EMBRY-RIDDLE Aeronautical University
SCHOLARLY COMMONS

International Journal of Aviation, Aeronautics, and Aerospace

Volume 2 | Issue 3 Article 9

8-27-2015

Economic Interrelationships and Impacts of the Aviation/Aerospace Industry in the State of Florida Using Input-Output Analysis

Kelly A. Whealan-George
Embry-Riddle Aeronautical University - Worldwide, georged8@erau.edu

Tim Brady
Ermbry-Riddle Aeronautical University - Daytona Beach, bradyt@erau.edu

Ian McAndrew
Embry-Riddle Aeronautical University – Worldwide, mcand4f1@erau.edu

Irwin Price
Embry-Riddle Aeronautical University, iprice@erau.edu

Robert T. Clair
KPMG, Inc., bobclair@kpmg.com

The aviation and aerospace industry have always had a significant economic impact in the areas where they have been introduced. It has been argued these are both positive and negative impacts on individual standpoints (Enterprise Florida, 2013; Florida Space Day, 2013; Harrington, J., Lee, H., Tischner, C., Duch, D., March 2012; Whealan George, 2013). Any discussion regarding expansion of these industries is highly polarizing, and as a result, has often led to the delay and sometimes total blockage of such expansion. (Arcieri, 2014; Dale, 2014; Hilkevitch, 2013). Justifying the anticipated economic influence of such expansion is the most highly scrutinized and polarizing aspect of the debate, both at the regional and national level. Economic impact analysis can be useful in mitigating this polarization, granted it yields unbiased and accurate data regarding anticipated economic impacts. Input-Output (IO) analysis is an economic impact quantitative technique used to assess how changes in a specified economy compound financially through local and regional economies (Blin & Murphy, 1973; Chiou-Shauang & Ames, 1965; Khandker, Koolwal, & Samad, 2010; Lang, 1983; Lynch, 2000). IO analysis is a widely accepted, feasible method of economic impact analysis that objectively quantifies the total economic impact of an industry(s). Furthermore, IO analysis can be used as an economic tool to review the interrelatedness of all other industries in a specified economy. It should not be confused as a substitute for all analysis; however, when applied with specific constraints, it is likely to produce meaningful, relevant results.

The IO analysis in this particular research uses a matrix of a set of linear equations for all industries in the economy in order to depict intra-industry relationships within an economy. Each row in the matrix embodies an equation representing the output from one industry broken down into inputs to other industries' production, or a final demand output value. The specific region studied was the State of Florida and Volusia County (VC) because of the geographic location of a proposed aviation and aerospace research park in Daytona Beach (DB) and its proximity to the desired expansion of the aviation and aerospace industry cluster within Florida and VC (Enterprise Florida, 2013). By reviewing a change in the final demand in specific industries related to a project, the resulting IO analysis output describes the total induced changes in all the other industries from the initial economic event (Miller, R.E. & Blair, P.D., 2009). This research used the current, appropriate, and specific research and industry interrelatedness output accounts of economic activity.

Published evidence of both economic contributions to the aviation and aerospace industry in Florida and the creation of an aerospace research park in VC were incomplete and varied. Enterprise Florida (2013) stated that Florida employs over 87,000 aerospace and aviation workers across the state. Florida Space Day

(2013) published that the total number of aerospace industry employees reported in Florida exceeded 132,000, with a combined total revenue of over 17 billion U.S. dollars. To foster an expansion of the aviation and aerospace industry in Florida, the Florida Legislature's approval for $9M to build a wind tunnel at Embry-Riddle Aeronautical University (ERAU). The addition of the wind tunnel was forecasted to spur the creation of additional engineering jobs (Embry-Riddle poised for success with research park, 2013). Most view the establishment of a university research park as a successful way to advance innovation and create economic growth (Battelle Technology Partnership Practice, 2013). Research parks are emerging as strong sources of entrepreneurship, talent, and economic competitiveness for regions, states, and nations (Battelle Technology Partnership Practice, 2007). For example, ERAU is partnering with an internationally renowned aircraft manufacturer to provide job opportunities and an economic boost for VC and the state of Florida (Embry-Riddle poised for success with research park, 2013).

There are numerous industry participants, associations, educational institutions, economic development organizations, and government entities that advocate the growth of a geographic cluster of industry dedicated to the aviation and aerospace industry within Florida and VC (Association of University Research Parks, 2013b; Enterprise Florida, 2013; Florida Space Day, 2013; Harrington, J., Lee, H., Tischner, C., Duch, D., 2012; Pisano & Shih, 2009). Florida ranks in the top five states for aerospace industry employment, and produces a large amount of economic output in Florida's economy (Space Florida, 2014; The Commission on the Future of the U.S. Aerospace Industry, 2002). Florida also has significant aviation and aerospace infrastructure already in place, which includes the related labor force and educational institutions to support this economic development effort (Enterprise Florida, 2013; Florida Space Day, 2013; Space Florida, 2014).

This research comprehensively describes the interrelatedness of the aviation and aerospace industries with all other industries in Florida and VC. The measures of the economic impact included not only direct economic output and industry employment descriptions, but also described the multiplier effects from the addition of such a facility to the economy. Because additional economic activity of one industry is not limited within that industry, the analysis describes the resulting economic activities in non-aviation and non-aerospace industry pertaining to their economic impact.

Significance of the Study

Investment, public or private, attracts competing interests; as a result, anticipating the economic importance of this project or activity is paramount. The results comprehensively describe the additional production impact from the aviation and aerospace industry on all the other non-aviation and non-aerospace industries within Florida and VC, with respect to production and employment. This analysis was structured to yield information about direct, indirect, and induced effects in the form of employment figures, labor income, and total economic output for specific industries in the region. Results will be useful in economic comparisons, planning, resource allocation, and identification of industry clusters.

Statement of the Problem

Economic policy often aims to diversify the economy and promote growth of beneficial industries, inter alia (Nobel Media, 2013). Potential economic policy options are often constrained by budgets requiring resource allocation that maximizes their impact with respect to the desired economic result (Los, 2011). For example, the FAA evaluated its investment in next generation capabilities, concluding that it will result in increased air space capacity, safety enhancements, and lower fuel costs, resulting in better economic growth within the aviation industry. The promotion of the aerospace and aviation industries in Florida and VC has not been addressed in detail using current industry output data. The present situation arose from a desired expansion of the aviation and aerospace industry cluster within Florida and VC, preferably brought on by outside industry and other related organizations. Many of the existing studies are either partial analyses, do not include the multiplier effects, or use data models that do not reflect the current economic relationships between industries (Association of University Research Parks, 2013b; Battelle Technology Partnership Practice, 2007; Embry-Riddle Aeronautical University, 2013b; Florida Space Day, 2013; Harrington, J., Lee, H., Tischner, C., Duch, D., 2012). The multiplier effects are critical, as they encompass the industry interrelatedness within a specified economy. To identify the aviation and aerospace industry's significance in the Florida economy, an economic analysis of Florida and VC was undertaken, based on a matrix of industry relationships. Additionally, the analysis can be used in deciding on future investments in regional economic growth based on a high level of confidence.

Research Questions

The research questions posed by this study include:

RQ 1: What is the composition of the aviation and aerospace industry in the Florida and VC economy, in terms of employment and economic output?

RQ2: What are the interdependencies of the aviation and aerospace industry's economic relationships with other industries in Florida and VC?

Delimitations

The analysis of the results was comprehensive, and applicable to other economic sectors within the region; however, there are limitations to generalizing the specific conclusions to regions outside of Florida and VC, or to other industries' interrelatedness measures. The relationships between industries represented in the IO analysis were unique to the region under study. As a result, it is inappropriate to suggest that the interrelatedness of the aviation and aerospace industry in Florida is the same in other economic regions.

An industry's multiplier effect may be different based on its regional size and geographic location. Multiplier effects may also vary widely, based on the type of industry within the region and other unique factors. Relative to another industry, if one industry procures more of its production within the region, that industry's multiplier will be larger compared to others, and will have a greater impact on its regional economy. A larger region will typically have fewer outflows from its economy into different regions, partially due to the larger region satisfying the additional spending from any one industry (Implan Group, 2004; Miller, 2011). Typical sources of outflows or leakages from a geographical economy often include: purchases from outside the region, tax payments, and the region's household savings characteristics. All these examples of leakage represent money that does not keep flowing through the region's economy, dampening multiplier effects (Implan Group, 2004; Miller, 2011). A clustered industry whereby businesses are in the same proximity to their suppliers, service providers, or associated institutions, will have a higher multiplier effect within a region than an industry that transacts from many different regions. A good example of a clustered industry is the computer technology industry located in Silicon Valley, California. Entrepreneurs, venture capitalists, technology service companies, engineers, and programmers are tightly located in a geographic area; thus, Stanford's Research Park is a major industrial force in the region. Other examples of geographic clusters in the US include the Research Triangle in North Carolina, the financial industry in Connecticut, the film industry in California, and the tourism industry in both central and south Florida (Porter, 2000). Industry clusters are not limited to the United States. Foreign examples include industry clusters surrounding ship building in Korea, Formula 1 in England, and the auto industry in Japan.

The IO data were specific to Florida and VC in terms of the economic interrelationships between industries that are present. Due to the unique characteristics of Florida, economic interrelationships with the aviation and aerospace industry may be different in another state or region. Items of significance to the aviation and aerospace industry in Florida and VC that are unique to the region include their geographic proximity to other industries and related industry organizations, Florida tax structure, the transportation infrastructure, and the concentration of industry-related laborers and academia.

Significant structural changes in the economy would decrease the validity of the estimation of economic impacts as time progresses past the most current data represented in the IO model. The use of IO in forecasting economic behavior is dependent upon the stability of the economy reflected in the analysis. Use of IO for forecasting in a rapidly changing economic environment, or over the long-term, requires the additional conditions of future technology forecasts and detailed final demand components (Dietzenbacher et al., 2013; Leontief, 1987).

Limitations and Assumptions

The estimates of this research reflect the assumption that the relationships defined in the current data are maintained or constant (Day, 2013). Changes to the types of industries in a region typically occur slowly, and seldom have an immediate impact. There have been exceptions; however, the structural changes expected in this research will likely be minimal. If unanticipated changes occur, the research will require revision in accordance with updated data. However, the principles of this methodology allow for expected natural variations. In order to have the maximum confidence in reflective outcomes, this research will be most representative for one year, or until significant structural changes in the economy take place. Significant changes that can quickly restructure part of the economy include, but are not limited to, energy price or availability shocks, environmental factors, and policy redirections.

Impact estimates based on a broader economic region are better than those based on a narrowly defined region because of the leaks in the system. An impact study can only track conducted transactions within the region under study. Therefore, if an area’s economy grows significantly or becomes more globalized, more leaks in the system occur. This causes money to leave the region under study, rendering it untraceable. Additionally, when an industry purchases most of its inputs from outside its region, it dampens the impact of an economic event.

Literature Review

Understanding how industries interact, and how their economic events impact other industries, is critical to comprehending a region's economy. Reviewed literature includes the definition of industry sectors, alternatives to quantifying industry interrelationships and economic impacts, and university research parks' impacts on a region's economy. Once a detailed description of the industry relationships is established, conducting 'what if' scenarios can aid in estimating the effects of specific significant economic events on a specified economy. Research parks are emerging as engines for growth in many regions. Consequently, the research views the creation of a research park in Florida dedicated to aviation and aerospace as an economic event.

