modeling techniques such as CGE are very data intensive). The Web Book states that, though they are becoming increasingly common in their use, regional level CGE models have yet to be thoroughly assessed at this level for accuracy and true usefulness. (Vargas, 1999)

According to the Web Book, the first step in developing a CGE model is to create a social accounting matrix. This is used as a base point (as opposed to the input-output model) due to its more comprehensive nature. Like I-O models, social accounting matrices provide a framework in which all the production of an economy can be expressed. How they are said to be more comprehensive comes from how they analyze income and production. While I-O models look at inputs and outputs of industries, the SAM models explore production from the point of view of the household and how each household's income is generated. The paper proceeds with a discussion of how to create a SAM model, of which the main key is presented as gathering the data (SAM models would tend to be even more data intensive than input-output models). (Vargas, 1999)

The following several sections deal with the details of constructing a CGE model. These details are of interest only in passing to the continuation of this paper, as we shall stay clear of any CGE models in attempting to judge the impact of the Lordstown plant closure. Among the few relevant points include a discussion on how to apply such models to situations of imperfect competition (the assumptions of the basic model the authors put forward include one of perfect competition). This is of some interest as the auto industry in the United States (and indeed around the world) is certainly not in a state of perfect competition. The adjustments mainly are concerned with making sure price adjustments take into consideration market power where concentrations exist. (Vargas, 1999) The exact mechanics of this are outside the scope of this study, though it may be a point of future exploration as to how a model with these kinds of accommodations would differ from those presented herein without those adjustments.

In its final chapter, this article returns to material of interest as it explores the applications of CGE models which can (without a great stretch of the imagination) be thought of as applications for our models as well. The first (and indeed primary) application that it explores is that of government policy. There are two studies in this section. The first explores the use of the CGE model in describing the loss of household welfare due to the changing prices of agricultural products in the 1980s. Though, according to the authors, there has not been much research on the potential impacts of long term solutions, the government officials were able to use CGE modeling and the like to explore the impact of short to medium term plans on the economy. (Vargas, 1999) The second application explores a more analytical tact as it tries to forecast the change in household welfare from a pair of proposed tax plans. These plans are to tax sport fishing which (as a small part of the gross state product) is seen as an alternative use of water resources to agriculture (which is an order of magnitude higher in terms of percentage of gross state product than fishing). Using this information, the legislators would be able to make a choice that is better overall for the people of the region. (Vargas, 1999)

An interesting note in the conclusion is that the authors state that it is unclear if the CGE model is better than alternative models (two of which will be explored in the main part of this study). The part of the model that they believe makes the system problematic is based in the fact that it uses only one year of data to calibrate it. (Vargas, 1999) Compared to this, this study will be using the three years worth of data wherever possible to both create and evaluate the models to be used.

It should be noted that there are many situations in which it is appropriate use impact modeling techniques such as those used in this study. While many times the studies are used to explore the impact on a single region of a proposed change, they can also analyze the comparative effects on two regions. This would be useful in a situation where there is a choice of investment (perhaps even government investment) between two regions. Building an impact model of the region may allow those making the investment to see where their money would make more of a positive (or negative) impact on the area a perhaps make a more informed decision. In the same vein, an industry or company may be looking for an area in which to move more resources (or take away resources and jobs); in such a case, economic impact modeling could provide them with information on how to best maximize (or minimize) the impact of the move of said resources. This information may then be balanced against what is best for the company to come up with a decision that is beneficial for all involved.

Such as study as this last case forms the basis for the paper "An Input-Output Analysis of the Incremental Contributions of Timber Harvests to the Regional Economics of the South and Pacific Northwest", which was done by Brian Cox and Ian Munn of Mississippi State University. In this paper, they implement an input-output model to determine the comparative impact (in terms of value added, personal income, output, and employment) of an annual increase in timber harvest of one-million board feet of timber. They use this as a measure (as opposed to more traditional units such as dollar amounts) as they believe that it will allow for the truest comparison between the regions for the purposes of deciding upon harvest policy, negating such differences as size of trees, tree coverage, and yield per tree. (Cox, 2000)

The first part of the paper lays out some basic data on the role of forestry in the United States economy as a whole. The paper states that the total output of the US forest products industry totaled some $210.9 billion for the year 1992, with the two regions studied herein (the Pacific Northwest and the South) accounting for approximately 10% and 31%, respectively, of that output. (Cox, 2000) The actual reason for the study is also made clear here (though a bit later on in the section). The five year period from 1986 to 1991 saw timber production nationwide grow by around 1.4 billion board feet. For that same five year period, however, timber production in the Pacific Northwest actually dropped by 2.55 billion board feet. This change in production contrary to the national change implies that production was generally relocating within the country during this time period. Where it was relocating to was the South, which experienced an increase in timber production of 1.99 billion board feet from 1986-1991, thus creating the need for this study. (Cox, 2000) While the paper does not directly explore reasons for the shift, it can be drawn from clues throughout that changes in government policy affected the timberlands of the Northwest to a greater degree than those of the South.

With these facts known, the study goes on to mention what might be the reasons why an identical change in output of around one million board feet would have such a different impact in the two regions. The main idea put forward here is the source of the timber, namely the land on which the primary sources are found. The timber industry in the Pacific Northwest relies primarily on large, old-growth trees in the region's many national forests. In fact, over 53% of the sources of timber within the region are on government owned land. This plays an important role in the industry, as the government limits the environmental impacts of the loggers. In the South, on the other hand, 90% of the timber sources are owned by individuals or corporations, where there would be fewer restrictions on how the timber can be harvested. Also, the South produces more hardwood from trees planted on lands which have been harvest several times in the past. These differences in ownership would be a primary cause of the differentiation in how government policies would have affected the two regions. Public lands would always be subject to far more stringent regulations than the privately held lands that are more common in the South. (Cox, 2000)

Another reason why the timber industry of the South would respond differently than the timber industry of the Pacific Northwest is that there are differences in the economic constitutions of the two regions. For instance, the substitution of inputs is more flexible in the South than in the Northwest, where the capital to labor ratios is far more fixed. This is primarily due to the fact that the timber industry in the South is more labor intensive than that of the Northwest, with an increasing likelihood of substituting capital for labor. Because of this differential in input substitution, increasing production in one area will not increase employment in the same way as increasing it by an identical amount in the other area. (Cox, 2000)

The final part of the study's introduction explains very briefly the alternative ways in which this problem could have been approached and ends with a rehashing of the purpose of the study. They basically explain how they came to settle upon a "per unit of output" approach as opposed to the competing "per dollar" method that is commonly seen. The authors apparently decide that it will lead to less distortion owing to the varying prices of the differentiated products that are produced. (Cox, 2000)

The next section of the paper contains the definitions and methodologies that will be used throughout. They take the time to define what an input-output model is and how it is set up. As this is covered elsewhere in this paper, it shall be skipped here except for the note that the authors will be using the data from the IMPLAN system, a product of the US Department of Agriculture Forest Service (in co-operation with the Federal Emergency Management Agency, the US Department of the Interior Bureau of Land Management, and the University of Minnesota). (Cox, 2000)

The definition of the regions themselves is the next important phase of this section, perhaps the most important choice made in the entire study. They decide to use identical regional definitions to those used by the US Forest Service in 1974 (the last time such things were re-defined). This means that the Pacific Northwest will consist of Washington and Oregon, while the South will contain Oklahoma, Texas, Arkansas, Louisiana, Mississippi, Alabama, Florida, Georgia, Kentucky, Tennessee, South Carolina, North Carolina, and Virginia. (Cox, 2000)

They continue on and explain how they came to choose one million board feet as the unit by which they will increment the output before explaining what that means in dollar terms for each region. In 1993 prices (used to maintain consistency with the 1993

IMPLAN data that is used), the delivered price in the South is $254.50 per thousand board feet, with that price in the Pacific Northwest being much higher, coming in at $449.49 per thousand board feet. (Cox, 2000)

Without really getting into the details of how the model was built, or how it works in a behind the scenes manner, they then move on to summarize the results of implanting the model. As it would turn out, the incremental impact of an extra million board feet was greater in the Pacific Northwest (precipitated by the much higher cost per thousand board feet). The increase in output value in the Northwest is $739,706 compared to the increase of $458,998 in the South. The increase in value added is $330,194 in the Northwest, generating an additional personal income in the same of $194,623. The same numbers for an increase in the South are $180,432 and $108,295, respectively. In the final (and likely most important) category of job creation, an increase of one million board feet of output will generate 6.41 new jobs in the Northwest but only 4.36 in the South (this may be due to the increasing likelihood mentioned earlier of the South to begin to substitute more capital for labor in their already very labor intensive system. (Cox, 2000)

In their conclusion, the authors interpret the results to support their ultimate policy making goal. They begin by providing the differentials between the numbers in the Northwest and the South (an exercise which shall be here left to the reader). They then use these numbers in almost an opposite sense, where the Northwest is losing production (causing large output drops and much unemployment, as has been seen in the time period from 1986 to 1991) and the South is gaining that production (with smaller increases in employment and output). They use this to support their conclusion that the policy changes of the recent years may have protected some forests, but have only really lead to large losses in jobs and output dollars as that output was replaced in another area. (Cox, 2000) This paper then is a fine example of an input-output model being used to both compare the economic impacts in two regions and an impact model being used to support a standpoint on a government policy.

While today CGE, SAM, and I-O models take most of the attention in terms of regional economic modeling (at least in the higher-level research), they are not the only options for such research. A new paper by Dr. Noel Roy and Dr. William Schrank (both of the University of Newfoundland) and Dr. Ragnar Arnason (of the University of Iceland) seeks to use the older premise of an Economic Base model to explore some commonly held beliefs about the economy of Newfoundland, namely its reliance on the cod fishing industry. This paper is entitled "The Fishery as Economic Base in the Newfoundland Economy," and was presented at the 2006 Portsmouth conference of the International Institute of Fisheries, Economics, and Trade (IIFET).

The paper begins with an exploration of the history of the island of Newfoundland, focusing on how it came to be that its economy was dominated by the cod fishing industry. As it would turn out, the island was originally settled as an English settlement placed entirely to supply dried cod. (Roy, 2006) This industry that was the cause for the birth of the settlement endured through many attempts to diversify the economic base. When Newfoundland became a Canadian province in 1949, fishing accounted for around twenty percent of its GDP (this is fairly high, though down from the near ninety percent it accounted for in the mid-1800s). (Roy, 2006) As the Canadian and provincial governments made attempts to modernize the area and increase alternative businesses to the fishing industry, the percentage of GDP produced in this industry slowly tailed off. By the turn of the twenty-first century, not even five percent of the island's GDP was produced through fishing. Yet Newfoundland still maintains its reputation (both internally as well as to the outside world) of being totally dependant on a fishing industry that is now a minor part of its employment and economic structure. (Roy, 2006) The study was done to determine which is more accurate; the long-held views of residents and outsiders alike or the numbers of the modern GDP tables.

The authors seek to do this by determining if the fishing industry is still the economic base of the area. If they can prove this, they believe that it will show that this industry holds an importance that belies the numbers. Alternatively, if it is not a base industry, it will give more weight to the theory the numbers suggest; specifically that fishing is now only of minimal importance to the local economy.

The paper starts by explaining in fairly detailed terms what an economic base model is and how a base industry is determined. As this will be done with the Youngstown area later in this paper, this description will be saved for that section. For the purposes of discussing the Newfoundland paper, it is sufficient to say that the authors will seek to prove that the incomes and production of the fishing industry are directly related (perhaps implying a causal link) to the income and production of the region as a whole.

As the paper moves on, it proceeds to explain some of the statistics that are used behind the scenes in collecting and analyzing the data. As these techniques are not something that this study will focus on, we shall skip over them in the Newfoundland paper to make more note of the results, these being the far more relevant things. Also being skipped over are the sections that cover the creation of the models that they use as well as the data collection itself. The only interesting thing here is that the authors decide to use a co-integration analysis in determining the strength of the relationship between the strength, size, and health of the fishing industry to that of the island as a whole. (Roy, 2006)

The result of this study is that it would seem that the impact of the fishing sector in Newfoundland is much greater than its portion of GDP. The numerical value of the elasticity between the size of the fishing industry and the overall economy is approximately three times the size of what the direct impact would be, which the authors state implies the presence of a fairly strong multiplier effect. (Roy, 2006) This elasticity value seems to prove that the impressions of the world are true in terms of the impact of the fishing industry on the economy of Newfoundland, which is exactly what the authors of the paper conclude.

Of course, anytime a study is done there can be interesting side points found from the modeling that were not intended, but are worthy of report nonetheless. Here, the authors have found three points that they think are worthy of mention. The first is that the numbers imply that future economic growth is linked to the usage of capital to a far higher degree than labor. This would make gaining a substantial increase in employment very difficult without a disproportionately large infusion of capital to cause it. Further, it explains to some degree why the problem of unemployment is so pronounced in this region. The second additional point is that, though in the standard economic base model the causation is in a single direction (the base causes the non-base to change but not the other way around), the numbers for Newfoundland seem to indicate that here the change can be initiated from either side. This means that while a change in the base does certainly cause a change in the non-base, a change in the non-base can also cause a change in the base (though to a lesser degree). Though the authors do not expound on why this may be, common sense seems to suggest that it might be related to the fact that the fisheries produce not only an export good, but also the main foodstuff for the island's population. Therefore an increase in the population of the island due to non-base sector production would cause an increased demand for the fish and so higher base sector employment. Third, the authors report that they have found that all variables in the study seem to be fairly closely related, which may impact the quality of the statements made overall. (Roy, 2006)

Another alternative to those methods already listed is the use of econometric modeling techniques in application to impact modeling. The study of such models is an entire field unto itself, and can therefore be given only cursory attention here. They are best applied in situations where a large amount of data on changes and their impacts exist, a large enough data set that it may be fed into a regression model. From this regression model can be gleaned the coefficients of an impact equation. This equation itself then becomes a powerful tool in and of itself, accepting any data entered and computing a predicted impact. Because of these features, the econometric model is the most flexible of all the models and the easiest to work with once it has been set up initially.

Such a model is currently made available online as the Ontario Tourism Regional Economic Impact Model (TREIM). This model is open to all, inviting website visitors to input a change and view the predicted economic impact. The stated goal of the model is to enable a detailed economic analysis of various parts of the province of Ontario by distributing direct tourism spending. (Canada, 2006)

Users of TREIM enter their shock to the economy into a data sheet (either using Microsoft Excel or EViews. These shocks are then categorized into a number of categories and sub-categories, each of which has its own impact coefficient. In addition, the model contains several variables that are representative of certain characteristics of the shock. Characteristics represented include region impacted (or whole province, if applicable), the year in which the shock occurs, exactly what impacts are desired, and whether or not to use the baseline or specific modifications. (Canada, 2006)

All of these variables and their corresponding coefficients are used to create a shock matrix (this is in terms of dollars), which is further compressed into a shock vector based on commodities. This vector is what shows to the user and what is ultimately readable as the economic impact of the shock. (Canada, 2006)

This is but one of the seven options the user has in terms of what they can enter and what it can output. All these options and equations are based upon an underlying macroeconomic model which is dynamic in its nature. Existing within the model are several sets of variables (including GDP growth, Consumer Price Index changes, population growth, and even the exchange rate between the Canadian dollar and the US dollar). These variables are estimated for the entire length of the model (from 1996-2008), but can also be overridden by the predictions of the users themselves. (Canada, 2006)

A complex set of equations uses all of this data (both that which exists within the model itself and the user entered variables) to generate numbers representing the direct and subsequent indirect impacts. These equations vary depending on if the impacts desired (if the household sector is desired versus the corporate sector) and also take into account the impact of taxes and the impact of changes on tax revenues. These are described in great detail within the methodology document produced for TREIM; however, as they are outside the scope of this study and are not applicable to the Youngstown-Warren region (which would have its own, entirely different set of equations), they shall not be presented here for the sake of brevity.

This document then goes on to discuss in great detail the data that was used to determine the coefficients and forms for these equations. This data was gathered primarily via survey methods including census documents and industry data sets (of employment, output, etc.). Most data comes from the base year of 1999 (meaning that the model has been estimated into the past from its date of creation, as well as into the future). (Canada, 2006) This data was then fed into econometric models of various standards forms, resulting in more precise equation forms and the exact coefficients which are finally those built into the model.

Few other models could accommodate the creation of a webpage that would allow users to users to enter a shock and immediately (with little further interaction on their part) a prediction of the economic shock is produced. The dynamic basis for this model also makes it better suited for certain types of analysis, including the impact of a shift years into the future (especially if a lag model is estimated). Yet for all of its advantages, the econometric model is hard pressed in static shock situations to replicate the advanced modeling capabilities of the CGE or I-O models. Therefore, it is not in itself the perfect model that can replace all others.

The studies reviewed here are only a small sample of the many economic impact analyses done on a regular basis. They are presented to provide something of a context to the reader for the models and data that will follow but are by no means supposed to represent an exhaustive list of methodologies or applications. Such as list would require far more space than can be allocated here (and would likely consume volumes before it was halfway complete) in addition to detracting from the main focus of this paper, which is to speak to the conditions in the Youngstown area.

The Economic Models

As was previously stated, we will look at two major modeling strategies for determining regional economic impacts. These models are as follows:

1.) The Economic Base Model

2.) A Simple Input-Output Model

In this study, the models are to be presented in this order so as to present the simplest model first, saving the more complex and detailed (and potentially accurate) model for second. This ordering is designed to give the reader an idea of how much work would be needed in each model to obtain its given result and level of accuracy as compared to the other model. By comparing amount of work needed to level of accuracy, perhaps some sort of conclusion and rule can be reached for selecting which model to use based upon the particular project at hand's need for accuracy and/or speed of work. It also allows for testing of the common sense conclusion that the model requiring the most in-depth work and most challenging procedures would be the one with the most accurate result. Of course, none of this is meant to imply that either model is particularly easy or quick to implement. Nor is it meant to imply that one model is always going to be more accurate than the other. Rather, they are simply general statements made for the enlightenment of the reader. Going forward with this in mind might allow for greater insight into the positives and negatives of each model.

The Economic Base Model

The first model we shall examine and implement is the economic base model. According to McCann (in his book, Urban and Regional Economics), this model is designed to focus on the links between aggregate sectors in the regional economy. It is therefore ideal for studying a dynamic economy, and specifically a given change in an established economy, exactly the case present in the Mahoning Valley.

The basic theory behind this model is fairly straight-forward. It states that there exist within an economy two aggregate sectors which interact in such a way that any change in one sector is reflected by a secondary change in the other sector. The degree by which a change in the primary sector (termed the base sector) has an impact on the other sector (the non-base sector) is the multiplier effect and the main direction in which secondary change is said to travel, though a converse effect (albeit a greatly reduced one) may be present in some situations (as noted in the Newfoundland paper perused in the review of literature section). It is fairly safe to say that the impact of the base sector on the non-base sector will always be greater than the impact of the non-base sector on the base sector (indeed the multiplier calculated in the direction of the former should generally be held to be greater than one while the effect in the later case would generally be much less than one).

The model starts off by dividing the economy into two distinct but rather generic sectors, the aforementioned base sector and non-base sector. (McCann, 2001) The basic sector is distinguished by being primarily dependant on conditions in the external economy (external to the region itself, could be national conditions or even international, depending on the markets the firms within the sector deal in primarily), while the non-basic sector, of course, would be dependant on conditions within that specific region of the country. (McCann, 2001) This distinction is usually a fairly subjective one and how the division of a region's industries ends up is always a function of the person who is doing the dividing. The truest test of a division between base and non-base sectors would be over time to see if they hold a fairly similar relationship in terms of the multiplier, which ought to remain constant over time. As can be seen in the mathematics section of this model, that is exactly what I shall endeavor to do here. Hampering this effort is the lack of data availability as the categories for industrial division were revised in 2001, rendering data before 2001 useless in consistency checking. It is important to note that the basic sector industries are also sometimes called the export-base industries, and would generally be within the manufacturing and production sectors, with service sector jobs usually (but not always) being categorized as non-basic.

Such differentiation and division into sectors is very central to the core of the model, but is not always as easy as it might at first appear. We have obtained a listing of all the industries present and counted in the Mahoning Valley with employment numbers for the years 2001, 2002, and 2003 (this being the last year's data that was published at the time the data was collected). This list follows here:

Line Code	Line Title	2001	2002	2003
10	Total employment	358179	353075	350942
20	Wage and salary employment	301061	294492	290624

40	Proprietors employment	57118	58583	60318
50	Farm proprietors employment	4077	4126	4120
60	Nonfarm proprietors employment 2/	53041	54457	56198
70	Farm employment	5241	5149	5062
80	Nonfarm employment	352938	347926	345880
90	Private employment	311707	306337	304390
100	Forestry, fishing, related activities, and other 3/	0	657	0
200	Mining	0	1455	0
300	Utilities	0	1110	1053
400	Construction	19102	18301	17947
500	Manufacturing	58865	54416	51016
600	Wholesale trade	0	11075	11631
700	Retail trade	48717	47183	47276
800	Transportation and warehousing	11861	11528	11305
900	Information	4294	4407	4698
1000	Finance and insurance	10855	11146	11328
1100	Real estate and rental and leasing	8801	8931	9045
1200	Professional and technical services	0	12040	12016
1300	Management of companies and enterprises	1609	1848	1853
1400	Administrative and waste services	18043	18155	17252
1500	Educational services	4590	4797	5028
1600	Health care and social assistance	45792	47477	48548
1700	Arts, entertainment, and recreation	4998	5094	4968
1800	Accommodation and food services	25056	25107	25072
1900	Other services, except public administration	21706	21610	22248
2000	Government and government enterprises	41231	41589	41490
2001	Federal, civilian	2837	2793	2716
2002	Military	1979	2016	2037
2010	State and local	36415	36780	36737
2011	State government	7356	7519	7741
2012	Local government	29059	29261	28996

Source: Regional Economic Information System, Bureau of Economic Analysis, U.S. Department of Commerce

Table 1: Regional Employment Data (Source: Bureau of Economic Analysis)

Now begins the somewhat arduous task of separating the above listed categories into basic and non-basic sectors. Omitting the seven listings that are merely totals of the prior entries, we have a total of twenty-six categories that need to be separated. The first is Farm Proprietors employment. Looking at total farm production versus goods consumption in the Mahoning Valley, the area is not a major exporter of farm goods leading to the conclusion that farm proprietors employment is dependant more on local demand for goods than external factors, and so should be termed a non-basic sector.

Non-farm proprietor employment is next. Looking at the make up of the small, locally-owned businesses in the area, the vast majority do business only at a local level. Therefore this sector too should be termed as a non-basic sector. The third sector that needs to be categorized is that of generic farm employment. As was stated earlier with farm proprietor employment, this area is not a major exporter of farm goods, and this employment, like the farm proprietor sector, should be lumped into the non-basic sector.

This brings us to the private, non-farm group of jobs. The first of these is Forestry, fishing, and related activities. Here employment in this area is very low, most of which is consumed immediately within the Mahoning Valley. Because of this, this is categorized as a non-basic industry. The next category is mining, and, while mining operations are somewhat widespread throughout the area (especially strip mining for coal), most of the resulting products are directly consumed in the area's numerous coal burning power facilities and other plants. Mining is thus consigned to the non-basic sector. Utilities and construction, the next two categories, are much the same as mining, in that, though widespread, they are primarily consumed directly within the region and should be grouped in with the non-basic sector jobs as well. Manufacturing is the next category. Here are included the Lordstown General Motors Assembly, in addition to numerous other plants producing everything from chemicals to specialty steel products. These plants sell the vast majority of their output to consumers that are not in the region, selling good both throughout the rest of the United States and the world as a whole. To this end, manufacturing is, for this area, a basic sector industry. Wholesale trade conducted within the Mahoning Valley has many of the same features as manufacturing, in that it brings goods into the area, and sends them out mainly in relationship to demand for said goods in the country as a whole, rather than the specific region. This is especially true with the wholesale goods that go out; making it a basic sector industry. Retail trade, on the other hand, is primarily dealing with the demand for goods within the region. Huge shopping areas in the suburbs of Boardman and Niles consist of miles of road lined with shops of every description and large shopping malls. These areas are the largest source of this category, and depend primarily on local shoppers, making this category a non-basic sector of employment. Transportation and warehousing, the next sector, has a unique feature in this region. Many large scale trucking operations are based out of the Mahoning Valley, and many others exist to serve the needs of the large wholesale trade businesses and manufacturing plants. This means that the Transportation and warehousing sector can depend primarily on external rather than internal influences, putting it squarely into the basic sector.

The remaining fifteen fields are in two main categories, the service industries (which, as the name suggests will be primarily non-basic sector employment) and government employment. In the service areas, Information is the first category. In the Mahoning Valley, most information services are small concerns, and exist primarily in support of larger industries. While this area is growing, it is not yet at a size or level of production as to be considered a base industry. Finance and Insurance is the next major sector. This would include all banks, corporate financial entities, and insurance providers in the area. Most of the banks in the Mahoning Valley are branch banks with their headquarters in other larger cities spread throughout the Northeast. For these branches, their existence in the Mahoning Valley is to provide services to local private citizens and small corporations, with larger (and out of region) corporate lending being handled by the headquarters. For those banks that are completely located within the region (such as The Home Savings and Loan Company), these are primarily concerned with home and auto loans to the general public, these being almost exclusively within the region. As such, the Finance and Insurance sector is to be categorized as a non-basic sector. Real estate, rentals, and leasing are the next category, with a fairly decent amount of employment in these areas (though it still palls in comparison to other areas of employment). Most real estate development in the Youngstown-Warren area is concentrated on the building and sales of private single-family homes and one or two bedroom apartments in relatively small apartment complexes. As demand for these sorts of things is primarily dependant on the employment in other areas (i.e. if a plant opens, there will be increased demand for housing, and if a plant should close, the housing demand would fall), this sector is to be categorized as non-basic.

A substantial industry in the area is that of Professional and Technical Services. The things included in this area (as the name would suggest) do exist primarily to serve other industries within the area, which is nearly the definition of a non-basic sector industry. Another sector which falls under this definition basically through its own definition is that of Management of companies and employees. Though people employed in this sector may be employed within the confines a base industry, their services are only in need because of the existence of these larger industries. The next category on the list is that of Administrative and waste services. With a reasonably large population in the area and several larger industrial areas, the amount of waste generated is rather prodigious. Thus a large workforce is needed to haul it away. However, because this workforce is primarily needed because of the existing population base within the area, it is a non-basic sector. Educational Services is next with the primary source of employment here being employed at Youngstown State University, smaller technical and trade schools, and within local school systems. Of course the trade schools and local systems exist to service the local population, but what of the major university? In many areas a large state university would be considered a basic industry as they would draw in many students from outside the area and thus have an employment based primarily on out of area concerns. However, in the case of Youngstown State University, nearly all the students come from within the area (in fact, most commute, with the University only having housing on campus for maybe one thousand of the thirteen thousand plus students enrolled). This means that demand for the education services provided by the university (and so the employment of the university) is primarily dependant on the existing population of the region, making Educational Services a non-basic sector industry.