Industry Definitions

Productive activity, cataloged into various classes or sectors by industrial classifications, quantifies economic activity in an economy. Industry sectors are the means by which impacts from an economic event may be traced. Industry classifications divide economic activity according to similar functions. The most detailed regional IO matrix used in this research depicts economic activity categorized into 440 industry sector codes. These codes relate to the North American Industry Classification Strategy (NAICS), developed under guidance by the U.S. Office of Management and Budget (OMB). The NAICS is the standard for Federal agencies in classifying business activities into industries within the U.S. economy. Through organization according to the NAICS standard, economic data is uniform, and useful in economic analysis and presentation. Business activity is also assigned a NAICS code, based on its primary business activity. A primary business activity is determined by the relative share of production valued by either revenue, or value of shipments (U.S. Census Bureau, 2012). Tables 1, 2, and 3 define the related NAICS categories for the aviation, aerospace, and education industries.

Industry Interrelatedness Studies

To get a sense of the impact on, or interdependence of, one industry in relation to all the others, economists turn to economic interrelatedness studies based on general equilibrium theory (Blaug, 1986). Leon Walras is considered by many as the father of general equilibrium theory (Sandmo, 2011). In *Elements of Pure Economics* (1884), Walras theorized that a system of simultaneous equations, as a representation of the economy, could represent all markets in the economy at equilibrium (Walras, 1877).

Table 1

Aviation industries defined by NAICS Code (U.S. Census Bureau, 2012).

NAICS	Title
336411	Aircraft manufacturing
336412	Aircraft engine and engine parts manufacturing
336413	Other aircraft parts and auxiliary equipment manufacturing
481111	Scheduled passenger air transportation
481112	Scheduled freight air transportation
481211	Nonscheduled chartered passenger air transportation
481212	Nonscheduled chartered freight air transportation
481219	Other nonscheduled air transportation
324110	Petroleum refineries (aviation fuel)
488119	Other airport operations
611512	Flight training
713990	All other amusement and recreation industries
813319	Other social advocacy organizations
926120	Regulation and administration of transportation programs

Table 2

Aerospace industries defined by NAICS Code (U.S. Census Bureau, 2012).

NAICS code	Title
336414	Guided missile and space vehicle manufacturing
336415	Guided missile and space vehicle propulsion unit and propulsion unit parts manufacturing
336419	Other guided missile and space vehicle parts and auxiliary equipment manufacturing
334511	Search, detection, navigation, guidance, aeronautical and nautical system and instrument manufacturing
334519	Other measuring and controlling device manufacturing
335991	Carbon and graphite product manufacturing

Table 3

Educational service industries defined by NAICS Code (U.S. Census Bureau, 2012).

NAICS code	Title
611310	Colleges, Universities and Professional Schools
611512	Flight training

General equilibrium systems are successful because they account for the interdependence of all economic agents in the model. Blin and Murphy (1973) categorized the IO system as a very special and rich class of general equilibrium models (Blin & Murphy, 1973). The IO matrix of a region's economy operates as a general equilibrium model, and as a source of economic interpretation of the industries' interrelatedness. The industry interrelatedness function is useful measure in both economic contexts the application of impact studies (Blin & Murphy, 1973; Chiou-Shauang & Ames, 1965).

Harris and Cox (1988) used IO analysis at an aggregate level to study the relationship between the non-traded service sector and the traded goods sectors. Momigliano and Sinniscalo (1982) used IO analysis to link employment growth to the degree of integration of service industries within the Italian economy. They distinguished real effects from what they termed "illusion" effects that may suggest structural changes in inter-industry relationships from outsourcing of production by Italian manufacturing firms to specialized business services. IO analyses pertaining to the interaction of strategic economic groups are few, except those providing routine summaries of aggregate direct and indirect output or employment values (Jones, 1992).

Romanelli and Khessina (2005) define industries that are significant to the economic wealth of a region as dominant industry clusters. Porter (1998) concluded that the Italian footwear and fashion industry was a dominant industry, not because of the number of producers in the region, but because of the relationships of the fashion producers with the leather goods producers and machinery/components manufacturers. Romanelli and Khessina (2005) and Porter (1998) view industry interrelatedness as a product of resource overlap rather than an input-output configuration. Porter (2000 and 2003), studying company strategy and competitiveness, delineates industry clusters using co-location patterns in a region rather than IO analysis.

More complex industry relationships can be modeled using econometric models. Hunt (1996) and Hunt (1997) evaluated rival regional econometric models, but found little consistency across the results. The differences in conclusions, oftentimes in direct conflict with alternatives, were usually explained by detailed analysis of the models' underlying structures, source data sets, and treatment of data. Additionally, the availability and consistency of data over a long time span, as required in econometric models, makes IO analysis a viable alternative, constructing a detailed snapshot of the industry linkages in a regional economy.

Saric (2012) notes that in the absence of data indicating the strength of industry linkages, the construct of interrelatedness is used as a proxy to determine clusters. interrelatedness is a complex concept, reflected by multiple indicators (Saric, 2012). Rumelt (1974) and Montgomery (1982) classified firms by similarity of products, outputs, and technologies that closely resembled the Standard Industry Classification (SIC) codes. SIC codes were the predecessor of the NAISC. They faced criticism because presenting interrelatedness through grouping industry solely by classification has little explanatory power (Saric, 2012). Stimpert & Dunhaime (1997) and Pehrsson (2006) determined interrelatedness of industries by surveying large diversified firms to determine their perceptions of relation. Stimpert and Dunhaime (1997) and Pehrsson's (2006) work attempted to show a relationship between industries by analyzing product market or resource market relationships, thus not capturing the full breadth information available in IO links.

Saric (2012) asserts that IO tables are commonly used as an initial step in determining industry clusters. Regional data can be limited. Outside the United States, the use of IO tables for regional analysis is not readily available. Researchers, consequently, are restricted to qualitative methodologies such as survey methods orregional IO table deductions (Hewings & Jensen, 2000; Kratke, 2002). However, in this study, the regional data is available and valid, thus allowing the use of IO analysis for a full description of the interrelatedness between industries.

Input-Output Analysis

Wassily Leontief developed IO analysis in the 1930s as a method of analyzing the interdependence of industries within an economy. Leontief's work began in 1920. The circular flow of goods constituted a need to develop a quantitative method for conceptualizing the enormous amounts of empirical data involved in all real economic situations and general equilibrium theory (Leontief, 1966). Leontief claimed the following: Input-Output analysis is a practical extension of the classical theory of general interdependence, which views the whole economy of a region, a country, and even of the entire world as a single system and sets out to describe and to interpret its operation in terms of directly observable basic structural relationships (Leontief, 1987, p. 860). Leontief's 1936 article, "Quantitative Input and Output Relations in the Economic System of the United States," and his 1937 article "Interrelation of Prices, Output, Savings and Investment," are recognized as the genesis of a major branch of quantitative economics (Aroche, 2009; Rose & Miernyk, 1989). For his work on IO analysis, Leontief was awarded the Nobel Prize in Economic Sciences in 1973 (Miller, R.E. & Blair, P.D., 2009; Nobel Media AB, 2014).

The outputs of one industry source the inputs of another industry, enabling the IO matrix table users to trace where each industry uses the product of another industry. The IO matrix also allows users to discover how a change in final demand in as few as one industry impacts every other industry's output. Industry product flow accounts and relationships describe economic interdependencies. Furthermore, analyzing an economy's IO matrix can assist in determining industry interrelationships (Leontief, 1949). In short, the IO model can be referred to as an impact model, enabling the researcher to trace specified changes in industry activities resulting from fluctuations in final demand.

IO transactions tables express a matrix of linear equations that facilitate the recognition of the inter-industry demand relationships. Each row or equation in the matrix generally represents one industry or sector of the economy. The equation for each row describes the total value of that industry's output as the sum of: all the values of that industry's output sold as final demand, the value of the industry's output used in its own production process, and the value of the industry's output sold as an input to other industries. The row's equation is a summation in which x is the total output from industry ; z is the intermediate output used as inputs required from industry for that industry in all other industries 1 through n, and f is the final demand of i's output (see Equation 1).

$$x_i = z_{i1} + \ldots + z_{in} + f_i \quad (1)$$

Final demand columns are included in the matrix, and detail which sectors of final demand the industry output terminates. These final demand sectors are the major Gross Domestic Product (GDP) accounts: personal consumption, gross private domestic investment, government purchases, and net exports (exports minus imports). Table 4 shows an example of a two-industry economy, which is discussed later.

Within the IO matrix, the columns also represent inter-industry supply relationships. Each column of the matrix represents what inputs are required from all the other industries in the economy to produce each industry's output. The equation for each column represents: the total value of an industry's required inputs as the sum of all the inputs that are needed from each industry, inputs needed from its own industry, and value added inputs to total production. The column's equation is a summation, in which x is the total value of inputs needed from industries 1 through n for that industry, plus value-added for that industry (see Equation 2). Value added includes labor, wages and profits, depreciation of capital, and taxes (George & Taylor, 1995; Miller, R.E. & Blair, P.D., 2009).

$$x_i = z_{1i} + \ldots + z_{ni} + va_i \qquad (2)$$

National income and product accounting rules are internationally accepted as a measure of a nation's economic activity (Arnold, 2011). Using these national income and product accounting rules, the value of gross national income (va_i), less the final demand (f_i), is equal to the intermediate consumption or production (x_i). This relationship provides the core of the mathematical depiction of the interrelatedness of industries in the economy. The matrix of simultaneous equations (Equation 3) represents the total accounting for production in the economy for one year (Miller, R.E. & Blair, P.D., 2009). In Equation 3, x and f represent the column vectors of industries one through, while Z reflects the matrix of intermediate outputs from industry one thru i to each industry.

$$x = Z_i + f \qquad (3)$$

Table 4 is an example of an input-output matrix of a two-sector economy. The only two sectors in this economy are manufacturing and services. Each row's equation represents the total value of that industry's output as the sum of all the values of that industry's output sold as final demand, the value of the industry's output used in its own production process, and the value of the industry's output that is sold as an input to other industries. The manufacturing sector uses $10 of its own production; it sells $40 to the service sector, and sells $50 as final demand for a total output of $100. Each column's amount represents the total value of an industry's required inputs as the sum of all the inputs that are needed from each industry, inputs needed from its own industry, and value added inputs to total production. The services sector requires $40 from the manufacturing sector and $25 from its own sector as inputs, and $75 of value-added inputs to show a total outlay of $140. Value added represents employee compensation, government services paid for by taxes, interest payments, rental payments, and profit. It is possible to expand this economy internationally by adding a column for outputs destined for export and a row for inputs from imports (Miller, R.E. & Blair, P.D., 2009).

Table 4

An example of an Input-Output matrix for a two-sector economy.

Sector	Manufacturing	Services	Final Demand	Total Output
Manufacturing	10	40	50	100
Services	30	25	85	140
Value Added	60	75	135	
Total Output	100	140		240

A region's IO table can help assess industry production requirements inputs by simulating a change in one or more industries. Simulating such a change is typically represented as a change to final industry demand(s) and allows inspection on the expected impacts in all the other industries (George & Taylor, 1995). This manipulation essentially solves a matrix algebraic problem regarding the number of industries or sectors by using one vector to represent the changed final demand(s), which uses numerical analysis software, and notes the resulting vector representing the change in output for each industry. Changes in one industry affect other industries, and feedback on the original industry until the disequilibrium from the shock significantly dampens (Min Tam, 2008; Pereira & Polenske, 1996; Polenske, Robinson, K. Hong, Moore, & Stedman, 1992).

With a full IO matrix table, the Leontief inverse (L) can be constructed (Equation 4).

$$L = (I-A)^{-1} \tag{4}$$

Leontief's inverse is the most influential tool in IO analysis because it captures all the indirect effects on the region's economy. The Leontief inverse is also known as the total requirements matrix (Miller, R.E. & Blair, P.D., 2009). The total requirements matrix represents the dependence of each industry's output on the values of the economy's final demand. Matrix A is an industry-by-industry square matrix showing the intermediate use of goods by all industries. Using an identity matrix (I), we can determine the requirements from each industry (x) to satisfy the total outputs for each industry (y) (Equation 5). Equation 5 explicitly captures the interdependence of the region's industries, as the output of each industry sector is dependent upon each industry sector's final demand and output (Miller, R.E. & Blair, P.D., 2009).

$$x = (I-A)^{-1} y \tag{5}$$

IO analysis accommodates or accounts for three principal types of effects or impacts in the economy: direct, indirect, and induced. Direct impacts are effects from business activity. Indirect impacts are caused by inter-industry changes in business. Induced effects are impacts created by the household sector spending of those employed by the direct and indirect altered industries (Miller, R.E. & Blair, P.D., 2009). Since the IO approach accounts for changes of inputs to industries based on changing outputs of industries, it is possible to achieve a more precise calculation of the impacts of a given or potential change in the economy. "Input-output analysis can be thought of as documenting and exploring the precise systems of inter-industry exchange through which different components of regional product become different components of regional income" (Bendavid-Val, 1972, pp.87-88).

IO analysis yields a comprehensive description of the inter-industry structure of an economy, and articulates strategic industries and opportunities for income and/or employment impacts (Day, 2013; Implan Group, 2004; Lynch, 2000; Miller, R.E. & Blair, P.D., 2009). The Leontief inverse is the foundation of the multiplier effect referred to in IO analysis. This multiplier is the source of impact analysis that is widely accepted in policy design (Baumol & Wolff, 1994).

IO analysis is accepted as a reliable method for descriptive analysis, forecasting, and assessing policy impact scenarios (Dietzenbacher & Lahr, 2008). An IO model's usefulness lies in its ability to estimate the indirect impacts of a final demand change, by detailing the interdependency of the economy's industry. Isard, et al. (1989) contend that because of IO's interdependency of industry capabilities, it is an indispensable part of economic impact research. IO models produce a multiplier index that is useful in measuring the total impact of a change in final demand on inter-industry demand that is useful in forecasting, and by extended application, employment impacts (Stimson, Stough, & Roberts, 2002).

IO analysis has been used for a wide range of economic impact studies, and in compiling economic impact analysis for a university research park within a region. When IO analysis is not used, survey studies, case studies, cost benefit analyses, or econometric models are employed; however, that is not a function of this research. The researchers for all seven economic impact studies published by the Association of University Research Parks (AURP) used IO analysis as the tool for projecting the impact on the region (Association of University Research Parks, 2013b).

IO analysis is not without its weaknesses. In doing an IO analysis, the researcher must assume there are no substitutions of inputs within the production process. For example, a change in final demand that would lead to a shortage of inputs in certain sectors of the economy would most likely induce higher market prices for those inputs, and some processes might try to adopt a change in the input mix of production. IO matrices are based on transactions over the period of one year, and any irregularities or short-term trends can either be exacerbated or lost in the analysis (Bendavid-Val, 1972). IO models assume a linear relationship between a change in demand and a change in inputs and outputs that minimizes the impacts of externalities and changes in returns to scale. IO does not directly capture natural resource externalities not traded in the markets, such as pollution, and fails to answer the more subjective question of whether or not a society has qualitatively improved or more efficiently allocated its resources (Letson, 2002).

Economic Impact Studies

"Like in an ant colony, little decisions on a micro level can have a big impact on a macro level" (Ted Talks, 2008).

There is often a need to evaluate the economic impact of major initiatives within an economy to facilitate decision making by policy makers and investors. Economic impact is any type of event that results in an addition or loss of spending in an economy. An economic impact study seeks to describe the cumulative effects of any significant change or shock within an economy, including direct, indirect, and induced effects (Day, 2013). Examples of economic impacts include, but are not limited to, the opening or closing of a military base, building a sports stadium or convention facility, or recovery from natural disasters.

Other Economic Impact Analysis Models

There are other methods of regional economic impact analysis. Econometric modeling is among them (Isard, Azis, Drennan, Miller, Salzman, & Thorbecke, 1998a). Econometrics is the building of a mathematical model grounded in economic theory, and statistically tested to determine if the model sufficiently describes the underlying phenomenon. Techniques can be time dependent or cross-sectional, and dummy variables can be included in an econometric model. Such models test the validity of a theory, forecast values of dependent variables, or predict the results of a policy decision.

Leontief and other followers critiqued the use of econometric modeling as a way of alternatively studying economic impacts. The main critique involved contemporary economists spending time building sophisticated statistical models on data with possible validity issues (Pressman, 1999). Econometrics modeling creates models that either abstractly or theoretically describe relationships that Leontief argued were essentially built-in rather than discovered. Econometric models used for impact or forecasting typically take three forms: autoregressive models, reduced-form models, and large scale structural models (Lang, 1983). Model builders create assumptions, then create models that use these assumptions. The model works if the assumptions are true (Friedman, 1953; Pressman, 1999; Samuelson, 1958).

Bergmann, Kehoe, and Levine (1982) endorsed general equilibrium models over econometric models as tools for policy analysis. General equilibrium models, like IO analysis, do not have a time component that allows for infinite feedback loops, resulting in the analyses reaching equilibrium. Econometric models often have an artificial truncation, in the form of a finite time horizon that can cause the calculated equilibrium to be rather sensitive to the truncation. They note that Samuelson (1958) even admitted that as a model's time period continues to be lengthened, it not only supplies more information, but also introduces more unknowns into a model (Bergman, Jorgenson, & Zalai, 1990; Samuelson, 1958).

Lucas (1976) was a strong advocate of solving problems through the application of economic tools to real-world data. He critiqued economic modeling because many assumptions embodied within models were unrealistic; he expounded, however, by contending that if the model behaved statistically well, it could have been considered a good model. The Lucas critique went even further by saying that once policy was changed, the econometric model used in forecasts was invalid (Lang, 1983; Lucas, 1976).

Friedman (1953) argued that a theory's validity should rest on its predictive accuracy rather than consideration of realistic assumptions. Focusing on the predictive validity of models prevents the understanding of underlying relationships in the economy when making policy and predictive statements. With IO analysis, the focus is not on the statistical predictive accuracy, but on the true state of the underlying industry interrelationships.

Econometric testing assumes economic relationships are stable over time, and can shadow any weaknesses in the data (Chow, 1960; Pressman, 1999). Because economic relationships are dependent on individual interactions, it is unrealistic to assume the structure of their relationships does not change over time, causing econometric models to weaken. Chow echoes Lucas's and Friedman's critique of econometric models. Rather than estimating values and theoretical models, Leontief believed that economists should investigate the empirical data and the relationships within them to best determine how to solve economic problems.

IO became popular after World War II as governments began to work on comprehensive economic development projects. This tool would allow a policy maker to project the consequences of changes in economic policy. Since Leontief derived IO analysis from early Soviet economic planning methods, Hungarian economists and other governments adopted this method as a Socialist tool. IO analysis quickly became a casualty of the political environment in the United States (Bockman, 2011). The U.S. Bureau of Labor Statistics (BLS) constructed a 50-sector matrix of inter-industry transactions, modeled on the 1947 U.S. economy and projected the U.S. economy in 1950 (Cornfield, Evans, & Hoffenberg, 1950). Some industry leaders, including General Motors Incorporated and U.S. Steel, viewed this approach as "push button" planning that subverts private enterprise (Kye's K.O's input-output studies, 1953). By 1953, public funding to U.S. departments supporting the construction of U.S. IO tables was terminated, thus ending the public research initiative (The Netherlands Economic Institute, 1953). Research on IO analysis continued through U.S. universities, with foundation funds and economists from approximately 40 other countries (The Netherlands Economic Institute, 1953). In the 1970s, the economic environment shifted from a state of government planning and directed changes to a more market-directed form of economic development (Pressman, 1999). Interest in IO analysis waned as economists turned more to modeling (Pressman, 1999). In addition, the government resources for the data collection piece of IO tables and the computer modeling requirements for IO analysis were tremendous. It was in the 1960s that computers calculated the matrices, and required much more time than today's computers (Lal, 2000). Furthermore, the data collected and used for policy analysis would be considerably obsolete when released for publication. For example, the U.S. Bureau of Economic Analysis (BEA) updates a benchmark IO table every five years, and publishes a yearly, higher-level aggregated IO table.

Despite the fact that the use of IO analysis in the United States was stifled politics, it is still used overwhelmingly, and internationally (Kye's K.O's input-output studies, 1953; Bockman, 2011). Economics Systems Research is a peer-reviewed journal of the International Input-Output Association (IIOA). Implan

Incorporated, a company born from its academic roots at the United States Forest Service and University of Minnesota, compiles IO data for all states and publishes it in a timeframe in which the data are still useful; typically between one and two years. Murray and Wood (2010) present the expanding academic and social significance of IO analysis as the most reliable analytical method for enumerating economic transactions by industry sector. In addition to economic analysis, IO analysis also proves useful for examining environmental, sustainability, and social well-being studies. (Wiedmann, 2010).

The use of simple economic base models in which only basic and non-basic sectors are detailed is another method of studying economic impacts (Dinc & Haynes, 1999; Haig, 1928; Quintero, 2007). Any economic impacts are traced through multiplier effects, commonly referred to as ripple effects, that only analyze at the basic and non-basic sector levels, and gross changes are aggregated to those levels. Inter-industry transactions and financial flows are not included. Typically, economic base analysis assumes the application of broad multipliers to the entire economy and its sectors. Despite the usefulness of economic base models, Galambos and Schreiber (1978) recommend the use of IO analysis to obtain a more complete, detailed picture of economic relationships than what is available in economic base models. Again, the assumptions are of exports as a sole source of economic growth, that one industry's exports does not affect another's, and no feedback among industries within a region weaken its conclusions (Davis, 1990). Drennan (1997) published a paper that contends the assumptions embodied within the economic base model "are just silly and wrong."

Cost benefit analysis (CBA) is another form of economic impact analysis, sometimes used when policies are evaluated. During the first month of the Reagan administration, President Reagan issued Executive Order 12291 that called for a CBA of all proposed regulations (Cowen, 1998). CBA compares the gross benefits of a policy or change with the opportunity costs of that change. If the benefits are greater than the costs, then the policy is considered positive or economically viable. CBA formats vary greatly, as some seek to include estimates of social benefits or costs, environmental impacts, efficiency estimates, and price impacts (Mishan & Quah, 2007). As with the value of any model, the information depends on the accuracy of the individual costs and benefit estimates. Usually, the outcome of a CBA is a generation of an individual value that is used for justification or feasibility decisions, rather than a description of the impacts within the economy. IO analysis deals strictly with transactions, and provides more intra-industry information for a full description of impacts from any project.

Current measures of industry composition and interrelatedness are essential to describe a region's economy adequately. IO matrix tables are not only a common method of quantitatively describing the composition of a region's economic activity, but one that provides rich detail. Although there are other methods of analyzing regional economic impact analysis such as econometric modeling, economic base models, or CBA, IO analysis is internationally recognized as a useful methodology. Using this representation of a region's economy, researchers can conduct "what if" scenarios to estimate the effect of specific significant economic events. There is a need to evaluate the economic impact of major initiatives within an economy to facilitate decision making by policy makers and investors.

Method

This research embodies theory from the literature, introduced and combined with the research questions. The research included the specific focus on the general concept of economic analysis, and ventured into the concepts of the application of the model. First, the composition of the economy by industry in Florida and VC was described and related to the aviation and aerospace industry particularly the implications, influences, and applications to the region. Subsequently, industry interrelations with the aviation and aerospace industry with Florida and VC were explained comprehensively. A detailed description of the industry relationships was established; this research conducted a sensitivity analysis to estimate the effects of specific significant economic events on the specified economy.