The following category is that of Health care and social assistance. People employed in this field are primarily doctors, nurses, and technicians in the regions' two major health system, Humility of Mary and Forum Health. Though this is a very large sector of employment, these critical services exist almost exclusively to service the local population. This makes this industry a non-basic sector. The next sector is the Arts, entertainment, and recreation sector. Though the area has a productive arts sector, it mainly sells its works on the local market. This means that demand would be dependant on the local population, as well as the disposable income they earn in a different sector, putting the arts squarely into the non-basic category. Accommodation and food services are the next category. Though the area does not have a large destination vacation industry, it does have quite a few hotels that cater to the business travelers and those that may just be passing by on the many major highways that cut directly through the area. By this token, the accommodation industry would be a basic industry, since the demand for these services would be dependant on how many people are passing through and other factors that are external to the region. The service sector is rounded out with a category described only as other services, except public administration. Included here would be small sectors, such as printing or distributing, that would be in existence to serve the existing industrial base. With this being the case, it is clear that this sector should be included in the non-basic group.

Next on the list are the various sectors that make up the governmental presence in the area. First is the Federal, civilian category. Included here would be the employees of the federal buildings, the local federal circuit courts, and the federal law enforcement within the area. These jobs are located in the area to serve the larger federal government as a whole, and so are independent of the demands of other industries in the region, making this a basic sector. The next item listed under the federal government category is the Military employment of the region. This is mainly made up of those employed at the air force base at the Youngstown-Warren airport at Vienna. As this base is placed and staffed according to US Air Force guidelines and orders, the employment there is independent of any influence by the local population (demonstrations to prevent its closure notwithstanding). This makes it a base industry. The third governmental category is that of state government. The argument here is much the same as that for the civilian federal government employment, that this employment level is decided in Columbus based on what services it wants to locate in the region. Thus the impact by local industry is negligible and this is a base sector industry. Finally, we have the employment by the local governments of the region. This employment is directly related to the needs and sizes of the local populace. Therefore, local government would fall into the non-basic sector.

This coding gives us a categorized employment view that looks like this:

Line Code	Line Title	2001	2002	2003	B/N
10	Total employment	358179	353075	350942	-
20	Wage and salary employment	301061	294492	290624	-
40	Proprietors employment	57118	58583	60318	-
50	Farm proprietors employment	4077	4126	4120	N
60	Nonfarm proprietors employment 2/	53041	54457	56198	N
70	Farm employment	5241	5149	5062	N
80	Nonfarm employment	352938	347926	345880	-
90	Private employment	311707	306337	304390	-
100	Forestry, fishing, related activities, and other 3/	0	657	0	N
200	Mining	0	1455	0	N
300	Utilities	0	1110	1053	N
400	Construction	19102	18301	17947	N
500	Manufacturing	58865	54416	51016	B
600	Wholesale trade	0	11075	11631	B
700	Retail trade	48717	47183	47276	N
800	Transportation and warehousing	11861	11528	11305	B
900	Information	4294	4407	4698	N
1000	Finance and insurance	10855	11146	11328	N
1100	Real estate and rental and leasing	8801	8931	9045	N
1200	Professional and technical services	0	12040	12016	N
1300	Management of companies and enterprises	1609	1848	1853	N
1400	Administrative and waste services	18043	18155	17252	N
1500	Educational services	4590	4797	5028	N
1600	Health care and social assistance	45792	47477	48548	N
1700	Arts, entertainment, and recreation	4998	5094	4968	N
1800	Accommodation and food services	25056	25107	25072	B
1900	Other services, except public administration	21706	21610	22248	N
2000	Government and government enterprises	41231	41589	41490	-
2001	Federal, civilian	2837	2793	2716	B
2002	Military	1979	2016	2037	B
2010	State and local	36415	36780	36737	-
2011	State government	7356	7519	7741	B
2012	Local government	29059	29261	28996	N

Source: Regional Economic Information System, Bureau of Economic Analysis, U.S. Department of Commerce

Table 2: Employment divided by Base/Non-Base (Source: Bureau of Economic Analysis)

This chart shows the divisions, with the Base sectors being coded blue and with a 'B' in the "B\N" column, and the Non-Base sectors being coded yellow with a 'N' in the "B\N" column.

With this task disposed of, the next step in the model is to go through some of the mathematics in deriving an equation form for the relationship between the base and the non-base employment. This series of derivations is found in McCann, but will be reproduced here for clarity and explanation. We start off with a fairly simple relationship, that total employment (*T*) is equal to the sum of base sector employment (*B*) and non-base sector employment (*N*). (McCann, 2001)

$$T = B + N \qquad (1)$$

This, of course, is fairly apparent as the numbers for the base sector and non-base sector are arrived at by dividing all of the components of the total number. If we say that the non-base sector employment is a function of the performance of the local economy and local population as a whole, then this can be re-written as:

$$T = B + nT \qquad (2)$$

where n is some coefficient between such that $0 < n < 1$, representing the change in non-base sector employment for each unit change in total employment within the community. (McCann, 2001) This perhaps is not as obvious of a modification as it introduces another T into the system. What this means to say is that the non-base sector employment is generally some fixed fraction of total employment. This then implies that non-base sector employment is mainly dependant on base sector employment. If a bit a re-arranging is done to equation 2, we come up with equation number 3. (McCann, 2001)

$$\frac{T}{B} = \frac{1}{1-n} \qquad (3)$$

This ratio (T/B) is called the economic base multiplier by McCann. It is representative of the relationship between base sector employment and total employment. (McCann, 2001) Now we are at a point where we might begin to examine what happens in a dynamic situation. In a dynamic case (and with one last bit of re-arranging), equation 3 can become equation 4.

$$\Delta T = \frac{1}{1-n}\Delta B \qquad (4)$$

This equation implies that the change in total employment is equal to the economic base multiplier multiplied by the change in the base sector employment and is arrived at through a simple substitution of changes in T and B for the variables themselves and some algebraic manipulation. (McCann, 2001)

Now that there is established a mathematical relationship between the base sector employment and total employment, we can examine what such a relationship looks like in numerical terms for the Youngstown-Warren area for the time period 2001-2003. Numerically, based on the discussion of division of sectors above, the total employment, basic, and non-basic sectors are as follows;

	2001	2002	2003
Non-Base	279925	297204	297636
Base	107954	114454	111518
Total	387879	411658	409154

Table 3: Employment Totals for 2001-2003

With this, we can work through the various derivations and find the value of the multiplier, $\frac{1}{1-n}$.

	2001	2002	2003
T/B =	3.5930	3.5967	3.6690
1/ (T/B) =	0.2783	0.2780	0.2726
(1/ (T/B)) -1 =	-0.7217	-0.7220	-0.7274
(-1)(1/(T/B))-1 =	0.7217	0.7220	0.7274

n =	0.7217	0.7220	0.7274
Multiplier (1/(1-n)) =	3.5930	3.5967	3.6690

Table 4: Multiplier Calculations for 2001-2003

As can be seen here, the multiplier changes a bit in value every year, but maintains a value somewhat close to 3.6 throughout.

But how are we to test such a result? One way of testing such a number might be to take one of the *n* values and apply it to the other two years. If the error between the predicted values using the single year *n* value and the actual values is low, then it might be said that we have found an assignment of base and non-base sectors that results in a consistent multiplier, and so have a plausible way of estimating the change that would occur from the major job loss should the Lordstown plant shut its doors permanently.

For lack of a clear-cut reason to choose any one number over another, we shall choose the 2002 value. With the selection of the value, the numbers would look as follows;

	2001	**2002**	**2003**
n =	0.7220	0.7220	0.7220
nT =	280036.3173	297204.0000	295396.1915
B + nT =	387990.3173	411658.0000	406914.1915
Expected =	387990.3173	411658.0000	406914.1915
Observed =	387879.0000	411658.0000	409154.0000
Observed - Exp =	-111.3173	0.0000	2239.8085
Error (diff/exp.) =	-0.0003	0.0000	0.0055
% error =	-0.0287	0.0000	0.5504

Table 5: Consistency Check Using 2002 Multiplier

As can be seen, applying the observed *n* value from 2002 to 2001 and 2003, the error is very low. This is especially true in for the year 2001, where applying the 2002 *n* of 0.7220 yields a percentage error of only -0.0287%. Even with the larger error in 2003, the percentage error is still only 0.5504%. This consistency of numbers is precisely what was sought in our data and confirms that the division of industries into the base and non-base sectors was successful in generating at least consistency in data. At this point, it can be said that we have with high probability (given available data) a fair estimation of the true value of n for the Youngstown-Warren area.

We can therefore use the multiplier from 2002 (as well as the data from that year) to estimate the total impact of a loss the 6,000 base sector jobs that would be involved in a shutdown of the Lordstown facility. In doing so, we will use equation 4 with the change in B being set equal to 6,000. This will give us the change in T which is the total amount of total jobs in the economy lost owing to the plant closure. Using these numbers, we can determine the number of non-base sector jobs to be lost in total. The calculations would be as follows;

	using 2002 data
B =	114454.0000
Jobs lost =	-6000.0000
Multiplier (1/(1-n)) =	3.5967
Change in Total =	-21580.2681
T* =	390077.7319
B* =	108454.0000
N* =	281623.7319
Change in N =	-15580.2681
nT* =	281623.7319

Table 6: Economic Base Model Predicted Changes

The total number of jobs lost in the economy is a surprisingly high 21,580. Taking out the 6,000 jobs that we know were lost in the base sector (the primary change due to the plant closure), we have a total of 15,580 jobs lost in the non-base sector (this is the secondary impact). Thus, according to the Economic Base model, the secondary impact of 6,000 lost base sector jobs is enormous.

An interesting variant on this model exists. While equation 2 may be a decent representation of an economy, it could be said to be a bit simplistic. This simplicity comes from the fact that it fails to consider that there might be some extraneous non-base sector employment which is not dependant on the base sector (i.e. that there is some fixed non-base sector employment in addition to the employment that is based on total employment) . There is no facility in the current equation for such a thing, so to work it into our model we will have to rework equation 2. (Once again, equations come from McCann.) The reworked equation would look something like this:

$$T = B + (N_0 + n_1 T) \qquad (5)$$

Here the extra N_0 represents the extraneous non-base employment at a zero level of base sector employment. (McCann, 2001) Following a similar progression to that going from equation 2 to equation 3, we can do a bit of rearranging on equation number 5 and arrive at equation 6. (McCann, 2001)

$$T = \frac{N_0}{1-n_1} + \frac{B}{1-n_1} \qquad (6)$$

Now, the question becomes how to work with this equation. While the change in T collapses to the same thing as equation 4, the equation itself is different and the steps needed to find n_1 would differ from those taken to find n. If we let $\hat{\mathrm{B}}_1 = \frac{1}{1-n_1}$ and $\hat{\mathrm{B}}_0 = \frac{N_0}{1-n_1}$ (which happens to let $\hat{\mathrm{B}}_0 = T - \hat{\mathrm{B}}_1 B$), then equation 6 can be re-written as:

$$T = \mathrm{B}_0 + \mathrm{B}_1 B + \mu_x \qquad (7)$$

or

$$\hat{T} = \hat{\mathrm{B}}_0 + \hat{\mathrm{B}}_1 B \qquad (8)$$

With the equations in this form, we could apply standard econometric regression techniques. The model we are studying in this case is $T = f(B$, cet. par.*)*, and the sign for B is predicted to be positive. Running the numbers through a linear regression,

$\hat{B}_0 = -13{,}361.25$ and $\hat{B}_1 = 3.7396$. While the number for $\hat{B}_1$ is not surprising (it is only a bit off the value of the multiplier uncovered in the more simple technique), the number for $\hat{B}_0$ is rather unsettling. The negative value seems to indicate that the base level of employment would be less than zero, which seems not only implausible but impossible. What might cause this error here? The most logical explanation is that this is due to the fact that we have only three data points for the regression to work on. This low number of data points would lend tremendous amount of error to the final calculation. If only for the mere basis of comparison, we can still calculate the projected new employment with the change in base of -6,000. Doing much the same calculations as we did earlier with the simpler base model, we arrive at numbers that are as follows;

	using 2002 data
B =	114454.0000
Jobs lost =	-6000.0000
Multiplier (1/(1-n)) =	3.7397
Change in Total =	-22438.0506
T* =	389219.9494
B* =	108454.0000
N* =	280765.9494
Change in N =	-16438.0506

Table 7: Econometric Model Predicted Changes

Here the change in N is much larger that previously (-22,438 vs. -21,580), which was not what one might anticipate with such changes in the model. With a degree of exogenous non-base sector employment, it would stand to reason that the overall impact of the loss of the 6,000 jobs would be smaller than it was previously (since there is a smaller portion of T that is dependant on the base sector employment in and of itself). Possible reasons for this discrepancy are numerous, but it seems most likely that it is somehow due to the error that was apparently worked into the regression. The error in the regression then leads to the belief that this value for the change in total employment very probably also has quite a bit of error. Therefore, we shall disregard this secondary result, and continue on with the other model, comparing only the first arrived upon value of 21,580.

In an intermediate analysis of the values arrived upon through the use of the economic base model (the full analysis will have to wait until the values from the Input-Output model have been calculated) shows that the value was perhaps a bit high at 21,580. But is this really so high as to be unreasonable? To determine this, one must look at the initial change for what it really is. The loss of 6,000 jobs is not necessarily the loss of only 6,000 citizens for the region. If we assume that there are an average of 2 dependants (spouse and/or child), then this means that around 18,000 people will be leaving the region. This number of people would need a rather large support infrastructure, including shops, medical care, police/fire protection, etc. Most importantly, this would mean the loss of around 6.000 children to the region, which is nearly an entirely school district worth. The loss of the many children would most definitely close several schools in the region which would entail the loss of many jobs for teachers, administrators, transportation workers, and other support staff. With all these changes in the community as a result of the plant closure, it is not hard to believe that many thousands more jobs would be lost in the area, perhaps even more than the 21,000 that are predicted by the economic base model. However, as was said before, it would be nearly impossible to finally judge the results of the base model without first having the results of the Input-Output model. Therefore, we shall move on directly to the building of that model.