Research Approach

The discussion of literature suggests IO analysis was theoretically appropriate, and practical to study industry interrelatedness, allowing the evaluation of the estimate of impact or interdependence of one industry on all the others (Miller, R.E. & Blair, P.D., 2009). As with any research technique, there were limitations, and one approach does not fit all applications. A thorough review of research techniques and the principal aspects of those techniques were highlighted accordingly for the research in this work. Furthermore, IO analysis exceptionally described industry interrelationships, vice solely categorizing industry into product or resource markets, or using qualitative survey methods to deduce dependencies (Hewings & Jensen, 2000; Kratke, 2002). The IO matrix of a region's economy and the industry interrelatedness function are accepted measures in economic contexts and the application of impact studies (Blin & Murphy, 1973; Chiou-Shauang & Ames, 1965). The power of IO analysis was in the linking of products of one industry to the purchases of another, seemingly unrelated industry. (Oosterhaven & Hewings, 2014).

Study Area

The study area chosen for this research was within the confines of county and state; more specifically, VC and Florida. Choosing VC instead of a narrower region like DB, or a specific zip code, was more appropriate because VC was considered the functional economy of ERAU. ERAU is a university devoted to the education of professionals for entry into the aviation and aerospace industries. ERAU estimates that 87% of its workforce at all DB locations lives within VC (B. Young, personal communication, February 24, 2014). The functional economy was defined as the residential area in which workers from the aviation and aer0space industries live. (Fox & Kumar, 2005; Implan Group, 2004). To conduct an IO analysis, it was important to choose the area of analysis where the work force lives. IO analysis was used to track economic transactions within the study area. If a worker lived outside the functional economy or study area, those transactions were not included in the analysis. This may have caused the impacts to be underestimated. Choosing the correct study area enabled the model to capture the true effects of the economic impact of the industry.

Industry Composition and Interrelatedness

This research used archival data to describe the current industry composition and interrelatedness in Florida and VC. The most current economic archival data had a time lag in availability from the calendar year. The archival data used for this research was the most contemporary and complete data set available, and was the gold standard for IO analysis (Sargento, 2009). Economic output and employment broken down by industry sectors based on the BEA 2012 benchmark industry sectors. Data files for the basis of this study were provided by Implan, Inc. These data files contained a full IO matrix table for states and counties for the year 2012. At the regional economic level, many data sets were time delayed due to collection and verification activities by the BEA. The IO matrix provided the framework for the economic relationships within the region where changes in economic activity regarding the impact analysis measured. This IO matrix acts as a chronological record of the economic relationships in Florida and VC.

Economic output data was presented for Florida and VC, and was defined as Gross Regional Product (GRP) and labor income for each industry sector. Employment values for each industry sector were obtained for use in the economic impact analysis. Since it was actual raw data, and defines actual economic relationships that were of interest in this research, no transformation of the data was necessary or appropriate (Implan Group, 2004). Descriptive measures for each industry's GRP, employment, and labor income were calculated as a real value, and a percentage of total value in an effort to fully describe the economic make-up of Florida and VC. By representing each industry as a percentage of the total, the most important industries to Florida and VC economies were easily identifiable. Statistical descriptors of the data, such as measures of central tendencies, indicated how the industries within the region's economy are concentrated. If the data were symmetrical, the standard deviation of these measures informed the region's distribution of industries in the economy, or a proxy for economic diversity.

Industry interrelatedness was represented by the multiplier effect factor, calculated using the Leontief inverse. Leontief's output multipliers measured the combined effects of direct and indirect repercussions of a change in final demand (Miller, R.E. & Blair, P.D., 2009) inter alia. Essentially, multipliers measured the total change in the entire economy from a unit change in one sector. This multiplier is the basis of impact analysis that was widely accepted in policy design (Baumol & Wolff, 1994). This multiplier was based upon a theoretical impact within the aviation and aerospace industry. The output multiplier, defined as M for a particular industry, was calculated as the total change in output from all sectors divided by the theoretical impact from the original industry (Equation 6). The output and changes in industry final demand were represented in U.S. dollars.

$$M = (\sum \Delta \text{ output each sector}) / \Delta \text{ industry final demand} \qquad (6)$$

Examining the size of the changes within each industry, resulting from the change in a different industry, determined which industries are most sensitive to changes within a different industry. A 10% exogenous shock was the proxy for the change in final demand in the aviation and aerospace industries. The results were scalable, and a 10% shock was enough to illuminate the results based on the economic relationships presented (George & Taylor, 1995). After the calculation of a change in industry final demand vector, statistical descriptors of the change in final demand, such as measures of central tendencies, indicated which industries were most sensitive or reactive to changes in the aviation and aerospace industries.

Economic Impact

Changes in final demand vector represented the data for the economic impact in the IO analysis. This change in final demand vector represented the initial shock or change in an economy that would ripple through the economy. The total change in spending was divided into a single vector, which distributed the spending into each industry sector and reflected the change in the final demand of both Florida and VC.

Equation 6 calculates the resulting change vector (X) from the simulation of an impact.

$$X = (I-A)^{-1} Y \qquad (6)$$

X = change of industry output required from a change in final demand
I = identity matrix
A = direct requirements matrix
Y = change in final demand vector

The total requirements matrix created a series of equations that detail the dependence of each of the gross industry outputs to the values in each of the industry final demands. Y was the change vector that indicates the additional growth in the industry sectors. Required change in output, resulting from the new investment in a university research park, was isolated by comparing the output prior to change to the output after the simulation of the university research park investment.

Statistical descriptors of the change in output variable, such as the mean and median measures of central tendencies, indicated how sensitive some industries are to the creation of a university research park. If the data were symmetrical, the standard deviation of these measures also described the breadth of the region's industries that experienced an impact.

Instrument Reliability. Detailed economic data tables compiled by official statistical agencies provided an ideal basis for an IO model analysis. The model depended on how well the data was collected, and how well it reflected the real-world economy. IO analysis was considered accurate, but not precise because of the possibility of data irregularities. Implan, Inc. exclusively created and provided data files. Implan constructed its database using data from a large variety of the same sources used by the BEA. Implan converted the data to a consistent format, and estimated any missing pieces while controlling against other data sources to maintain accuracy. Implan reviewed any data irregularities, and rebalanced the IO matrices to assure the matrix sums to the row and column vectors. Rebalancing was conducted by calculating the difference between the old and new row and column differences until the difference dropped to zero (Implan, 2014).

Jensen (1980) validated that the use of IO analysis and the employment of the Implan model and data was holistically accurate. Holistic accuracy meant the main description and features of the economy are accurately portrayed, while acknowledging each cell of the table need not be precise. When Jensen (1980) compared the output of Implan's data to other models on a specific industry in his region of study, multipliers varied by at most 5%. Jensen (1980), therefore, concluded that the IO model was holistically accurate.

Instrument validity. Implan collected data for the IO model from a variety of reliable sources. In construction of the IO tables, Implan received data in published series, sets of relationships, and estimates, and converted it all into a consistent, usable format while maintaining accuracy. Data used in the construction of Implan's IO tables included the BEA's benchmark tables, annual industry accounts, annual survey of manufacturers, and annual survey of governments. Data was also compiled from: BLS employment and wages statistics, the Census Bureau's county business patterns data and annual census of retail trade, and the Department of Commerce import and export trade. For validation, the data was processed through a program that calculated ratios on every value in the database. Any outliers were examined, and either documented, or fixed if a program or data malfunction was the cause (Implan Group, 2004). Data received from various government publishing agencies were considered accurate, and exposed to numerous validity tests and checks prior to publication (Bureau of Economic Analysis, 2011; United States Department of the Labor, 2011; U.S. Department of Commerce, 2011; U.S. Department of Transportation, 2011).

Assumptions and Limitations of the Model

While IO analysis was a means of examining economic relationships within an economy, there were underlying model assumptions that should be incorporated into any discussion or implications of the results. IO analysis has been designed to assume constant returns to scale or, where the same amount of inputs are required, to produce each unit of output without any attention to the level of production. However, depending on the industry's level of production regarding capacity, this may not be reality, and multiplier affects can be over- or underestimated. For instance, if economies of scale develop within an industry, that industry's multiplier would be exaggerated in the IO analysis. Additionally, inputs were not assumed to vary in the production of product. Any type of substitution or technological alteration of the production process would require an updating of the data to reflect the underlying economic structure of the economy with accuracy. In IO analysis the assumption was that there were no supply restrictions or constraints to raw materials or labor that were inputs to industry production. This theoretically allows unlimited production. All assumptions and any effects on the interpretation of the results were addressed in the discussion section.

Implications for Output

The estimates of this research were based on the assumption that the relationships defined in the current data were maintained or constant (Day, 2013). Regional industry changes occurred slowly. If there are any major structural changes in the regional economy, the estimates will not be representative, as the underlying relationship will be holistically inaccurate. If unanticipated changes occur, the research would need to be revised accordingly with updated data. However, the principles of this methodology were allowed for expected natural variations. The time scale will be fixed, adding one year to inspire the maximum confidence in reflective outcomes.

Impact estimates based on a broader economic region were better than a narrowly-defined region because of the leaks in the system. System leaks could take the form of purchases from outside the region, tax payments, and an increase in the region's household savings characteristics. An impact study can only track transactions as they were conducted within the region under study. If an area's economy grew significantly, or became more globalized, more leaks in the system occurred as money moved out of the region under study and cannot be traced. Additionally, if an industry purchased most of its inputs from outside the region, the economic impact from an event is dampened.

Through the use of IO analysis, this study provided the means for a comprehensive description of the interrelatedness between the aviation and aerospace industries with all other industries in Florida and VC. Implan collected data for the IO from a variety of reliable sources. The measures of the economic impact included not only direct economic output and industry employment descriptions, but also described the multiplier effects from the addition of a research park to the economy. As additional economic activity in one industry was not limited within that industry, the analysis described the additional economic activities in non-aviation and non-aerospace industries as a result of the economic impact.

Results

The purpose of this quantitative, descriptive study was to develop current, comprehensive estimates of the magnitude and importance of the aviation and aerospace industries to all other Florida industries. It produced results that can be used in policy analysis and in preparing other economic descriptive statistics.

The IO models for Florida and VC were a comprehensive representation of the economic relationships represented in the respective regions in 2012. Three types of economic measures by industry were reported in the model: value added, employment, and labor income. Measurements of value added and employment were used to research industry economic makeup of the region, interdependencies, and economic impacts.

Value added was a broad measure of economic activity, which includes the combination of labor income, other property type income, and indirect business taxes. Gross Value Added is synonymous with Gross Regional Product, the regional expression of Gross Domestic Product. Employment included full and part-time jobs for both employees and self-employed workers. Two components composed labor income: employee compensation and proprietor income. These represented a complete picture of income paid to the labor force within the region selected.

This study answered the following descriptive research questions.
RQ 1: What is the composition of the aviation and aerospace industry in the Florida and VC economy, in terms of employment and economic output?
RQ2: What are the interdependencies of the aviation and aerospace industries' economic relationships with other industries in Florida and VC?

Industry Sector Definitions

The most detailed regional IO matrix used in this research depicted economic activity categorized into 440 industry sector codes from Implan Inc. The 440 industry sector codes were generated from the NAICS developed under guidance by the U.S. OMB. Using the NAICS standard to organize the data provides uniformity, and allows for use in economic analysis and presentation. Business activity is assigned a NAICS code. A primary business activity is determined by the relative share of production valued by either revenue or value of shipments (U.S. Census Bureau, 2012).

For purposes of this research, the complete description of the aviation and aerospace sub-industries presented in Tables 1 and 2 were narrowed further to reflect pure aviation and aerospace sub-industries. Tables 5 and 6 present translation from NAICS to the Implan industry codes. The following categories were omitted from the final aviation and aerospace industry category: petroleum refineries, flight training, other social advocacy organizations, all other amusement and recreation industries, regulation and administration of transportation programs, and other measuring and controlling device manufacturing. This is because in the data, they either included other activity that was not directly connected to the aviation and aerospace industry, or could not be sufficiently narrowed to support the study. For example, NAICS category 813319, other social advocacy organizations, not only included aviation advocacy organization but also 18 other advocacy organizations that did not involve aviation. Including this category in the research would overstate results.

Research Question One

Using the 2012 IO matrix of the Florida and VC economy, the research explored the economic structures of the regions to provide an overall description of the economies, and provide information regarding the composition of the aviation and aerospace industries in the Florida and VC economies.

The GRP for Florida was $793B, and there were a total of 10.1M jobs in the state in 2012. Four-hundred and thirty of the 440 industries available in the database were represented in Florida. There were 7.8M households, and the average household income was $99.7K. Household income included income from all sources: employment wages or labor income, investment income, inheritance, and transfer payments from the government. The average labor income per worker for Florida was $61.4K across all industries. The Shannon-Weaver (S-W) Diversity Index measured economic diversity on the number of industries in a region. An S-W Diversity Index of 1.0 indicates a region’s economic activity was totally diversified with all industries contributing equally to the region’s employment (Attaran, 1986; Implan Group, 2004; Shannon & Weaver, 1949). The distribution of employment across the regions was 0.73, indicating a balanced economy (Leefers, 2007). The aviation and aerospace industries in Florida accounted for $12.4B of output, or 1.6% of total Florida output. The aviation and aerospace industry also accounted for 127K jobs, or 1.26% of Florida’s employment (Table 7), and the average labor income per worker in the Florida aviation and aerospace industries was $93K.

Table 5

Aviation industries defined by NAICS and Implan codes (U.S. Census Bureau, 2012; Day, 2013).

NAICS code	NAICS Title	Implan Code	Implan Title
336411	Aircraft manufacturing	284	Aircraft manufacturing
336412	Aircraft engine and engine parts manufacturing	285	Aircraft engine and engine parts manufacturing
336413	Other aircraft parks and auxiliary equipment manufacturing	286	Other aircraft parts and auxiliary equipment manufacturing
481111	Scheduled passenger air transportation	332	Air transportation
481112	Scheduled freight air transportation	332	Air transportation
481211	Nonscheduled chartered passenger air transportation	332	Air transportation
481212	Nonscheduled chartered freight air transportation	332	Air transportation
481219	Other nonscheduled air transportation	332	Air transportation
324110	Petroleum refineries (aviation fuel)	n/a	
488119	Other airport operations	338	Scenic and sightseeing transportation and support
611512	Flight training	n/a	
713990	All other amusement and recreation industries (recreational flying clubs)	n/a	
813319	Other social advocacy organizations	n/a	
926120	Regulation and administration of transportation programs	n/a	

Table 6

Aerospace industries defined by NAICS and Implan codes (U.S. Census Bureau, 2012; Day, 2013).

NAICS code	NAICS Title	Implan code	Implan Title
336414	Guided missile and space vehicle manufacturing	287	Guided missile and space vehicle manufacturing
336415	Guided missile and space vehicle propulsion unit and propulsion unit parts manufacturing	288	Propulsion units and parts for space vehicles and guided missiles
336419	Other guided missile and space vehicle parts and auxiliary equipment manufacturing	288	Propulsion units and parts for space vehicles and guided missiles
334511	Search, detection, navigation, guidance, aeronautical and nautical system and instrument manufacturing	249	Search, detection, and navigation instruments manufacturing
334519	Other measuring and controlling device manufacturing	n/a	
335991	Carbon and graphite product manufacturing	274	Carbon and graphite product manufacturing

Table 7

Composition of the aviation and aerospace industry in Florida, 2012 (Implan Group, 2013).

Industry	Total Value Added (U.S. Dollars)	Employment
Aircraft manufacturing	782,764	4,763
Aircraft engine and engine parts manufacturing	762,412	3,984
Other aircraft parts and auxiliary equipment manufacturing	442,060	3,873
Air transportation	4,879,240	36,189
Scenic and sightseeing transportation and support activities for transportation	3,293,306	61,181
Guided missile and space vehicle manufacturing	918,645	6,413
Propulsion units and parts for space vehicles and guided missiles	151,718	1,134
Search, detection, and navigation instruments manufacturing	1,165,838	8,818
Carbon and graphite product manufacturing	2,570	8
Total	12,398,553	127,364

In 2012, the GRP for VC was $13.6B, and there were a total of 198.7K jobs. VC housed 273 of the 440 different industries in the data set. There were 215.8K households, and the average household income was $77.9K. The average labor income per worker for VC was $29.1K across all industries. The S-W Diversity Index was 0.69, representing a slightly less diversified economic region in comparison to Florida as a whole. The aviation and aerospace industry in VC accounted for $149M, or 1.10%, of total VC GRP. The aviation and aerospace industry in VC accounted for 1,964 jobs, or 1.0%, of total VC employment (Table 8), and the average labor income per worker in the aviation and aerospace industries for VC was $46.5K. The VC average labor income for the aviation and aerospace industries was about half of the Florida value because of the absence of the three highest average labor income sectors in VC: guided missile and space vehicle manufacturing, propulsion units and parts for space vehicles and guided missiles manufacturing, and carbon and graphite product manufacturing.

Table 8

Composition of the Aviation and aerospace industry in Volusia County, 2012 (Implan Group, 2013).

Industry	Total Value Added (Thousands of . Dollars)	Employment
Aircraft manufacturing	1,876	15
Aircraft engine and engine parts manufacturing	5,484	43
Other aircraft parts and auxiliary equipment manufacturing	1,974	23
Air transportation	9,215	95
Scenic and sightseeing transportation and support activities for transportation	55,326	1,033
Guided missile and space vehicle manufacturing	-	-
Propulsion units and parts for space vehicles and guided missiles	-	-
Search, detection, and navigation instruments manufacturing	75,088	754
Carbon and graphite product manufacturing	-	-
Total	148,962	1,964

The aviation and aerospace industry, comprised of nine sub-industries, was a small portion of the Florida economy. Aviation and aerospace accounted for less than 2% of the entire Florida economy in terms of employment and value added. In VC, aviation and aerospace represented approximately 1% of the economy in terms of employment and value added. There was a large difference between the Florida and VC average labor income for the aviation and aerospace industry, because VC's aerospace sector was only concentrated in the search, detection, and navigation instruments manufacturing sector. Additionally, VC's air transport sector was one-fifth the size of Florida's. These differences in the aviation and aerospace industries composition of Florida and VC are important as the estimations from a shock to the entire aviation and aerospace industry will be distributed differently, the regions have different concentrations of industries.

Research Question Two

The interdependencies of the aviation and aerospace industries' economic relationships with other industries in Florida and VC were estimated. IO analysis was exceptionally valuable in describing correlations with other industries in Florida and VC. The power of a region's economic IO matrix was in the linking of one industry's products with another industry's purchases.

To discover the interdependencies of the aviation and aerospace industries' economic relationships with other industries in Florida and VC, a 10% exogenous shock was used as the proxy for change in final demand in the aviation and aerospace industry. The purpose of this shock is not to show a specific size of growth, but to identify the inter-industry relationships. Table 9 represents the exogenous change in demand used as a proxy for change in the aviation and aerospace industries' final demand. After calculating a change in industry final demand vector, statistical descriptors of the change in final demand like measures of central tendencies indicated what industries were most sensitive or reactive. A 10% change in final demand of aviation and aerospace industry only represented 0.16% of the total Florida gross regional product.

Table 9

Change in Final Demand in the Aviation and aerospace industry in Florida, 2012.

Industry	Change in Final Demand
Aircraft manufacturing	78,276,428
Aircraft engine and engine parts manufacturing	76,241,165
Other aircraft parts and auxiliary equipment manufacturing	44,206,001
Air transportation	487,924,011
Scenic and sightseeing transportation and support activities for transportation	329,330,553
Guided missile and space vehicle manufacturing	91,864,519
Propulsion units and parts for space vehicles and guided missiles	15,171,815
Search, detection, and navigation instruments manufacturing	116,583,830
Carbon and graphite product manufacturing	256,970
Total	1,239,855,289

A 10% ($1.2B) shock to the aviation and aerospace industry was projected to increase Florida's GRP by $1.2B, or initiate a growth of 0.14%. Intermediate expenditures increased by $1.1B. Therefore, the total impact to economic activity in Florida from a $1.2B shock to the aviation and aerospace industry was projected to be $2.2B. Job numbers were projected to increase by 13.4K, or show a growth of 0.13%. Florida labor income was projected to increase by $770M or show a growth of 0.16%. Table 10 and Figures 2 through 5 detail the breakdown of the types of effects in each measure: employment, labor income, GRP, and intermediate expenditures. Due largely to sector competition, each category of the top ten most sensitive industries (displayed in figures 2 through 5) show some differences. For example, the ball and roller bearing industry was the fifth most sensitive when ranked by employment, but did not reach the top ten ranking by labor income, indicating that other industries' increases in income far outweighed the employment gain of the ball and roller bearing industry. It is incorrect to assume that the ball and roller bearing industry pays lower wages, because labor income includes employment earnings and proprietor income.

The structure of this analysis also intended to yield information about direct, indirect, and induced effects. Direct effects are the economic activities resulting from business activity such as additional demand from an industry. Indirect effects are those caused by inter-industry changes in business, such as additional orders for raw materials from other industries due to increased demand. Induced effects are those impacts created by the household sector spending of those employed by the direct and indirect altered industries. Presumably, as an increase in demand and labor income occurs in the direct and indirect industries, those workers will expend additional earnings in the regional economy.

The average total impact to non-aviation and aerospace industry was 0.05%. Table 11 shows the top ten most affected non-aviation and aerospace industries in terms of each sector's GRP. The average impacts were not normally distributed. One-hundred and eighty-six industries' average impact for value added was above the mean, with 232 average impacts below the mean. Tables 12 and 13 show the top ten most affected non-aviation and aerospace industries in terms of employment and labor income.

Table 10

Total Impact Summary of a Change in Final Demand in the Aviation and Aerospace Industry in Florida, 2012.

Impact Type	Employment	Labor Income (Thousands of Dollars)	Value Added (Thousands of Dollars)	Intermediate Expenditures (Thousands of Dollars)
Direct Effect	5,639	400,117	534,755	705,1004
Indirect Effect	3,614	186,933	270,663	193,450
Induced Effect	4,120	182,962	321,611	201,239
Total	13,372	770,011	1,127,029	1,099,789

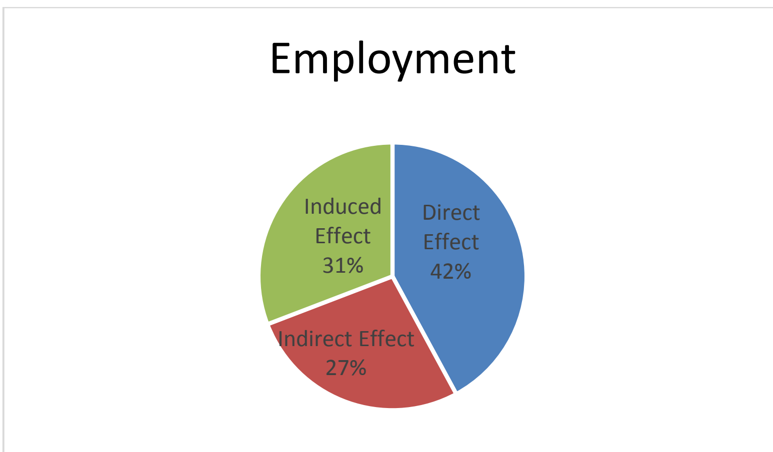

Figure 2. Total Employment Impact Summary of a Change in Final Demand in the Aviation and Aerospace Industry in Florida, 2012.