A Simple Input-Output Model

An input-output model is the second way by which we will attempt to quantify the change in total employment that the Mahoning Valley would experience if the Lordstown assembly plant were to close entirely. These models break down the aggregate flows of expenditures into separate flows by dividing them up by industry. For example, a farm may produce a certain number of bushels of wheat but where is it that this wheat is going? The input-out tables would show this wheat as being produced by the farm, and also show how much of it goes to say, the bakery or to the wholesale markets. But how does this help us decide what the change in employment would be? The key is that, because we can already quantify the reduction in manufacturing that would happen with the closure of the Lordstown plant, we can translate this (using the input-output tables) to a decrease in the inputs that would be needed from local companies/individuals. This would enable us to quantify the trickle down in job loss that would occur from a large employer shutting its doors. Though this sounds as though it might be a fairly easy thing to accomplish, it turns out to be anything but. This model needs far more data than the economic base model needed to arrive at its results. A problem arises here in that some of the data tables and lists needed for this model are not readily available for the Youngstown-Warren region. To get around this limitation, we will need to derive some of the missing data before we can even begin to estimate our model. Even before that, however, it is necessary to discuss where the input-output model comes from in terms of its mathematics.

The most basic need in terms of the creation of an input-output model is the calculation of a table that shows what each industry uses from each other industry. The natural starting place for this table is the transaction table (which is itself a squaring of the make and use matrices available from the Bureau of Economic Analysis). A transaction table is generally a collection of rows that are each of the form:

$$X_{1i} + X_{2i} + X_{3i} + ... + X_{ji} + Y_i = Z_i \quad (9)$$

for all rows i and columns j. (Schaffer, 1999) Creating a requirements table (the matrix that shows the fraction of each industries output that comes from each input) is then simply a matter of turning this table of totals into one of fractions. If we call q_j the sum of each column j of the transaction table, then each element of the direct requirement table can be calculated as:

$$a_{ji} = x_{ji} / q_j \quad (10)$$

The y column is a vector that is exogenous to the system (which will ultimately be the place where we can place the initial impact of the change that we will study), and is therefore not converted to the direct requirements table. (Schaffer, 1999) Equation ten can be re-written in such a way as to be able to substitute for x in equation nine. (Schaffer, 1999)

$$x_{ji} = a_{ji} * q_j \quad (11)$$

Substituting this into equation nine for all x variables then yields equation twelve. (Schaffer, 1999)

$$a_{1i} * q_1 + a_{2i} * q_2 + ... + a_{ji} * q_j + y_i = z_i \quad (12)$$

It also must be noted that this is an equilibrium model, meaning that supply must equal demand within this system. (Schaffer, 1999)

$$q_i = z_i \quad (13)$$

Substituting this relationship into equation twelve gives us equation fourteen. (Schaffer, 1999)

$$a_{1i} * q_1 + a_{2i} * q_2 + ... + a_{ji} * q_j + y_i = q_i \quad (14)$$

Combining the matrix/system of equations represented by equation fourteen into one equation yields equation fifteen, shown here:

$$q = A * q + y \quad (15)$$

Note that here the a's have been replaced by matrix A and the individual q's and y's have been combined into the corresponding vectors. (Schaffer, 1999)

The amount of mathematics done to get to this point is hardly trivial in its theory. Though we are hardly near the completion of the mathematics of the model itself, we have enough to pause for a moment and attempt to gather the data that will be needed for the equations we have derived to mean anything in a practical sense.

The first data table that we need in order to complete the model is a regional direct requirements table. This is a matrix that shows what fraction of an industry's output is derived from a specific input (which was in turn the output of another industry). Such a matrix is not available for the Youngstown area so we must derive it from the national direct requirements table, which is available for download from the Bureau of Economic Analysis website.

Such a derivation is no easy or quick task. It requires the use of Location Quotients, which are a method of comparing the business composition of an area to that of the nation as a whole. (Location, 2006) Such numbers may then be used to "regionalize" data that is available for the nation but not the smaller area. Such numbers are only estimates though, and do add error to the final model. Without more specific data though, this is unavoidable.

The specific equation to calculate a location quotient for a specific industry is given in equation sixteen. (McCann, 2001)

$$LQ_{ir} = \frac{E_{ir}/E_r}{E_{in}/E_n} \qquad (16)$$

In this equation, the resulting value (*LQ*) is the location quotient for that industry (*i*) in that region (*r*). The E_{ir} that is the numerator of the numerator is to represent the employment in the specified industry within the specified region. The denominator of the numerator (E_r) is the total employment of all industries within the region. The numerator of the denominator (E_{in}) is to represent the employment of that industry in the nation as a whole while the denominator of the denominator (E_n) is to represent the nation's employment in total. (McCann, 2001)

To use this equation, we must acquire lists of the employment for both the region and the nation in the same categories. Such data is easily obtained from the Bureau of Economic Analysis and follows directly for 2001-2003 (national data presented first, followed by regional data.

National Employment 2001-2003

Industry Code(s)	Industry Title	2003	2002	2001
81	Farm earnings	45594000	32257000	42811000
100	Forestry, fishing, related activities, and other 7/	26962000	26435000	25983000
201	Oil and gas extraction	28402000	27076000	32472000
202	Mining (except oil and gas)	15368000	15266000	15263000
203	Support activities for mining	12739000	11922000	12428000
300	Utilities	73585000	71428000	70299000
400	Construction	430782000	413862000	408573000
511	Wood product manufacturing	22356000	22259000	22362000
512	Nonmetallic mineral product manufacturing	27325000	27328000	27218000
513	Primary metal manufacturing	31128000	31417000	33512000

514	Fabricated metal product manufacturing	77061000	77135000	79803000
515	Machinery manufacturing	75537000	75305000	79538000
516	Computer and electronic product manufacturing	124396000	125263000	138316000
517	Electrical equipment and appliance manufacturing	27415000	27616000	29037000
518	Motor vehicles, bodies and trailers, and parts manufacturing	105819000	86704000	80404000
519	Other transportation equipment manufacturing	54441000	52503000	50038000
521	Furniture and related product manufacturing	22975000	23136000	23862000
522	Miscellaneous manufacturing	45573000	44746000	42597000
531 + 532	Food, Beverage, and Tobacco Products	83663000	81383000	75932000
533 + 534	Textile and Textile product mills	17486000	18380000	19222000
535 + 536	Apparel, Leather, and allied product manufacturing	13913000	14468000	15559000
537	Paper manufacturing	34605000	35067000	34335000
538	Printing and related support activities	35453000	35963000	37728000
539	Petroleum and coal products manufacturing	24194000	19549000	24024000
541	Chemical manufacturing	91395000	87500000	79538000
542	Plastics and rubber products manufacturing	39790000	39639000	39457000
600	Wholesale trade	365248000	352479000	350889000
700	Retail trade	483598000	470024000	457313000
801	Air transportation	36665000	38702000	40592000
802	Rail transportation	16200000	16438000	16422000
803	Water transportation	4007000	3826000	4048000
804	Truck transportation	73258000	72388000	73158000
805	Transit and ground passenger transportation	11313000	10991000	10755000
806	Pipeline transportation	7595000	7272000	13529000
807-809	Other Transportation	60637000	57752000	56940000
811	Warehousing and storage	22251000	20898000	20033000
901	Publishing industries, except Internet	72158000	72428000	75729000
902	Motion picture and sound recording industries	26582000	26326000	26692000
903	Broadcasting, except Internet	64700000	58325000	51253000
906	ISPs, search portals, and data processing	29501000	30296000	37217000
1001+1002	Central Banks, Credit intermediation, etc	187510000	169746000	153649000
1003	Securities, commodity contracts, investments	158008000	163869000	182321000
1004	Insurance carriers and related activities	165878000	155048000	147498000
1005	Funds, trusts, and other financial vehicles	20447000	20059000	21989000
1101	Real estate	138648000	124154000	121327000
1102+1103	Rental and leasing services, lessors of intangible assets	37120000	35806000	35509000
1300	Management of companies and enterprises	145304000	139996000	140466000
1401	Administrative and support services	237369000	230108000	223805000
1402	Waste management and remediation services	17259000	16610000	16105000
1500	Educational services	93434000	87522000	81625000
1601	Ambulatory health care services	330741000	312300000	290694000
1602+1603	Hospitals, Nursing and residential care facilities	281590000	261930000	241928000
1604	Social assistance	57916000	54371000	50547000
1701+1702	Performing arts, sports, museums, zoos, parks, etc	41756000	39181000	36064000
1703	Amusement, gambling, and recreation	35622000	34124000	33431000
1801	Accommodation	53888000	51495000	51648000
1802	Food services and drinking places	141383000	135196000	128009000
1900	Other services, except public administration	213989000	204877000	193496000
2001	Federal, civilian	219213000	213278000	201864000
2002	Military	109607000	95748000	84859000

2011+2012	State and Local government	835168000	804854000	761958000
Totals:		**6383522003**	**6112026002**	**5973675001**

Table 8: National Employment Data (Source: Bureau of Economic Analysis)

Youngstown-Warren Regional Employment 2001-2003

Industry Code(s)	Industry Title	2003 (region)	2002 (region)	2001 (region)
81	Farm earnings	22507	6015	16409
100	Forestry, fishing, related activities, and other 7/	8541	9312	8622
201	Oil and gas extraction	0	0	0
202	Mining (except oil and gas)	14154	13722	13290
203	Support activities for mining	7110	7110	7110
300	Utilities	74251	71243	68235
400	Construction	513171	506874	530864
511	Wood product manufacturing	46192	49407	51988
512	Nonmetallic mineral product manufacturing	47218	49384	50577
513	Primary metal manufacturing	988547	964910	1009632
514	Fabricated metal product manufacturing	325682	323823	331679
515	Machinery manufacturing	138324	133229	135748
516	Computer and electronic product manufacturing	24628	25718	29896
517	Electrical equipment and appliance manufacturing	72130	81950	82687
518	Motor vehicles, bodies and trailers, and parts manufacturing	1023582	1023582	1023582
519	Other transportation equipment manufacturing	43012	38481	41866
521	Furniture and related product manufacturing	14521	13437	16444
522	Miscellaneous manufacturing	29658	27071	20218
531 + 532	Food, Beverage, and Tobacco Products	68308	71964	69451
533 + 534	Textile and Textile product mills	16134	15569	14409
535 + 536	Apparel, Leather, and allied product manufacturing	1602	1602	1602
537	Paper manufacturing	30115	30115	30115
538	Printing and related support activities	24968	26391	26098
539	Petroleum and coal products manufacturing	18235	18235	18235
541	Chemical manufacturing	16656	16681	13732
542	Plastics and rubber products manufacturing	83073	82123	79602
600	Wholesale trade	456182	429045	401908
700	Retail trade	1014823	1012627	947081
801	Air transportation	5416	5438	5460
802	Rail transportation	33015	33346	33838
803	Water transportation	0	0	0
804	Truck transportation	200984	213465	218567
805	Transit and ground passenger transportation	14086	14571	13858
806	Pipeline transportation	0	0	0
807-809	Other Transportation	43325	39183	40750
811	Warehousing and storage	0	0	0
901	Publishing industries, except Internet	25949	28744	30227
902	Motion picture and sound recording industries	0	0	0
903	Broadcasting, except Internet	23945	23945	23945
906	ISPs, search portals, and data processing	25044	25419	25794
1001+1002	Central Banks, Credit intermediation, etc	183372	172716	151469
1003	Securities, commodity contracts, investments	0	0	0

1004	Insurance carriers and related activities	135223	128278	121816
1005	Funds, trusts, and other financial vehicles	0	0	0
1101	Real estate	138185	125137	119669
1102+1103	Rental and leasing services, lessors of intangible assets	42594	42594	42594
1300	Management of companies and enterprises	84408	82686	73650
1401	Administrative and support services	282679	280090	257452
1402	Waste management and remediation services	37215	35330	33091
1500	Educational services	83024	72875	68264
1601	Ambulatory health care services	653994	601895	585340
1602+1603	Hospitals, Nursing and residential care facilities	766015	719182	681892
1604	Social assistance	90583	88132	85681
1701+1702	Performing arts, sports, museums, zoos, parks, etc	0	0	0
1703	Amusement, gambling, and recreation	29477	30242	30112
1801	Accommodation	28178	28002	27309
1802	Food services and drinking places	247309	242756	234994
1900	Other services, except public administration	343575	328568	332980
2001	Federal, civilian	152363	159668	155463
2002	Military	56510	37706	29151
2011+2012	State and Local government	1250447	1211264	1154555
Totals:		**10100239**	**9820852**	**9619001**

Table 9: Regional Employment Data (Source: Bureau of Economic Analysis)

Two primary conclusions can be drawn through the examination of these numbers. First is that the relative importance of industries on the national level is much different from that on the local/regional level. The second is that the manufacturing industry (especially the sub-category including motor vehicles) is one of the most important to this region, with it holding more than ten percent of the total regional employment just in that one sub-category. It goes without saying that the regional employment is an additive component of the national employment and is (as it should be) a much smaller number.

Now that we have the numbers we need to calculate location quotients for all the industries in the years 2001-2003, it must be decided which year will be selected for use. In order to obtain something of a more accurate and complete data set (at the regional level each column is missing at least a few values which I have extrapolated from the other two years of data), it has been decided that this study will compute the average location quotients for the region from 2001 to 2003. Because of the nature of the calculations involved, it does not matter to that high of a degree if the average is taken before or after the location quotients are calculated (i.e. if the numbers averaged are the location quotients themselves or the employment numbers used to calculate those quotients). For simplicity in demonstrating the use of equation sixteen, the average shall be taken of the resulting location quotients themselves, and presented will be the calculations of only the 2003 quotients, followed by a list of the quotients for all three years and then the averages.

The quotients were calculated using Microsoft Excel, which greatly simplified the process of using a large list of numbers. The calculations of 2003 are as follows:

Calculation of Location Quotients for 2003

Industry Title	2003	nation/nation total	2003 (region)	region/region total	LQ (region/nation)
Farm earnings	45594000	0.007142452	22507	0.002228363	**0.311988528**
Forestry, fishing, related activities, and other 7/	26962000	0.004223687	8541	0.000845624	**0.200209798**
Oil and gas extraction	28402000	0.004449268	0	0	**0**
Mining (except oil and gas)	15368000	0.002407448	14154	0.001401353	**0.58209055**
Support activities for mining	12739000	0.001995607	7110	0.000703944	**0.35274671**
Utilities	73585000	0.011527336	74251	0.00735141	**0.637737158**
Construction	430782000	0.067483436	513171	0.050807808	**0.752893013**
Wood product manufacturing	22356000	0.003502142	46192	0.004573357	**1.305874299**
Nonmetallic mineral product manufacturing	27325000	0.004280552	47218	0.004674939	**1.0921345**
Primary metal manufacturing	31128000	0.004876305	988547	0.097873625	**20.07126818**
Fabricated metal product manufacturing	77061000	0.012071863	325682	0.03224498	**2.671085717**
Machinery manufacturing	75537000	0.011833123	138324	0.013695121	**1.157354796**
Computer and electronic product manufacturing	124396000	0.019487048	24628	0.002438358	**0.125127117**
Electrical equipment and appliance manufacturing	27415000	0.004294651	72130	0.007141415	**1.662862698**
Motor vehicles, bodies and trailers, and parts manufacturing	105819000	0.016576899	1023582	0.101342354	**6.113468744**
Other transportation equipment manufacturing	54441000	0.008528364	43012	0.004258513	**0.499335281**
Furniture and related product manufacturing	22975000	0.00359911	14521	0.001437689	**0.399456704**
Miscellaneous manufacturing	45573000	0.007139162	29658	0.002936366	**0.411304017**
Food, Beverage, and Tobacco Products	83663000	0.013106088	68308	0.006763008	**0.516020369**
Textile and Textile product mills	17486000	0.00273924	16134	0.001597388	**0.58315001**
Apparel, Leather, and allied product manufacturing	13913000	0.002179518	1602	0.00015861	**0.072773026**
Paper manufacturing	34605000	0.005420989	30115	0.002981613	**0.550012707**
Printing and related support activities	35453000	0.005553831	24968	0.002472021	**0.445101927**
Petroleum and coal products manufacturing	24194000	0.003790071	18235	0.001805403	**0.476350692**

Chemical manufacturing	91395000	0.014317331	16656	0.00164907	**0.115179976**
Plastics and rubber products manufacturing	39790000	0.006233236	83073	0.008224855	**1.319516011**
Wholesale trade	365248000	0.057217317	456182	0.045165466	**0.789367075**
Retail trade	483598000	0.075757239	1014823	0.100475147	**1.326277844**
Air transportation	36665000	0.005743694	5416	0.000536225	**0.093358889**
Rail transportation	16200000	0.002537784	33015	0.003268735	**1.288027087**
Water transportation	4007000	0.00062771	0	0	**0**
Truck transportation	73258000	0.01147611	200984	0.019898935	**1.733944277**
Transit and ground passenger transportation	11313000	0.001772219	14086	0.00139462	**0.786934537**
Pipeline transportation	7595000	0.001189782	0	0	**0**
Other Transportation	60637000	0.009498988	43325	0.004289502	**0.451574671**
Warehousing and storage	22251000	0.003485693	0	0	**0**
Publishing industries, except Internet	72158000	0.011303791	25949	0.002569147	**0.227281898**
Motion picture and sound recording industries	26582000	0.004164159	0	0	**0**
Broadcasting, except Internet	64700000	0.010135471	23945	0.002370736	**0.233904873**
ISPs, search portals, and data processing	29501000	0.00462143	25044	0.002479545	**0.536532046**
Central Banks, Credit intermediation, etc	187510000	0.029374067	183372	0.018155214	**0.618069477**
Securities, commodity contracts, investments	158008000	0.02475248	0	0	**0**
Insurance carriers and related activities	165878000	0.025985342	135223	0.013388099	**0.515217357**
Funds, trusts, and other financial vehicles	20447000	0.003203091	0	0	**0**
Real estate	138648000	0.021719671	138185	0.013681359	**0.629906374**
Rental and leasing services, lessors of intangible assets	37120000	0.005814972	42594	0.004217128	**0.725218991**
Management of companies and enterprises	145304000	0.022762356	84408	0.00835703	**0.367142575**
Administrative and support services	237369000	0.037184645	282679	0.027987358	**0.752658993**
Waste management and remediation services	17259000	0.00270368	37215	0.003684566	**1.362796796**
Educational services	93434000	0.014636748	83024	0.008220004	**0.561600416**
Ambulatory health care services	330741000	0.05181168	653994	0.064750349	**1.249724943**
Hospitals, Nursing and residential care facilities	281590000	0.044112012	766015	0.075841275	**1.719288488**
Social assistance	57916000	0.009072734	90583	0.008968402	**0.9885004**
Performing arts, sports, museums, zoos, parks, etc	41756000	0.006541217	0	0	**0**
Amusement, gambling, and recreation	35622000	0.005580305	29477	0.002918446	**0.522990369**
Accommodation	53888000	0.008441735	28178	0.002789835	**0.330481238**
Food services and drinking places	141383000	0.022148118	247309	0.02448546	**1.105532305**
Other services, except public administration	213989000	0.03352209	343575	0.034016522	**1.014749428**
Federal, civilian	219213000	0.034340447	152363	0.015085089	**0.439280494**
Military	109607000	0.017170302	56510	0.005594917	**0.325848499**
State and Local government	835168000	0.130831851	1250447	0.123803704	**0.94628107**
Totals:	6383522003	0.999999686	10100239	1	

Table 10: Calculations of Regional Location Quotients

The same process that produced these location quotients was then repeated for the years 2001 and 2002. The resulting location quotients were then combined to a single table and the averages taken, resulting in the following table:

Location Quotients for 2001-3 for Youngstown-Warren

Industry Title	**LQs 2001**	**LQs 2002**	**LQs 2003**	**Avg LQs for 2001-3**
Farm earnings	0.238033654	0.116050679	0.311988528	**0.22024287**
Forestry, fishing, related activities, and other 7/	0.20607739	0.219229846	0.200209798	**0.208505678**

Oil and gas extraction	0	0	0	**0**
Mining (except oil and gas)	0.540750211	0.55940737	0.58209055	**0.560749377**
Support activities for mining	0.35528754	0.371156021	0.35274671	**0.359730091**
Utilities	0.60279504	0.620740006	0.637737158	**0.620424068**
Construction	0.806910251	0.762220262	0.752893013	**0.774007842**
Wood product manufacturing	1.443790195	1.381398123	1.305874299	**1.377020873**
Nonmetallic mineral product manufacturing	1.154007089	1.124642372	1.0921345	**1.123594654**
Primary metal manufacturing	18.71002556	19.11428786	20.07126818	**19.2985272**
Fabricated metal product manufacturing	2.581132972	2.612716181	2.671085717	**2.621644957**
Machinery manufacturing	1.059913429	1.101059991	1.157354796	**1.106109405**
Computer and electronic product manufacturing	0.134230833	0.12777633	0.125127117	**0.12904476**
Electrical equipment and appliance manufacturing	1.768467618	1.846818476	1.662862698	**1.759382931**
Motor vehicles, bodies and trailers, and parts manufacturing	7.905996292	7.347160603	6.113468744	**7.122208546**
Other transportation equipment manufacturing	0.519604792	0.456140104	0.499335281	**0.491693392**
Furniture and related product manufacturing	0.427968937	0.361451531	0.399456704	**0.396292391**
Miscellaneous manufacturing	0.294761528	0.376518316	0.411304017	**0.360861287**
Food, Beverage, and Tobacco Products	0.568022168	0.550322953	0.516020369	**0.544788497**
Textile and Textile product mills	0.46552916	0.527170669	0.58315001	**0.52528328**
Apparel, Leather, and allied product manufacturing	0.063942918	0.068911236	0.072773026	**0.068542393**
Paper manufacturing	0.544700077	0.534466244	0.550012707	**0.543059676**
Printing and related support activities	0.429590891	0.456705204	0.445101927	**0.443799341**
Petroleum and coal products manufacturing	0.471380996	0.580520082	0.476350692	**0.509417257**
Chemical manufacturing	0.107218752	0.118645168	0.115179976	**0.113681299**
Plastics and rubber products manufacturing	1.252885949	1.289371728	1.319516011	**1.287257896**
Wholesale trade	0.71132573	0.757540095	0.789367075	**0.7527443**
Retail trade	1.286130975	1.340804614	1.326277844	**1.317737811**
Air transportation	0.083534103	0.087446377	0.093358889	**0.088113123**
Rail transportation	1.279647226	1.262498284	1.288027087	**1.276724199**
Water transportation	0	0	0	**0**
Truck transportation	1.855386483	1.835253778	1.733944277	**1.808194846**
Transit and ground passenger transportation	0.800205926	0.825065024	0.786934537	**0.804068496**
Pipeline transportation	0	0	0	**0**
Other Transportation	0.444448834	0.422247107	0.451574671	**0.439423537**
Warehousing and storage	0	0	0	**0**
Publishing industries, except Internet	0.247881688	0.246988503	0.227281898	**0.240717363**
Motion picture and sound recording industries	0	0	0	**0**
Broadcasting, except Internet	0.290139709	0.255503069	0.233904873	**0.259849217**
ISPs, search portals, and data processing	0.430416542	0.522166728	0.536532046	**0.496371772**
Central Banks, Credit intermediation, etc	0.612217361	0.633241034	0.618069477	**0.621175958**
Securities, commodity contracts, investments	0	0	0	**0**
Insurance carriers and related activities	0.512896605	0.514898988	0.515217357	**0.51433765**
Funds, trusts, and other financial vehicles	0	0	0	**0**
Real estate	0.612541932	0.627279435	0.629906374	**0.62324258**
Rental and leasing services, lessors of intangible assets	0.744940534	0.740335621	0.725218991	**0.736831715**
Management of companies and enterprises	0.325621563	0.367580431	0.367142575	**0.35344819**
Administrative and support services	0.714394507	0.757533621	0.752658993	**0.74152904**
Waste management and remediation services	1.276029702	1.323762371	1.362796796	**1.320862956**
Educational services	0.519373946	0.518199944	0.561600416	**0.533058102**
Ambulatory health care services	1.250500174	1.199457262	1.249724943	**1.23322746**
Hospitals, Nursing and residential care facilities	1.750415222	1.708793538	1.719288488	**1.726165749**

Social assistance	1.052690643	1.008793632	0.9885004	**1.016661558**
Performing arts, sports, museums, zoos, parks, etc	0	0	0	**0**
Amusement, gambling, and recreation	0.559373458	0.551552176	0.522990369	**0.544638668**
Accommodation	0.32837033	0.338423113	0.330481238	**0.332424894**
Food services and drinking places	1.140060477	1.117486171	1.105532305	**1.121026318**
Other services, except public administration	1.068704846	0.998086278	1.014749428	**1.027180184**
Federal, civilian	0.478277324	0.465916245	0.439280494	**0.461158021**
Military	0.213337484	0.245085027	0.325848499	**0.26142367**
State and Local government	0.941012114	0.936607713	0.94628107	**0.941300299**

Table 11: Regional Location Quotients 2001-2003 and Averages

Of note within this table is the fact that the three highest average location quotients are both in the manufacturing category, with the sub-category including motor vehicles being by far the second largest (the largest sub-category by nearly three times is the metal products manufacturing category, which has always been the dominant industry in the Mahoning Valley, and will continue to be for the foreseeable future) and the metal fabrication category (a product that is much used in the production of automobile parts) being third, also much larger than the fourth largest quotient.

With these numbers in hand, we can proceed localize the national direct requirements table (presented on the following page) which has been downloaded from the Bureau of Economic Analysis. Immediately upon first examination of this table, though, there comes a problem. The problem is that the table contains only sixteen industries, not the sixty or so for which we have prepared location quotients. This leads to the question of how to deal with this problem? We cannot just add the location quotients, as they are based upon fractions, and adding them would lead to numbers which are completely incorrect for the purposes of an input-output model. We must go back and make summations at the level of the employment data itself, then recalculate sixteen new location quotients to use in our regionalization. When aggregated to the