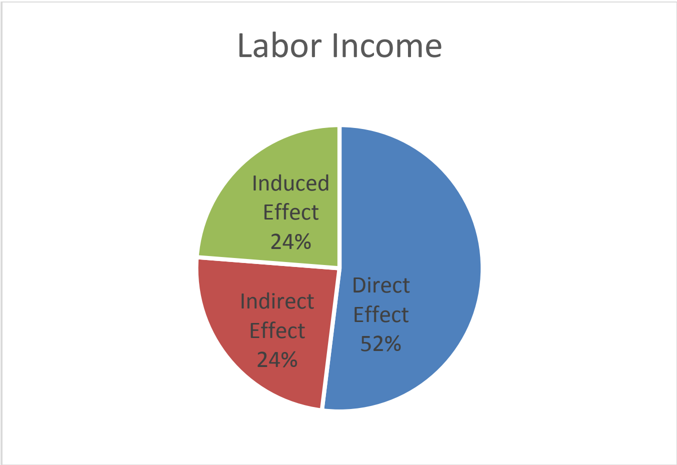

Figure 3. Total Labor Income Impact Summary of a Change in Final Demand in the Aviation and Aerospace Industry in Florida, 2012.

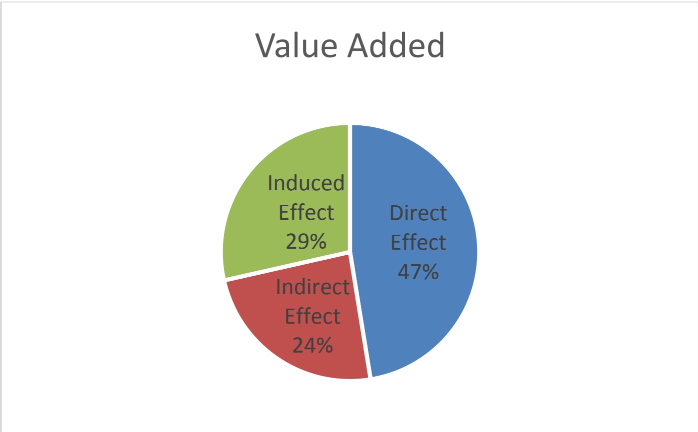

Figure 4. Total Value Added Impact Summary of a Change in Final Demand in the Aviation and Aerospace Industry in Florida, 2012.

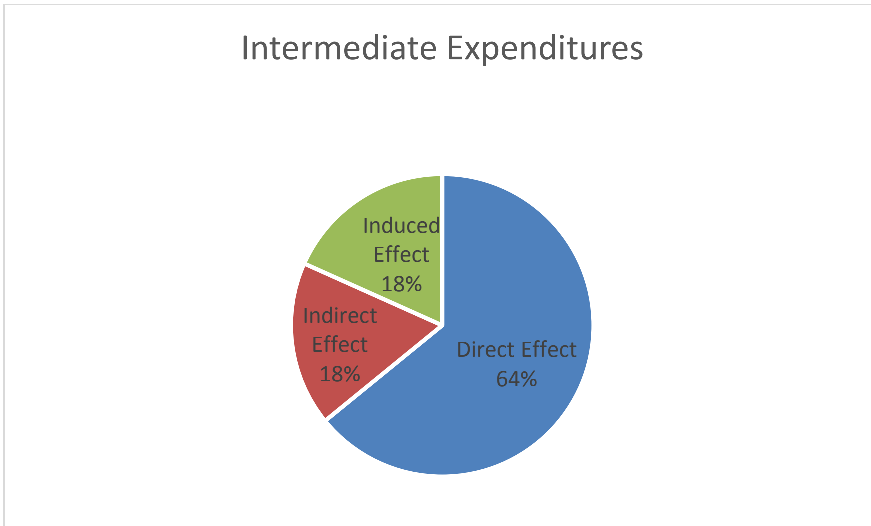

Figure 5. Total Intermediate Expenditures Impact Summary of a Change in Final Demand in the Aviation and Aerospace Industry in Florida, 2012.

Table 11

Top Ten Most Sensitive Non-Aviation and Non-Aerospace Industries, by Value Added, to a Change in Final Demand in the Aviation and Aerospace Industries in Florida, 2012.

Industry	Change (%)
All other forging, stamping, and sintering	0.67
Specialized design services	0.49
Commercial and industrial machinery and equipment rental and leasing	0.46
Couriers and messengers	0.42
U.S. postal service	0.33
Warehousing and storage	0.26
Mining and quarrying sand, gravel, clay, and ceramic and refractory minerals	0.25
Dry-cleaning and laundry services	0.25
Petroleum refineries	0.23
Management of companies and enterprises	0.21

Table 12

Top Ten Most Sensitive Non-Aviation and Non-Aerospace Industries, by Employment, to a Change in Final Demand in the Aviation and Aerospace Industries in Florida, 2012.

Industry	Change (%)
All other forging, stamping, and sintering	0.70
Specialized design services	0.47
Commercial and industrial machinery and equipment rental and leasing	0.44
Couriers and messengers	0.41
Ball and roller bearing manufacturing	0.32
U.S. postal service	0.33
Petroleum refineries	0.26
Warehousing and storage	0.25
Mining and quarrying sand, gravel, clay, and ceramic and refractory minerals	0.24
Dry-cleaning and laundry services	0.24

Table 13

Top Ten Most Sensitive Non-Aviation and Non-Aerospace Industries, by Labor Income, to a Change in Final Demand in the Aviation and Aerospace Industry in Florida, 2012.

Industry	Change (%)
All other forging, stamping, and sintering	0.67
Specialized design services	0.49
Commercial and industrial machinery and equipment rental and leasing	0.46
Couriers and messengers	0.42
U.S. postal service	0.33
Warehousing and storage	0.26
Mining and quarrying sand, gravel, clay, and ceramic and refractory minerals	0.25
Dry-cleaning and laundry services	0.24
Petroleum refineries	0.23
Management of companies and enterprises	0.21

Table 14 shows the ranking of the multipliers of all the aviation and aerospace sub-industries. The multiplier is a prediction of how the state's economy will respond to a change in that sector's final demand. Essentially, multiplying the change in final demand of a sector by the multiplier will reveal which sector affects the region's economy the most.

Examining the changes within each industry in VC, resulting from a change in a different industry, determined which industries were most sensitive to changes within the aviation and aerospace industries. A 10% exogenous shock was used as the proxy for change in final demand in the aviation and aerospace industries. A 10% change in final demand of aviation and aerospace industries is 0.11% of the total VC gross regional product. Table 15 represents the exogenous change in demand used as a proxy for change in the aviation and aerospace industry's final demand.

A 10% ($14.9M) shock to the aviation and aerospace industry was projected to increase VC's GRP by $14.1M, or show a growth of 0.07% of GRP. Intermediate expenditures increased by $12.1M. Therefore, a $22.6M total impact to economic activity in VC from a $14.9M shock to the aviation and aerospace industries was projected. Job numbers were projected to increase by 149 jobs, or a growth of 0.08%. VC's labor income was projected to increase by $7.3M, or a growth of 0.09%.

Table 14

Aviation and Aerospace Industries Sector Multipliers in Florida, 2012.

Industry	Multiplier
Scenic and sightseeing transportation and support activities for transportation	2.08
Guided missile and space vehicle manufacturing	2.00
Search, detection, and navigation instruments manufacturing	1.91
Propulsion units and parts for space vehicles and guided missiles manufacturing	1.87
Other aircraft parts and auxiliary equipment manufacturing	1.76
Aircraft engine and engine parts manufacturing	1.66
Transport by air	1.61
Carbon and graphite product manufacturing	1.55
Aircraft manufacturing	1.50

Table 15

Change in Final Demand in the Aviation and Aerospace Industries in VC, 2012.

Industry	Total Value Added (Thousands of Dollars)
Aircraft manufacturing	187
Aircraft engine and engine parts manufacturing	548
Other aircraft parts and auxiliary equipment manufacturing	197
Air transportation	921
Scenic and sightseeing transportation and support activities for transportation	5,532
Guided missile and space vehicle manufacturing	-
Propulsion units and parts for space vehicles and guided missiles	-
Search, detection, and navigation instruments manufacturing	7,508
Carbon and graphite product manufacturing	-
Total	14,893

Table 16 and Figures 6 through 9 detail the breakdown of the types of effects in the following measures: employment, labor income, GRP, and intermediate expenditures.

Table 16

Total Impact Summary of a Change in Final Demand in the Aviation and Aerospace Industries in VC, 2012.

Impact Type	Employment	Labor Income ($)	Value Added ($)	Intermediate Expenditures ($)
Direct Effect	79.5	4,508,844	14,893,000	9,138,287
Indirect Effect	35.3	1,567,669	3,935,314	1,614,985
Induced Effect	33.7	1,268,227	3,758,230	1,395,883
Total	148.5	7,344,740	22,586,544	12,149,155

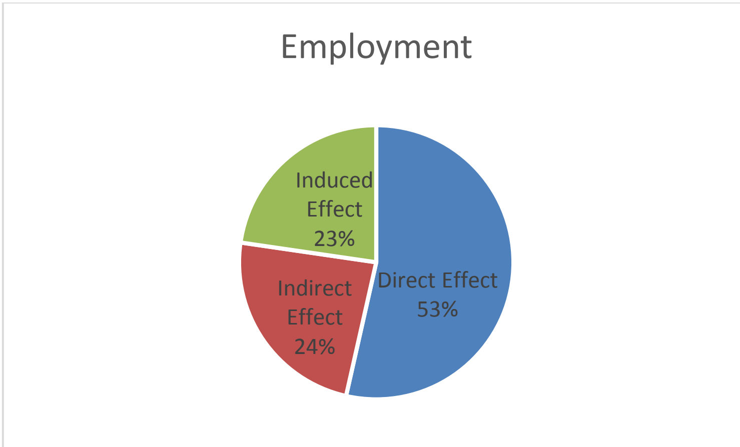

Figure 6. Total Employment Impact Summary of a Change in Final Demand in the Aviation and Aerospace Industries in VC, 2012.

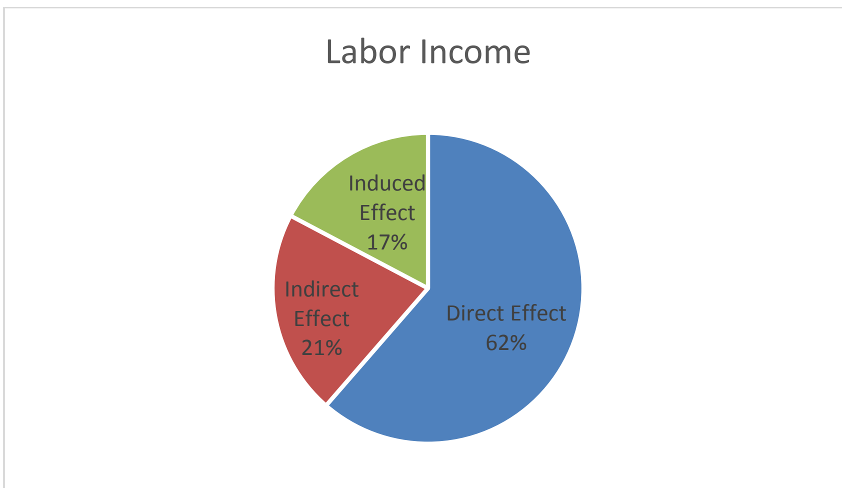

Figure 7. Total Labor Income Impact Summary of a Change in Final Demand in the Aviation and Aerospace Industry in VC, 2012.