National Direct Requirements Table

Commodities / Industries		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
IOCode	Industry Name	Same as Identical code on left side															
1	Agriculture, forestry, fishing, and hunting	0.2300401	0.0000016	0.0000008	0.0011815	0.0409316	0.0002341	0.0000653	0.0000135	0.0000022	0.0003217	0.0026787	0.0003086	0.0124465	0.0004334	0.001024	0
2	Mining	0.0016186	0.1377364	0.2546882	0.0051139	0.053411	0.0000156	0.0000073	0.0065981	0.0000007	0.0001958	0.0000802	0.0000067	0.0000711	0.0000288	0.0043445	0
3	Utilities	0.017794	0.0085369	0.0003295	0.002818	0.0117126	0.006327	0.01277	0.0051143	0.0044915	0.0121062	0.0075733	0.0078366	0.0221158	0.0120124	0.0195289	0
4	Construction	0.0045234	0.0002166	0.006152	0.0009116	0.0019	0.0023523	0.0042874	0.0024485	0.0027386	0.0084407	0.0045168	0.0059738	0.00878	0.0052008	0.0200727	0
5	Manufacturing	0.1601055	0.0903725	0.0155466	0.2554702	0.3281065	0.0397943	0.0327189	0.1178973	0.0652075	0.0127204	0.040883	0.084699	0.1507429	0.1650387	0.0956546	0
6	Wholesale trade	0.0357965	0.0146675	0.0034	0.0312864	0.0608988	0.0283753	0.0055137	0.025469	0.0124265	0.0017391	0.0066849	0.012472	0.0259638	0.0226923	0.0120492	0
7	Retail trade	0.0004679	0.0013813	0.0001872	0.0611244	0.0032134	0.00306	0.0048421	0.0041333	0.0007324	0.0029166	0.0043565	0.002095	0.0047119	0.0140107	0.0000103	0
8	Transportation and warehousing	0.0233461	0.0220958	0.0654474	0.0155503	0.0293067	0.0160761	0.0173432	0.1149929	0.0087123	0.0071075	0.0124241	0.01124	0.0127167	0.0118364	0.0171486	0
9	Information	0.0035897	0.0023447	0.0005519	0.0087502	0.0092027	0.0156869	0.0159108	0.014777	0.2029391	0.0085258	0.0389103	0.0255781	0.0243733	0.0257145	0.0274098	0
10	Finance, insurance, real estate, rental, and leasing	0.0493611	0.076126	0.0104005	0.029292	0.0272635	0.0487936	0.0804274	0.0523051	0.0629797	0.1796845	0.0657632	0.0969211	0.0917099	0.080141	0.0309826	0
11	Professional and business services	0.0164443	0.0746836	0.0095828	0.0731515	0.0783553	0.0998922	0.1345144	0.083102	0.1154735	0.0663758	0.1544699	0.0942184	0.0671616	0.0835846	0.1016414	0
12	Educational services, health care, and social assistance	0.0000518	0.0002953	0.0007752	0.0001019	0.0007512	0.0008605	0.0005776	0.0008645	0.0023577	0.0003155	0.0011944	0.0088764	0.0006498	0.0011619	0.0152049	0
13	Arts, entertainment, recreation, accommodation, and food services	0.0015748	0.0019184	0.0014764	0.0018805	0.0048249	0.0058944	0.0063567	0.0072874	0.014627	0.0059898	0.0159823	0.0154245	0.028745	0.0090931	0.0099004	0
14	Other services, except government	0.0100548	0.001407	0.0004208	0.0093273	0.011283	0.0083667	0.0071305	0.0127518	0.013826	0.0069016	0.0123198	0.0074331	0.0107937	0.0124469	0.0144202	0
15	Government	0.0003482	0.0001732	0.0003695	0.001018	0.0007281	0.0036883	0.0046301	0.001712	0.004268	0.0025377	0.0066808	0.0101424	0.0043097	0.0067222	0.0037351	0
16	Other	0.0002986	0.0060778	0.0000844	0.0005238	0.007509	0.0146864	0.000613	0.0290132	0.0087982	0.0064061	0.0029376	0.0001541	0.0005891	0.0004214	0.0103716	0
S002	Scrap, used and secondhand goods	0.0000015	0	0	0.0000073	0.0047659	0.0000033	0.0003568	0.000007	0	-0.000197	0.0000055	0.0000016	0.0000032	0.0011289	0.0054259	0
V001	Compensation of employees	0.1227788	0.1394701	0.1199979	0.3335043	0.2041806	0.3763676	0.3880815	0.3425223	0.2025985	0.1682363	0.4390779	0.4921855	0.3338541	0.3592227	0.5201636	0
V002	Taxes on production and imports, less subsidies	-0.0134282	0.0530937	0.1099509	0.0058545	0.0110748	0.1502617	0.1450057	0.0266614	0.0374733	0.0674965	0.0108687	0.0068806	0.0610931	0.033361	-0.0060476	0
V003	Gross operating surplus	0.3352304	0.3694015	0.4006381	0.1620324	0.1105803	0.1790638	0.1388475	0.1523293	0.2403474	0.4421772	0.1725924	0.1175505	0.1391686	0.1547483	0.0929601	1
Total		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

sixteen categories presented in the National Direct Requirements table, the national and regional employment numbers look as follows:

National Aggregate Employment for 2001-3

Industry	2001	2002	2003	2001-3 Avg
Agriculture, forestry, fishing, and hunting	101266000	85768000	100958000	95997333
Mining	27691000	27188000	28107000	27662000
Utilities	70299000	71428000	73585000	71770667
Construction	408573000	413862000	430782000	417739000
Manufacturing	932482000	925361000	954525000	937456000
Wholesale trade	350889000	352479000	365248000	356205333
Retail trade	457313000	470024000	483598000	470311667
Transportation and warehousing	235477000	228267000	231926000	231890000
Information	75729000	72428000	72158000	73438333
Finance, insurance, real estate, rental, and leasing	662293000	668682000	707611000	679528667
Professional and business services	380376000	386714000	399932000	389007333
Educational services, health care, and social assistance	664794000	716123000	763681000	714866000
Arts, entertainment, recreation, accommodation, and food services	249152000	259996000	272649000	260599000
Other services, except government	193496000	204877000	213989000	204120667
Government	963822000	1018132000	1054381000	1012111667
Other	84859000	95748000	109607000	96738000
Total	**5858511000**	**5997077000**	**6262737000**	**6039441667**

Regional Aggregate Employment for 2001-3

Industry	2001	2002	2003	2001-3 Avg
Agriculture, forestry, fishing, and hunting	5898	5806	5719	5808
Mining	1455	1455	1455	1455
Utilities	1167	1110	1053	1110
Construction	19102	18301	17947	18450
Manufacturing	58865	54416	51016	54766
Wholesale trade	10519	11075	11631	11075
Retail trade	48717	47183	47276	47725
Transportation and warehousing	11861	11528	11305	11565
Information	4294	4407	4698	4466
Finance, insurance, real estate, rental, and leasing	19656	20077	20373	20035
Professional and business services	31716	32043	31121	31627
Educational services, health care, and social assistance	50382	52274	53576	52077
Arts, entertainment, recreation, accommodation, and food services	30054	30201	30040	30098
Other services, except government	21706	21610	22248	21855
Government	39252	39573	39453	39426
Other	1979	2016	2037	2011
Total	**358624**	**355077**	**352951**	**353549**

Table 12-13: National and Regional Aggregate Employment Data

The location quotients are now recalculated and averaged in exactly the same way as before, resulting in the following table:

Industry	2003	2002	2001	Avg LQs for 2001-3
Agriculture, forestry, fishing, and hunting	0.191618303	0.109675796	0.151329413	0.150874504
Mining	0.471383709	0.47025414	0.451024706	0.464220852
Utilities	0.628719763	0.612142638	0.594246802	0.611703068
Construction	0.742247351	0.751663366	0.795467455	0.763126057
Manufacturing	1.966509736	1.985509391	2.000878669	1.984299265
Wholesale trade	0.778205682	0.747048021	0.701238418	0.74216404
Retail trade	1.307524708	1.322234214	1.267892349	1.29921709
Transportation and warehousing	0.797437401	0.822737846	0.81240541	0.810860219
Information	0.224068206	0.243567665	0.244366477	0.237334116
Finance, insurance, real estate, rental, and leasing	0.439719222	0.430206935	0.402619368	0.424181842
Professional and business services	0.629888724	0.631811825	0.586174999	0.615958516
Educational services, health care, and social assistance	1.300216864	1.270176632	1.308789745	1.29306108
Arts, entertainment, recreation, accommodation, and food services	0.696929367	0.710523998	0.718528623	0.708660663
Other services, except government	1.000401202	0.984262593	1.05354954	1.012737778
Government	0.828982535	0.826400837	0.832126269	0.82916988
Other	0.321241108	0.241690552	0.210312145	0.257747935

Table 14: Regional Aggregate Location Quotients (Source: Bureau of Economic Analysis)

Note that aggregating the employment totals gives manufacturing a much lower location quotient than some of the individual components of the category had previously had. This will make our model somewhat more imprecise than it would have been before, but, without further data, it would be impossible to work around this limitation.

There are a few more transformations that must be done to the locations quotient list before it can be used to regionalize the direct requirements table. First, there is a distinction possible on the location quotients between goods that the region imports (which would have a location quotient of less than one) and those goods of which the region is a net exporter (which would have a location quotient equal to or greater than one). For the purposes of an input-output study, any item which the region is a net exporter of should use the same value in the direct requirements table as the nation as a whole uses. To make sure that these values then go unchanged in the national table, it is necessary to go through the list of location quotients and replace any number greater then one with the number one. This leaves a list that looks like this:

Location Quotients for 2001-3 for Youngstown-Warren

Industry	Avg LQs for 2001-3
Agriculture, forestry, fishing, and hunting	0.150874504
Mining	0.464220852
Utilities	0.611703068
Construction	0.763126057
Manufacturing	1
Wholesale trade	0.74216404
Retail trade	1
Transportation and warehousing	0.810860219
Information	0.237334116
Finance, insurance, real estate, rental, and leasing	0.424181842
Professional and business services	0.615958516
Educational services, health care, and social assistance	1
Arts, entertainment, recreation, accommodation, and food services	0.708660663
Other services, except government	1
Government	0.82916988
Other	0.257747935

Table 15: Regional Location Quotients After Adjustment

These numbers are then to become the diagonal elements of a matrix that will be called (for our purposes) *diag(LQ)*. To regionalize the direct requirements table, all that is required is to multiply that matrix (which we have earlier called *A*) by the location quotient matrix. Our regionalized direct requirements matrix can thus be written *(A * diag(LQ))* and this shall be how it is denoted in later equations (and how the regionalization shall have been substituted into early equations)..

In order to determine the impact that a plant closure will have on the employment of the Mahoning Valley, we must have some base set of numbers to represent output. The gross regional product would be an ideal measure for this, however it is sadly unavailable. Therefore we must search for a suitable replacement, something which can server as a proxy of sorts, which data is readily available for. The Bureau of Economic Analysis provides data for each region on the personal income generated by each industry within that region. As the income generated by an industry should be directly proportional to its unit output, this may be used as a suitable proxy value to output itself.

The regional data, once downloaded, must be aggregated and averaged as the employment data and location quotients were into the sixteen categories on our regional direct requirements table. Such aggregation leaves us with the following data table:

Personal Income Generated Per Industry, Youngstown Warren Region, 2001-3 (Number is Thousands USD)

Industry	2001	2002	2003	2001-3 Avg
Agriculture, forestry, fishing, and hunting	47362	39089	48663	45038
Mining	49241	49241	49241	49241
Utilities	78047	79061	80075	79061
Construction	598345	574231	574710	582429
Manufacturing	3068342	3139473	3336979	3181598
Wholesale trade	440488	468294	496100	468294
Retail trade	1048820	1079892	1058530	1062414
Transportation and warehousing	428613	428186	409280	422026
Information	159527	167442	175577	167515
Finance, insurance, real estate, rental, and leasing	549357	567741	588704	568601
Professional and business services	793969	821091	823917	812992
Educational services, health care, and social assistance	1547707	1650134	1761325	1653055
Arts, entertainment, recreation, accommodation, and food services	337074	348840	355466	347127
Other services, except government	756444	761278	835678	784467
Government	1516289	1612656	1665054	1598000
Other	34123	43871	62935	46976

Table 16: Regional Personal Income by Industry (Source: Bureau of Economic Analysis)

As would be the common sense expectation, manufacturing generates the largest amount of personal income in the region by far. The final column containing the averages is our beginning output quantity for the model, and henceforth will be denoted as the vector q, as denoted in the earlier equations. (Schaffer, 1999)

From these components then, a vector list of external demand must be created (it is, after all, these demands which change when the factory closes). The internal demand to the region would be equal to $(A * diag(LQ)) *q$ when the system is in equilibrium (the demand of the region would be equal to regional income scaled by the direct requirements matrix, since savings is a part of the finance category). When the region is in equilibrium with other regions in terms of its imports and exports, the q vector will itself equal total demand. If we call the external demand vector y (as we have earlier), that leaves us with an equation that looks something like equation seventeen.

$$(A * diag(LQ)) * q + y = q \qquad (17)$$

Of course, equation seventeen is only equation fifteen, but derived in another fashion and modified so as to be regionalized. It can be proved (though that is an exercise for another time) that $(A*diag(LQ))*q + y$ is equal to the inverse of $(I-A)$ (where I is the identity matrix of the identical size as A) multiplied by y. This substitution into equation seventeen gives us equation eighteen (Schaffer, 1999):

$$(I - (A * diag(LQ)))^{-1} * y = q \qquad (18)$$

At this point it is worthy of pausing and noting that we very nearly have the total output multipliers for the region. All that is required to gather these numbers is to sum the columns of the $(I-(A*diag(LQ)))^{-1}$ matrix. This operation results in the following list of multipliers for each industry.

Industry	Multiplier
Agriculture, forestry, fishing, and hunting	1.128621
Mining	1.309396
Utilities	1.321713
Construction	1.699049
Manufacturing	2.205298
Wholesale trade	1.342203
Retail trade	1.487094
Transportation and warehousing	1.66651
Information	1.181913
Finance, insurance, real estate, rental, and leasing	1.189077
Professional and business services	1.35797
Educational services, health care, and social assistance	1.62043
Arts, entertainment, recreation, accommodation, and food services	2.566796
Other services, except government	2.77888
Government	2.546368
Other	2

Table 17: Regional Input-Output Multipliers

Since we are trying to determine the y vector, we must re-arrange equation eighteen into equation nineteen which solves for y (Schaffer, 1999).

$$y = q * (I - (A * diag(LQ))) \quad (19)$$

This equation has been programmed into the application that was custom-built to work on this project (see description in Appendix 1). As such, the exhaustive calculations that may have been required to derive the y vector have been compressed into a few seconds. The vector which results from the running of this equation is displayed in the following table:

External Demand (y) for Goods Produced in Youngstown-Warren 2001-3 (Numbers in Thousands USD)

Industry	2001-3 Avg External Demand
Agriculture, forestry, fishing, and hunting	-94121.41
Mining	-147051.59
Utilities	-37892.75
Construction	521532.81
Manufacturing	1466565.96
Wholesale trade	170422.82
Retail trade	998815.42
Transportation and warehousing	192636.75
Information	-27547.36
Finance, insurance, real estate, rental, and leasing	-19513.50
Professional and business services	-147633.37
Educational services, health care, and social assistance	1612707.40
Arts, entertainment, recreation, accommodation, and food services	256668.77
Other services, except government	677258.08
Government	1556174.69
Other	-10815.60

Table 18: Regional External Demand by Industry

Please note that the negative numbers in this table merely denote that imports are greater than exports for that industry (i.e. external demand being negative shows a flow of that amount into the region). It is this set of numbers into which we must introduce the change in order to show the effect of the closure of the Lordstown facility.