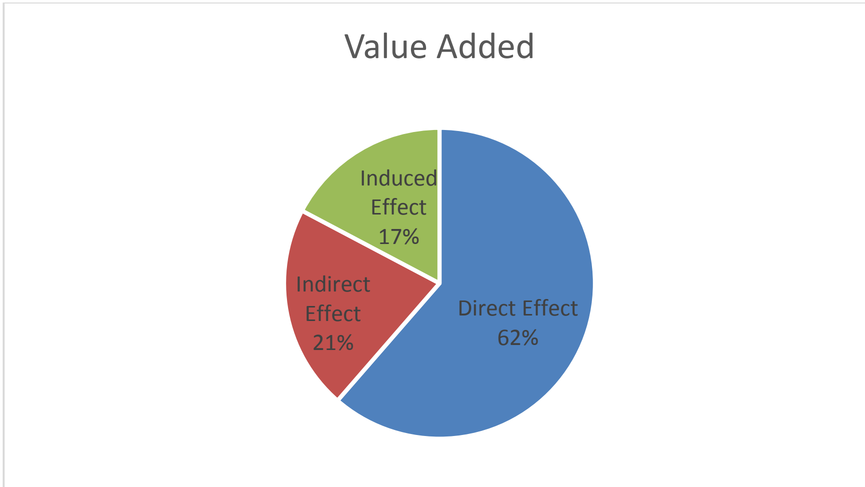

Figure 8. Total Value Added Impact Summary of a Change in Final Demand in the Aviation and Aerospace Industry in VC, 2012.

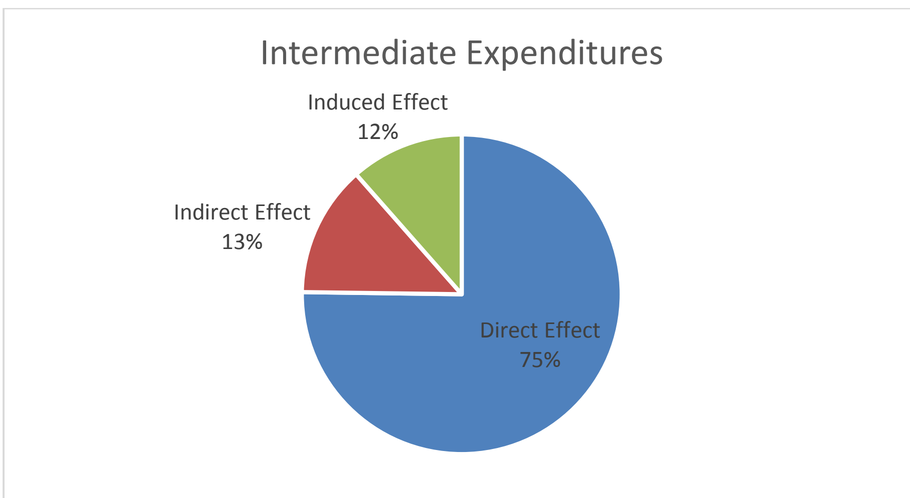

Figure 9. Total Intermediate Expenditures Impact Summary of a Change in Final Demand in the Aviation and Aerospace Industry in VC, 2012.

The average total impact to non-aviation and non-aerospace industries was 0.11% GRP. The distribution of average impacts was not normal. There were 23 above the mean and 246 below the mean for value added, indicating that in addition to the aviation and aerospace industry, the impact from the shock was concentrated in a fairly small group of industries. The top ten most affected non-aviation and non-aerospace industries, in terms of each industry's GRP, are shown in Table 17.

Tables 18 and 19 show the top 10 non-aviation and non-aerospace industries most affected, in terms of each industry's employment and labor income.

Table 20 shows the ranking of all multipliers for all aviation and aersospace sub-industries. The multiplier is a prediction of how the region's economy will respond to a change in that sector's final demand. Multiplying the change in final demand of a sector by the multiplier will reveal which sector affects the region's economy the most.

To determine how interrelated the aviation and aerospace industries were to non-aviation and aerospace industries in Florida and VC, a 10% exogenous shock to final demand was used to model the region's economic changes. This $1.2M increase solely in the aviation and aerospace industries was projected to increase Florida's economy as measured by GRP by 0.14% and add 13.4K jobs. Roughly half of effects were indirect and induced effects. Narrowing the scope of the analysis to VC, the results were a bit lower than the statewide experience. A $14.9M increase in VC's aviation and aerospace industries was projected to increase the region's value added by 0.08%, and 149 jobs. The direct effects outweighed the indirect and induced effects, indicating that, within VC the non-aviation and non-aerospace industries were less impacted by shocks to the aviation and aerospace industry than in Florida overall.

Table 17

Top Ten Most Sensitive Non-Aviation and Non-Aerospace Industries, by Value Added, to a Change in Final Demand in the Aviation and Aerospace Industries in VC, 2012.

Industry	Change (%)
Couriers and messengers	0.38
Specialized design services	0.31
Scientific research and development services	0.28
U.S. postal service	0.24
Warehousing and storage	0.22
Management of companies and enterprises	0.20
Computer systems design services	0.17
Watch, clock, and other measuring and controlling device manufacturing	0.17
Support activities for oil and gas operations	0.15
Employment services	0.15

Table 18

Top Ten Most Sensitive Non-Aviation and Non-Aerospace Industries, by Employment, to a Change in Final Demand in the Aviation and Aerospace Industries in VC, 2012.

Industry	Change (%)
Couriers and messengers	0.36
Specialized design services	0.34
Scientific research and development services	0.29
Warehousing and storage	0.25
U.S. postal service	0.22
Management of companies and enterprises	0.20
Computer systems design services	0.17
Employment services	0.14
Commercial and industrial machinery/equipment rental/leasing	0.14
Dry-cleaning and laundry services	0.13

Table 19

Top Ten Most Sensitive Non-Aviation and Non-Aerospace Industries, by Labor Income, to a Change in Final Demand in the Aviation and Aerospace Industry in VC, 2012.

Industry	Change (%)
Couriers and messengers	0.38
Specialized design services	0.31
Scientific research and development services	0.28
U.S. postal service	0.24
Warehousing and storage	0.22
Management of companies and enterprises	0.20
Computer systems design services	0.17
Watch, clock, and other measuring and controlling device manufacturing	0.17
Support activities for oil and gas operations	0.15
Employment services	0.15

Table 20

Aviation and Aerospace Industry Sector's Multipliers in VC, 2012.

Industry	Multiplier
Scenic and sightseeing transportation and support activities for transportation	1.67
Search, detection, and navigation instruments manufacturing	1.44
Transport by air	1.37
Other aircraft parts and auxiliary equipment manufacturing	1.36
Aircraft engine and engine parts manufacturing	1.22
Aircraft manufacturing	1.17

Comparing Florida and VC's regional results from a shock to the aviation and aerospace industries showed there were some differences in the non-aviation and non-aerospace industries most affected. Primarily, the composition and concentration of industries created differences. For example, petroleum refineries have limited representation in VC, yet were present in Florida.

Results Summary

The purpose of this quantitative descriptive study was to develop current, comprehensive estimates of the magnitude and importance of the aviation and aerospace industries to all other Florida industries. Quantitatively, the aviation and aerospace industries, comprised of 12 sub-industries, was a small portion of the Florida economy. Aviation and aerospace accounted for approximately 2% of the entire Florida economy in terms of employment and value added. In terms of employment and value added to VC, the aviation and aerospace industry was smaller than Florida's share, representing approximately 1.0% of the economy.

To determine how interrelated the aviation and aerospace industries were to non-aviation and non-aerospace industries in Florida and VC, a 10% exogenous shock to final demand was used to model the region's economic changes. This $1.2B increase in only the aviation and aerospace industries was projected to increase Florida's economy by 0.14% and 13.4K jobs. Roughly half of the effects were indirect and induced effects. Narrowing the scope of the analysis to VC, the results were lower than the statewide experience. In VC, a $14.9M increase in the aviation and aerospace industries was projected to increase the region's value added by 0.07% and 149 jobs. The direct effects outweighed the indirect and induced effects, indicating that within VC, the non-aviation and non-aerospace industries were less impacted by changes to the aviation and aerospace industries than in Florida.

Discussion, Conclusions, and Recommendations

The IO models generated for Florida and VC comprehensively represented the economic relationships in Florida and VC in 2012. The model reported three types of economic measures by industry: value added, employment, and labor income. Value added, a broad measure of economic activity, combines labor income, other property type income, and indirect business taxes. Value added is equivalent to GRP, the regional expression of GNP. Employment included full and part-time jobs for both employees and self-employed workers. Labor income had two components: employee compensation and proprietor income, thus representing a complete picture of income paid to the labor force within the selected region. The study used measurements of value added and employment to research industry economic makeup of the region, interdependencies, and economic impacts.

Discussion

Research Question One.

Florida. Even though the definition of the aviation and aerospace industries used in this research was a combination of nine sub-industries in the data (Tables 5 and 6), it represented a small portion of the Florida economy at 1.6%. By aggregating all the aviation and aerospace sub-industries' employment, the study shows aviation and aerospace industry as the 16th largest industry in Florida. The S-W diversity index of 0.73 indicates that the Florida economy was diversified through a significant number of industries sharing the state's economic activity. The aggregate services and trade industries represented the largest sectors of the Florida economy. The Florida aviation and aerospace industries' average labor income was 51% higher than the average Florida industry labor income average. The Florida aviation and aerospace industries' average labor income was only 12% lower than the U.S. average of $104.4K, using the same aviation and aerospace industry definition. Because the aviation and aerospace industries generate higher labor income, the study shows that these industries are a positive asset to the Florida economy.

Volusia County. The same characteristics of the aviation and aerospace industries in Florida were evident in VC. With the aggregate of the nine sub-industries that comprise the aviation and aerospace industry (Tables 5 and 6), it was still a small portion of the VC economy at 1.10%. Aggregating all the aviation and aerospace sub-industries' employment shows the aviation and aerospace industry as the 26th largest industry in VC. The Shannon-Weaver index of 0.69 indicates that the VC economy is less diverse than the Florida economy, with respect to the number of industries sharing the state's economic activity. The food services and drinking places, real estate establishments, and health care services were the largest employers in the VC economy. The VC aviation and aerospace industries' average labor income was 60% higher than the average VC industry labor income average. However, the aviation and aerospace industries' average labor income in VC was lower than the Florida average, and 55% lower than the U.S. average.

The aviation and aerospace industries' employment contribution was a positive asset to the VC economy because of the higher labor income generated by the aviation and aerospace industries per worker. Stimulating these industries' economic development and growth would be beneficial to the local and state economy, because the aviation and aerospace industries' wage rates are higher than the average VC and Florida wage rates. However, the form of economic stimulation would be vitally important, as not all shocks are exogenous and without negative tradeoffs.

Research Question Two. Industry multipliers derived from a 10% exogenous shock to the aviation and aerospace industries provided description of the most interrelated, or sensitive, industries to the aviation and aerospace industries. In Florida, the average employment change from the exogenous shock to the aviation and aerospace industries for all non-aviation and non-aerospace industries was 0.05%. Many impact studies measure effects of economic impacts by total employment, labor income, and gross regional product, as the data for research question two presented. However, a much more descriptive measure would also include the types of jobs created from a positive shock to the aviation and aerospace industries. To give policymakers more information, it would be more beneficial to look at the average labor income per employee of the top non-aviation and non-aerospace industries affected by the shock. Table 23 shows the average labor income per employee in Florida for the top most sensitive non-aviation and non-aerospace industries, in terms of employment and value added changes to a shock in the aviation and aerospace industries. The average labor income per employee of $68K for these industries was 11% higher than the average of $61K for the state of Florida.