The next question is how to represent that change. Known is the fact that a complete shutdown of the plant would entail the loss of approximately 6,000 jobs. What is not known, however, is how much personal income this would cause the loss of (personal income being the units for all the numbers in the y and q vectors). According to a National Public Radio online comparison of General Motors and Toyota, the average labor cost per US hourly worker for GM is $73.73. (Geng, 2005) Subtracting out healthcare costs (which NPR also provides information on) leaves an average hourly cost of $50.73. (Geng, 2005) Though this is more reasonable, it is still likely high (as it would contain all other benefit costs and the higher labor costs in some markets). Some of the things still needing to be removed from the figure would be such things as taxes (which alone would take some twenty to thirty percent) and pension contributions. To this end we need to make another adjustment to the per hour labor cost in order to obtain a truer proxy for hourly wage. The most logical adjustment seems to be to take off the same $23 dollars which was removed by health care costs (assuming that health care is approximately half of the total nonmonetary costs of employment). This gives us a value of $27.73 on an hourly rate, which can be used as a proxy for average per hour salary (though this will still be distorted by unnamed labor costs and the salaries of higher level employees). Multiplying this by the typical forty hour work week and fifty-two weeks that are in a standard year, then again by the 6,000 workers involved leads to a projected decrease in personal income of $346,070,400 in the Youngstown area. This is shown against the manufacturing numbers in the table below which represents external demand after the close of the factory.

External Demand (y) for Goods Produced in Youngstown-Warren 2001-3 (in Thousands USD)

Industry	2001-3 Avg External Demand	change	New Demand
Agriculture, forestry, fishing, and hunting	-94121.41	0	-94121.41
Mining	-147051.59	0	-147051.59
Utilities	-37892.75	0	-37892.75
Construction	521532.81	0	521532.81
Manufacturing	1466565.96	-346,070	1120495.56

Wholesale trade	170422.82	0	170422.82
Retail trade	998815.42	0	998815.42
Transportation and warehousing	192636.75	0	192636.75
Information	-27547.36	0	-27547.36
Finance, insurance, real estate, rental, and leasing	-19513.50	0	-19513.50
Professional and business services	-147633.37	0	-147633.37
Educational services, health care, and social assistance	1612707.40	0	1612707.40
Arts, entertainment, recreation, accommodation, and food services	256668.77	0	256668.77
Other services, except government	677258.08	0	677258.08
Government	1556174.69	0	1556174.69
Other	-10815.60	0	-10815.60

Table 19: Regional External Demand Showing Changes

This new y vector is fed into equation eleven along with the earlier created matrices (again, this is calculated using the computer program described in Appendix 1) and a new output vector (expressed in terms of personal income), q, is created. This is then compared with the original output vector (also expressed in terms of personal income) to come up with percentage changes in each industry. These vectors and changes are as follows.

Personal Income Generated Per Industry with Project Changes, Youngstown Warren Region, 2001-3 (in Thousands USD)

Industry	2001-3 Avg	After Change	Change	%Change
Agriculture, forestry, fishing, and hunting	45038	22529	-22509	-49.978
Mining	49241	17816	-31425	-63.818
Utilities	79061	71890	-7171	-9.07
Construction	582429	580954	-1475	-0.253
Manufacturing	3181598	2654068	-527530	-16.581
Wholesale trade	468294	434157	-34137	-7.29
Retail trade	1062414	1060190	-2224	-0.209
Transportation and warehousing	422026	403012	-19014	-4.505
Information	167515	159933	-7582	-4.526
Finance, insurance, real estate, rental, and leasing	568601	545742	-22859	-4.02
Professional and business services	812992	759447	-53545	-6.586
Educational services, health care, and social assistance	1653055	1652543	-513	-0.031
Arts, entertainment, recreation, accommodation, and food services	347127	343499	-3627	-1.045
Other services, except government	784467	777396	-7071	-0.901
Government	1598000	1597155	-844	-0.053
Other	46976	41917	-5060	-10.771

Table 20: Regional Personal Income Showing Predicted Changes

It is of some note that agriculture and mining suffer the largest percentage drops, though this could well be due to the fact that they are such a small part of the regional economy to begin with (note that other columns suffer greater numerical drops). The loss of the plant also causes manufacturing to fall by a number that is rather larger than the actual initial drop of $346,070,400 (larger by over 30%).

Now that we have percentage drops in output, it is not too much a leap to make the assumption that an identical percentage drop will occur in that industry's employment. Applying these predicted changes, converting the percentages to actual numbers of jobs lost, and totaling them will give us the numbers that we desire to compare with the results of the base model. After such operations, the regional employment table looks as follows.

Regional Aggregate Employment for 2001-3

Industry	2001-3 Avg	Predicted Change %	Predicted Change	After Change
Agriculture, forestry, fishing, and hunting	5808	-0.49977577	-2903	2905
Mining	1455	-0.638184077	-929	526
Utilities	1110	-0.090697264	-101	1009
Construction	18450	-0.002531934	-47	18403
Manufacturing	54766	-0.165806502	-9081	45685
Wholesale trade	11075	-0.072896861	-807	10268
Retail trade	47725	-0.002093438	-100	47625
Transportation and warehousing	11565	-0.045054277	-521	11044
Information	4466	-0.045263381	-202	4264
Finance, insurance, real estate, rental, and leasing	20035	-0.040201572	-805	19230
Professional and business services	31627	-0.065861895	-2083	29544
Educational services, health care, and social assistance	52077	-0.000310218	-16	52061
Arts, entertainment, recreation, accommodation, and food services	30098	-0.010449368	-315	29784
Other services, except government	21855	-0.009013809	-197	21658
Government	39426	-0.000528472	-21	39405
Other	2011	-0.107706203	-217	1794
Total	353549		-18343	335206

Table 21: Regional Employment Showing Predicted Changes

Thus the input-output model has arrived at a final total loss of 18,343 jobs. Of great interest among these numbers (besides the obvious near extinction of mining and agriculture in the region) is that a loss of 6,000 initial jobs in the manufacturing sector caused an additional loss of over 3,000 jobs in that same sector. The total loss in jobs is around equivalent to a 5.19% drop in employment. Unemployment in the region would likely increase by a similar number, with most of the newly unemployed people unable to find employment at all.

Comparison of Model Results

The two models studied in this paper have provided very different results in terms of the overall impact of the closure of the Lordstown plant. While the Economic Base model reported a seemingly high loss in jobs of 21,580, the Input-Output model reported a somewhat lower loss of 18,343 jobs. This is a difference of 3,237 jobs, a rather large differential. But why was the difference so large and what is the real value that we would expect?

The first place to look would be sources of error that would make the models incorrect. Obviously, due to its much more data intensive nature, the I-O model would have much more potential for error. The approximations that we were forced to use to regionalize our data introduce a tremendous potential for error, in the location quotients (which are, after all, only a somewhat precise approximation) alone a large amount of error is likely introduced. Further error (or more correctly perhaps, imprecision) is introduced into the model because we are forced by the data available (namely the National Direct Requirements table) to use only sixteen different categories for employment, as opposed to the more than sixty individual categories that we have job data available for. The best example of this is that the location quotient for manufacturing as a whole is around 2, which makes it a net exporter. This is despite the fact that less than half of the sub-categories in this category are net exporters; they are more than offset by the presence of the three largest values for the location quotients.

This aggregation as therefore introduced much possibility for error in the modeling process.

The single largest error introduced into the input-output model, however, is created by the proxy that we have to use to convert the job loss number (in terms of number of employees) to a monetary amount (in terms of personal income). It is entirely possible that the amount of money taken from the average hourly wage was too high, meaning the loss in personal income to the Youngstown-Warren area would have been larger and enhancing the overall effect on the local economy. It would be very difficult, however, to determine the precise average hourly wage (without going to the company and asking for data, which they likely hold privileged at any rate) and therefore practically impossible to calculate an exact figure for personal income lost.

Even with all these sources of error in the I-O model, we cannot over look the economic base model. The economic base model is not without errors in itself despite the fact that we have nearly all of the data that we need. Data errors would basically be limited to the fact that some data fields are missing (due to non-disclosure of information by the companies in those industries). These data fields have been filled in where possible through extrapolation of existing data points, which introduces error into the modeling process. There may have also been an error in how the divisions between base and non-base sectors were made. The divisions were made using knowledge of the region gained from living within it. As has been seen in other regions and in other studies, this information and these impressions can be correct (as in the Newfoundland study of the Review of Literature section) or very incorrect.

Probably the biggest source of possible error in the economic base model is the theory itself. The theory is fairly simplistic in both backing and computation. In economics, as in most other disciplines, the simplest solutions are often the most elegant and clearest in thought. Usually, however, it eventually turns out that these simple solutions are a bit too simple to capture the complexities of something the size of a country's economy (or even that of a single region). The much more complex input-output model is more complex and therefore better equipped to handle the complexities of a major economy.

What is then the true value for what job loss would occur if the Lordstown assembly plant were to close? It is very likely that the truest estimation would be somewhere in between the two estimated values. A number very close to 20,000 jobs lost would be an appropriate estimate given the results that have been obtained.

Conclusion

Given the number of jobs involved in a shut down of the Lordstown plant, an analysis of what would happen to the surrounding area was clearly needed. A loss of 6,000 jobs would be bad enough, but a loss of 20,000 total jobs to the region would be catastrophic. It would entail the closing of virtually entire communities (the village of Lordstown itself only has a little over 3,000 residents), whole school districts worth of children leaving the area, and large losses in terms of tax revenue for the governments of the region. (Lordstown, 2006) Only twenty-five years removed from the loss of the steel industry, the psyche of the area has still not recovered, and such a blow as the loss of the General Motors plant would only add to the impression that the area is headed only to ruin (though it has in fact started to recover by developing new sectors such as technology). This would only enhance the impact of the job losses.

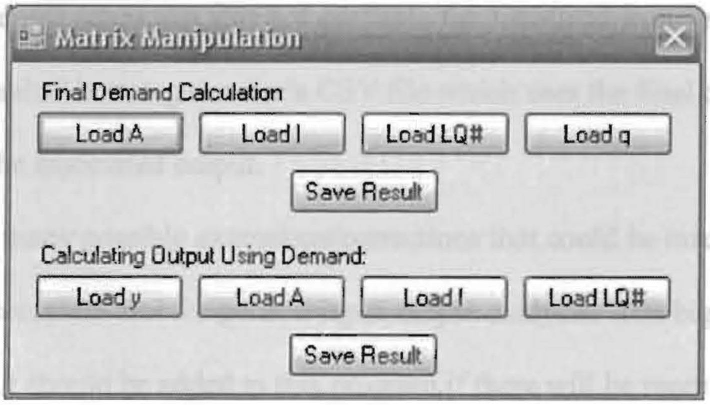
Such secondary impacts as the ones represented in this study verify the very need for such studies. If General Motors decides to close a plant, and are undecided based on other factors between a couple of alternatives, they might use the size of the secondary impacts to make their decision. For example, if choosing between closing the assembly line in Lordstown and one in, say, Chicago, a secondary impact study might show that, while Chicago (being a big city with a large diversity of industries and many sources of employment) would be able to handle the loss of jobs with minimal secondary impact, a small town such as Lordstown would be completely decimated by the loss of its only major employer. All other things equal, considering the overall impact of the economy, they would hopefully choose to close the plant in Chicago, where those displaced workers have a much greater chance of finding new employment in the immediate area.

Finally, comparing the two models used proved somewhat inconclusive here, with the input-output model and the economic base model providing similar numbers. Both have many possible reasons for error, and it is probable that neither is entirely correct. What is clear is that the economic base model provides a very good estimation of the regional impact with a minimal (comparatively) amount of work. The input-output model, on the other hand, has a much more complex model that ought to be much more accurate. This complexity though adds to the difficulty in computation of the model, which in turn increases the cost of computing the result. Also, the rather more data-intensive nature of the input-output model makes for some trouble in obtaining accurate data, which takes away the advantage of this model's precision. If accurate data is available, and time/money exists to perform such calculations as are necessary, the input-output model is preferable to the economic base model for its greater accuracy. However, the economic base model can be a good substitute when data becomes a problem, or there is not the time to do a more in-depth study.

Appendix 1: Program for Matrix Manipulations

Through the course of calculating all the matrix arithmetic and inversions that would be required, it was decided that a computer program would be easiest way to accomplish the repeated calculations. This program was created in Visual Basic .NET using Microsoft's Visual Studio .NET 2005 and targets the .NET framework version 2.0.

Since this was a program designed mainly for use in this research project not much mind was paid to the design of the graphical user interface (though it was, as any VB.NET application, entirely driven by the graphical user interface). Because of this, it is not visually impressive, though it is entirely functional. A screen capture of the interface:



The "Load" buttons in each section are designed to be clicked in any order and lead to a dialog showing to the user, prompting for the selection of comma-separated values (CSV) file. These files were generally created from downloads from the Bureau for Economic Analysis (with some manipulations) and Microsoft Excel. The characters that follow the word "Load" on each button are explained as follows:

A – the National Direct Requirements Matrix

I – an Identity Matrix of the correct size (here always 16x16)

LQ# - the Location Quotient diagonal matrix (explained in the I-O model above)

q – the quantity of (or proxy for) output in the region

y – the final demand vector for the region

After each of these matrices and vectors are loaded, the appropriate "Save Results" button is to be clicked. This button actually performs the matrix operations that the formulas (listed above in the I-O model itself) call for and saves the resulting matrix to a CSV file. It, of course, does prompt the user to save the file wherever they desire. All matrix operations are performed using the Bluebit Matrix Library which was a downloaded addition to the standard .NET libraries. Clicking the first "Save Results" actually produces a CSV which is the *y* vector (the final demand for the region using the known current output), since this was not available for download from any site. The second "Save Results" button generates a CSV file which uses the final demand to generate to find the associated output.

There are many possible extensions/corrections that could be made to make this program a more complete tool for general input-output analysis. The biggest change is that error checking should be added to this program if there will be more users (right now the program does none). Second, there should be some verification that each matrix was in fact successfully loaded (right now it is left to the memory of the user to decide if they have already clicked one/all of the load buttons or not). Perhaps some sort of system of checkmarks could be implemented here. The final (and maybe most useful of all) would be the internal creation of the identity matrix based on the other matrices loaded. After all, the identity matrix is always almost the same, with the only differences being the number of rows and columns, which should prove fairly easy to compute based upon the sizes of the other matrices.

Though a fairly simplistic tool (which was not terribly difficult or long in its design and implementation), this program has proven itself time and again as a tremendous time saver through the production of this paper. The value of a computer in doing repetitive calculations over large sets of numbers cannot be ignored. Without the advent of the computer and the creation of such tools, even relatively simple operations with groups of numbers the size of those used in this study (a 16x16 matrix alone contains some 256 individual elements) would be very long, time-consuming exercises in simple mathematics. With the use of the computer and custom programs such as this, these long tasks can be completed in mere seconds (this program never operated longer than one or two seconds per button click on the files used in this study).

Complete Code Listing of MatrixState.vb

```
Imports Bluebit.MatrixLibrary

Public Class MatrixState

    Dim sLines As String()
    Dim bFSet As Boolean = False
    Dim MatrixA As Double()()
    Dim MatrixI As Double()()
    Dim MatrixLQNum As Double()()
    Dim VectorQ As Double()
    Dim VectorY As Double()

    Private Sub Button1_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles btnLoadA.Click, btnLoadA2.Click
        Dim oFD As New OpenFileDialog
        oFD.CheckFileExists = True
        oFD.Multiselect = False
        oFD.InitialDirectory =
System.Environment.GetFolderPath(Environment.SpecialFolder.Desktop) &
"Thesis Stuff\"
        oFD.Filter = "CSV Files (*.csv)|*.csv"
        oFD.FilterIndex = 1
```

```
        sLines = Nothing
        If oFD.ShowDialog() = Windows.Forms.DialogResult.OK Then
            Dim iFStream As New IO.StreamReader(oFD.FileName)
            While Not iFStream.EndOfStream
                If Not sLines Is Nothing Then
                    ReDim Preserve sLines(sLines.Length)
                Else
                    ReDim sLines(0)
                End If
                sLines(sLines.Length - 1) = iFStream.ReadLine()
            End While
            iFStream.Close()
            bFSet = True
            ReDim MatrixA(sLines.Length - 1)
            Dim i As Integer
            For i = 0 To sLines.Length - 1
                ReDim Preserve MatrixA(i)(sLines.Length - 1)
                Dim sTemp As String() = sLines(i).Split(",")
                Dim j As Integer
                For j = 0 To sLines.Length() - 1
                    If j < sTemp.Length() Then
                        MatrixA(i)(j) = Val(sTemp(j))
                    Else
                        MatrixA(i)(j) = 0
                    End If
                Next
            Next
        End If
    End Sub

    Private Sub Button2_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles btnLoadI.Click, btnLoadI2.Click
        Dim oFD As New OpenFileDialog
        oFD.CheckFileExists = True
        oFD.Multiselect = False
        oFD.InitialDirectory =
System.Environment.GetFolderPath(Environment.SpecialFolder.Desktop) &
"Thesis Stuff\"
        oFD.Filter = "CSV Files (*.csv)|*.csv"
        oFD.FilterIndex = 1
        sLines = Nothing
        If oFD.ShowDialog() = Windows.Forms.DialogResult.OK Then
            Dim iFStream As New IO.StreamReader(oFD.FileName)
            While Not iFStream.EndOfStream
                If Not sLines Is Nothing Then
                    ReDim Preserve sLines(sLines.Length)
                Else
                    ReDim sLines(0)
                End If
                sLines(sLines.Length - 1) = iFStream.ReadLine()
            End While
            iFStream.Close()
            bFSet = True
            ReDim MatrixI(sLines.Length - 1)
            Dim i As Integer
            For i = 0 To sLines.Length - 1
                ReDim Preserve MatrixI(i)(sLines.Length - 1)
```

```
                Dim sTemp As String() = sLines(i).Split(",")
                Dim j As Integer
                For j = 0 To sLines.Length() - 1
                    If j < sTemp.Length() Then
                        MatrixI(i)(j) = Val(sTemp(j))
                    Else
                        MatrixI(i)(j) = 0
                    End If
                Next
            Next
        End If
    End Sub

    Private Sub Button3_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles btnLoadLQs.Click, btnLoadLQs2.Click
        Dim oFD As New OpenFileDialog
        oFD.CheckFileExists = True
        oFD.Multiselect = False
        oFD.InitialDirectory =
System.Environment.GetFolderPath(Environment.SpecialFolder.Desktop) &
"Thesis Stuff\"
        oFD.Filter = "CSV Files (*.csv)|*.csv"
        oFD.FilterIndex = 1
        sLines = Nothing
        If oFD.ShowDialog() = Windows.Forms.DialogResult.OK Then
            Dim iFStream As New IO.StreamReader(oFD.FileName)
            While Not iFStream.EndOfStream
                If Not sLines Is Nothing Then
                    ReDim Preserve sLines(sLines.Length)
                Else
                    ReDim sLines(0)
                End If
                sLines(sLines.Length - 1) = iFStream.ReadLine()
            End While
            iFStream.Close()
            bFSet = True
            ReDim MatrixLQNum(sLines.Length - 1)
            Dim i As Integer
            For i = 0 To sLines.Length - 1
                ReDim Preserve MatrixLQNum(i)(sLines.Length - 1)
                Dim sTemp As String() = sLines(i).Split(",")
                Dim j As Integer
                For j = 0 To sLines.Length() - 1
                    If j < sTemp.Length() Then
                        MatrixLQNum(i)(j) = Val(sTemp(j))
                    Else
                        MatrixLQNum(i)(j) = 0
                    End If
                Next
            Next
        End If
    End Sub

    Private Sub Button4_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles btnLoadQ.Click
        Dim oFD As New OpenFileDialog
        oFD.CheckFileExists = True
```

```
        oFD.Multiselect = False
        oFD.InitialDirectory =
System.Environment.GetFolderPath(Environment.SpecialFolder.Desktop) &
"Thesis Stuff\"
        oFD.Filter = "CSV Files (*.csv)|*.csv"
        oFD.FilterIndex = 1
        sLines = Nothing
        If oFD.ShowDialog() = Windows.Forms.DialogResult.OK Then
            Dim iFStream As New IO.StreamReader(oFD.FileName)
            While Not iFStream.EndOfStream
                If Not sLines Is Nothing Then
                    ReDim Preserve sLines(sLines.Length)
                Else
                    ReDim sLines(0)
                End If
                sLines(sLines.Length - 1) = iFStream.ReadLine()
            End While
            iFStream.Close()
            bFSet = True
            ReDim VectorQ(sLines.Length - 1)
            Dim i As Integer
            For i = 0 To sLines.Length - 1
                VectorQ(i) = Val(sLines(i))
            Next
        End If
    End Sub

    Private Sub Button5_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles btnSaveRes.Click
        Dim I, A, LQs As Bluebit.MatrixLibrary.Matrix
        Dim q As Bluebit.MatrixLibrary.Vector
        I = New Bluebit.MatrixLibrary.Matrix(MatrixI.Length,
MatrixI(0).Length)
        Dim k, j As Integer
        For k = 0 To MatrixI.Length - 1
            For j = 0 To MatrixI(k).Length - 1
                I(k, j) = MatrixI(k)(j)
            Next
        Next
        A = New Bluebit.MatrixLibrary.Matrix(MatrixA.Length,
MatrixA(0).Length)
        For k = 0 To MatrixA.Length - 1
            For j = 0 To MatrixA(k).Length - 1
                A(k, j) = MatrixA(k)(j)
            Next
        Next
        LQs = New Bluebit.MatrixLibrary.Matrix(MatrixLQNum.Length,
MatrixLQNum(0).Length)
        For k = 0 To MatrixLQNum.Length - 1
            For j = 0 To MatrixLQNum(k).Length - 1
                LQs(k, j) = MatrixLQNum(k)(j)
            Next
        Next
        q = New Bluebit.MatrixLibrary.Vector(VectorQ)
        Dim Result As Bluebit.MatrixLibrary.Matrix
        Result = Bluebit.MatrixLibrary.Matrix.Subtract(I,
Bluebit.MatrixLibrary.Matrix.Multiply(A, LQs))
```

```
        Dim Result2 As Matrix
        Result2 = Bluebit.MatrixLibrary.Matrix.Multiply(Result, q)

        Dim sFD As New SaveFileDialog
        sFD.InitialDirectory =
System.Environment.GetFolderPath(Environment.SpecialFolder.Desktop)
        sFD.DefaultExt = ".csv"
        sFD.OverwritePrompt = True
        sFD.ValidateNames = True
        sFD.CheckPathExists = True
        sFD.Filter = "Comma Delimited File (*.csv)|*.csv"
        sFD.FileName = "New Matrix " &
Now.ToShortTimeString.Replace(":", ".") & ".csv"
        If sFD.ShowDialog = Windows.Forms.DialogResult.OK Then
            If System.IO.File.Exists(sFD.FileName) Then
                System.IO.File.Delete(sFD.FileName)
            End If
            Dim ofStream As New IO.StreamWriter(sFD.FileName)
            For k = 0 To Result2.Rows - 1
                Dim sTempOut As String = ""
                For j = 0 To Result2.Cols - 1
                    sTempOut = sTempOut & Result2(k, j) & ","
                Next
                ofStream.WriteLine(sTempOut.Substring(0,
sTempOut.Length - 1))
            Next
            ofStream.Close()
        End If
    End Sub

    Private Sub Button6_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles btnLoadY.Click
        Dim oFD As New OpenFileDialog
        oFD.CheckFileExists = True
        oFD.Multiselect = False
        oFD.InitialDirectory =
System.Environment.GetFolderPath(Environment.SpecialFolder.Desktop) &
"Thesis Stuff\"
        oFD.Filter = "CSV Files (*.csv)|*.csv"
        oFD.FilterIndex = 1
        sLines = Nothing
        If oFD.ShowDialog() = Windows.Forms.DialogResult.OK Then
            Dim iFStream As New IO.StreamReader(oFD.FileName)
            While Not iFStream.EndOfStream
                If Not sLines Is Nothing Then
                    ReDim Preserve sLines(sLines.Length)
                Else
                    ReDim sLines(0)
                End If
                sLines(sLines.Length - 1) = iFStream.ReadLine()
            End While
            iFStream.Close()
            bFSet = True
            ReDim VectorY(sLines.Length - 1)
            Dim i As Integer
            For i = 0 To sLines.Length - 1
                VectorY(i) = Val(sLines(i))
```

```
            Next
        End If
    End Sub

    Private Sub Button10_Click(ByVal sender As System.Object, ByVal e
As System.EventArgs) Handles btnSaveRes2.Click
        Dim I, A, LQs As Bluebit.MatrixLibrary.Matrix
        Dim y As Bluebit.MatrixLibrary.Vector
        I = New Bluebit.MatrixLibrary.Matrix(MatrixI.Length,
MatrixI(0).Length)
        Dim k, j As Integer
        For k = 0 To MatrixI.Length - 1
            For j = 0 To MatrixI(k).Length - 1
                I(k, j) = MatrixI(k)(j)
            Next
        Next
        A = New Bluebit.MatrixLibrary.Matrix(MatrixA.Length,
MatrixA(0).Length)
        For k = 0 To MatrixA.Length - 1
            For j = 0 To MatrixA(k).Length - 1
                A(k, j) = MatrixA(k)(j)
            Next
        Next
        LQs = New Bluebit.MatrixLibrary.Matrix(MatrixLQNum.Length,
MatrixLQNum(0).Length)
        For k = 0 To MatrixLQNum.Length - 1
            For j = 0 To MatrixLQNum(k).Length - 1
                LQs(k, j) = MatrixLQNum(k)(j)
            Next
        Next
        y = New Bluebit.MatrixLibrary.Vector(VectorY)
        Dim Result As Bluebit.MatrixLibrary.Matrix
        Result = Bluebit.MatrixLibrary.Matrix.Subtract(I,
Bluebit.MatrixLibrary.Matrix.Multiply(A, LQs)).Inverse
        Dim Result2 As Matrix
        Result2 = Bluebit.MatrixLibrary.Matrix.Multiply(Result, y)

        Dim sFD As New SaveFileDialog
        sFD.InitialDirectory =
System.Environment.GetFolderPath(Environment.SpecialFolder.Desktop)
        sFD.DefaultExt = ".csv"
        sFD.OverwritePrompt = True
        sFD.ValidateNames = True
        sFD.CheckPathExists = True
        sFD.Filter = "Comma Delimited File (*.csv)|*.csv"
        sFD.FileName = "New Matrix " &
Now.ToShortTimeString.Replace(":", ".") & ".csv"
        If sFD.ShowDialog = Windows.Forms.DialogResult.OK Then
            If System.IO.File.Exists(sFD.FileName) Then
                System.IO.File.Delete(sFD.FileName)
            End If
            Dim ofStream As New IO.StreamWriter(sFD.FileName)
            For k = 0 To Result2.Rows - 1
                Dim sTempOut As String = ""
                For j = 0 To Result2.Cols - 1
                    sTempOut = sTempOut & Result2(k, j) & ","
                Next
```

```
                ofStream.WriteLine(sTempOut.Substring(0,
sTempOut.Length - 1))
            Next
            ofStream.Close()
        End If
    End Sub
End Class
```

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