Table 23

Most Sensitive Non-Aviation and Aerospace Industries Ranked by Average Labor Income in FL, 2012.

Industry	Average Labor Income ($)
Transport by pipeline	111,173
Management of companies and enterprises	107,181
U.S. postal service	93,628
Petroleum refineries	88,400
Ball and roller bearing manufacturing	79,565
Commercial and industrial machinery and equipment rental and leasing	75,725
Mining and quarrying sand, gravel, clay, and ceramic and refractory minerals	55,868
All other forging, stamping, and sintering	47,881
Warehousing and storage	40,946
Specialized design services	39,360
Dry-cleaning and laundry services	38,288
Couriers and messengers	36,902

Combining the results in Table 23 with the above average wages presented for the aviation and aerospace sector from research question one reveals the Florida economy would benefit from an exogenous expansion of the aviation and aerospace industries, in terms of employment. Expanding the aviation and aerospace industries in Florida would carry jobs that have higher labor income, and would generate higher tax revenues for the state and local governments.

In VC, the average employment change from an exogenous shock to the aviation and aerospace industries for all non-aviation and non-aerospace industries was 232 jobs or 0.06%. Again, a more descriptive measure of the impact included the types of jobs created from a positive shock to the aviation and aerospace industry. To give policymakers more information, look at the average labor income per employee of the top non-aviation and non-aerospace industries affected by the shock. Table 24 shows the average labor income per employee in VC for the top most sensitive non-aviation and non-aerospace industries, in terms of employment and value added changes to a shock in the aviation and aerospace industries. The total average labor income per employee of $55.7K for these industries was 91% above the average labor income of $29.1K for VC. An exogenous expansion of the aviation and aerospace industries in VC would have a significant impact on the labor income profile of VC.

Table 24

Most Sensitive Non-Aviation and Non-Aerospace Industries Ranked by Average Labor Income in VC, 2012.

Industry	Average Labor Income ($)
Management of companies and enterprises	127,900
U.S. postal service	91,788
Commercial and industrial machinery and equipment rental and leasing	73,377
Support activities for oil and gas operations	66,059
Watch, clock, and other measuring and controlling device manufacturing	60,235
Scientific research and development services	50,200
Computer systems design services	36,217
Couriers and messengers	34,558
Specialized design services	28,278
Warehousing and storage	23,053
Employment services	21,454

Combining the information in Table 24 with the above average wages for the aviation and aerospace sector from research question one in VC shows the VC economy would benefit from an exogenous expansion of the aviation and aerospace industries, in terms of employment. This expansion would also benefit the local government, as the new jobs created in the aviation and aerospace industries would have higher labor income than the average VC labor income, thus generating higher tax revenues for the state and local governments. In addition, the new jobs created by the indirect and induced effects of a shock in the aviation and aerospace industries, in the most sensitive industries, to changes in the aviation and aerospace industries also had a higher average labor income than the average VC labor income. VC's labor income would more greatly benefit from the growth in the aviation and aerospace industries than statewide labor income.

Assumptions and Limitations of Results

IO analysis assumes that no supply or resource constraints exist. If the excess resources were unused, and available in the regional economy to meet the requirements of an economic expansion, then the results would be accurate. However, if there is any limited supply of resources, then the economy could experience wage and/or price increases, or a move to fulfill the resources by importing the needed inputs. Imports are considered a leakage to the Florida economy, and would dampen the expected results.

Recommendations

Looking forward, Florida policymakers should consider diversifying job opportunities in order to make them more financially desirable to residents. This research indicated the average labor income of the aviation and aerospace industry is higher than average labor income in Florida and VC. Attracting and growing the aviation and aerospace industries would be a positive move for Florida's economy. It is unlikely that the entirety of newly created aviation and aerospace industry jobs would be sourced from the local population, as there could be specialized training and skills required. Nonetheless, growing these types of jobs would have a positive influence on the region's economy and tax revenues. The local government could work towards a home-grown, long-term solution to any scarcity of potential employees for a growing aviation and aerospace community. One such solution might be a scholarship program that requires the recipient to reside within the region's industry for a specified amount of time. Thus, it would be a desirable course of action to spur the growth of this sector. Its direct effect would culminate in additional jobs in Florida, which would bring higher-wage jobs to the state.

The average labor income for both the aviation and aerospace industries in Florida and VC was below the U.S. average labor income for the aviation and aerospace industries. Given this characteristic, government entities, trade associations, and organizations like the Chamber of Commerce may employ this information in attracting aviation and aerospace companies and organizations to expand and locate in Florida and VC.

The aviation and aerospace industries in Florida and VC also had positive, indirect, and induced effects on the economy. The interdependencies of the aviation and aerospace industries with other industries in Florida and VC provided almost a two-fold indirect and induced effect. As the aviation and aerospace industries expand, so do other industries. The average labor income in Florida of the most sensitive non-aviation and non-aerospace industries was $52K, which is 15% lower than the average Florida labor income. The average labor income in VC of the most sensitive non-aviation and non-aerospace industries was $55K, significantly higher than the average VC labor income. The indirect and induced benefits of the aviation and aerospace industries would further contribute to creating jobs for Florida residents; however, the jobs were associated with a lower labor income in Florida. Interestingly, if these jobs were located in VC, the additional income would be very positive.

It is important to note that these industry interdependencies also presented risk in an aviation and aerospace industry contraction. If the aviation and aerospace industries experience a contraction, then through the interdependencies of other industries, the region would contract twice as much.

References

Acemoglu, D. (2008, September 10). Can America invent its way back? *Business Week*, Retrieved from: http://www.businessweek.com/stories/2008-09-10/can-america-invent-its-way-back

Adventus Research Inc. (2010). *Economic impact of the University of Ontario institute of technology on Durham region and Durham municipalities.* Guelph, ON: Adventus Research Inc.

Anttiroiko, A. (2004). Editorial: Global competition of high-tech centres. *International Journal of Technology Management*, *28*(3-6), 289-323.

App, B. (2006). *Economic impact analysis in convention tourism: the case of the convention markets in Stuttgart, Germany.* Bournemouth University.

Arcieri, K. (2014, February 5). North Carolina considered incentive package of up to $2.5B to Boeing. *The Business Journal*. Retrieved from http://www.bizjournals.com/triad/blog/2014/02/boeing-could-have-gotten-25b.html

Arnold, R. (2011). *Economics* (10th ed.). Mason, OH: South-Western Cengage Learning.

Aroche, F. (2009). 1932-1938: Wassily Leontief's early papers. Besides the input-output model. *13th Annual European Society for the History of Economic Thought,* Thessalonki, Greece: European Society for the History of Economic Thought.

Association of University Research Parks. (2013a). AURP awards of excellence. Retrieved from http://www.aurp.net/aurp-awards-of-excellence

Association of University Research Parks. (2013b). Economic impact studies. Retrieved from http://aurp.memberclicks.net/index.php?option=com_content&view=article&id=92&Itemid=116#Economic%20Impact%20Studies.

Attaran, M. (1986). Industrial diversity and economic performance in the U.S. areas. *Annals of Regional Science, 20*(2), 44-55. http://dx.doi.org/10.1007/bf01287240

Battelle Technology Partnership Practice. (2007). *Characteristics and trends in North American research parks, 21st century directions.* Tucson, AZ: Association of University Research Parks.

Battelle Technology Partnership Practice. (2013). *Driving regional innovation and growth.* Tucson, AZ: Association of University Research Parks.

Bendavid-Val, A. (1972). *Regional and local economic analysis for practitioners.* NY: Praeger.

Bergman, L., Jorgenson, D., & Zalai, E. (1990). Indeterminacy in applied general equilibrium models. *General equilibrium modeling and economic policy analysis* (111-140). Cambridge, MA: Basil Blackwell, Inc.

Blaug, M. (1986). *Great economists before Keynes*. Atlantic Highlands, NJ: Humanities Press International.

Blin, J. M., & Murphy, F. (1973). *On measuring economic interrelatedness*. Chicago, Il.: Graduate School of Management, Northwestern University. http://dx.doi.org/10.2307/2296761

Bockman, J. (2011). *Markets in the name of socialism: The left-wing origins of neoliberalism.* Palo Alto, CA: Stanford University Press. http://dx.doi.org/10.11126/stanford/9780804775663.001.0001

Bureau of Economic Analysis. (2011). Industry economic accounts information guide. Retrieved from http://www.bea.gov/industry/iedguide.htm#bioa

Cavusgil, S., Calantone, R., & Zhao, Y. (2003). Tacit knowledge transfer and firm innovation capability. *Journal of Business Marketing, 18*(1), 6. doi:10.1108/08858620310458615

Chiou-Shauang, Y., & Ames, E. (1965). Economic interrelatedness. *Review of Economic Studies, 32*(4), 299. http://dx.doi.org/10.2307/2295837

Chow, G. (1960). Tests of equality between sets of coefficients in two linear regressions. *Econometrica, 28*(3), 591-605. http://dx.doi.org/10.2307/1910133

Clark, W. W., Jr. (2003a). Science parks: practical and successful cases. *International Journal of Technology Transfer & Commercialisation, 2*(2), 179-206. http://dx.doi.org/10.1504/ijttc.2003.003166

Clark, W. W., Jr. (2003b). Science parks: theory and background. *International Journal of Technology Transfer & Commercialisation, 2*(2), 150-178. http://dx.doi.org/10.1504/ijttc.2003.003165

Cornfield, J., Evans, W., & Hoffenberg, M. (1950). *Full employment patterns.* (No. R 1868). Washington DC: U.S. Department of Labor.

Cowen, T. (1998). *Using cost-benefit analysis to review regulation.* Unpublished manuscript.

Cumming, D., & Sofia, J. (2013). Technology parks and entrepreneurial outcomes around the world. *International Journal of Managerial Finance*, *9*(4), 279-293. doi:10.1108/IJMF-02-2013-0018.

Dale, P. (2014). Stop Stansted expansion. Retrieved on March 25, 2014, Retrieved from http://www.stopstanstedexpansion.com/news.html

Davenant, C. (1699). *An essay on the probable methods of making a people gainers in the balance of trade*. London, UK: James Knapton.

Davis, H. (1990). *Regional impact analysis and project evaluation*. Vancouver, B.C.: UBC Press.

Day, F. (2013). *Principles of impact analysis and Implan applications*. Huntersville, NC: MIG.

Dietzenbacher, E., & Lahr, M. (2008). *Wassily Leontief and input-output economics*. Cambridge, United Kingdom: Cambridge University Press. doi:10.1017/cbo9780511493522

Dietzenbacher, E., Lenzen, M., Los, B., Guan, D., Lahr, M., Sancho, F., Cuihong, Y. (2013). Input-output analysis: the next 25 years. *Economics Systems Research, 25*(4), 369-389. doi.: 10.1080/09535314.2013.846902

Dinc, M., & Haynes, K. (1999). Sources of regional inefficiency: an integrated shift-share data envelopment analysis and input-output approach. *The Annals of Regional Science, 33*(4), 469-489. http://dx.doi.org/10.1007/s001680050116

Drennan, M. (1997). The performance of metropolitan area industries. *Federal Reserve Bank of New York Economic Policy Review,* (February), 49-60.

Embry-Riddle Aeronautical University. (2013a). *Building partnerships in aviation and aerospace*. Daytona Beach, FL: Embry-Riddle Aeronautical University.

Embry-Riddle Aeronautical University. (2013b). *Presidential report 2013.* Daytona Beach, FL: Office of the President, Embry-Riddle Aeronautical University. Retrieved from http://www.erau.edu/administration/president/presidential-report-2013.pdf

Embry-riddle poised for success with research park. (May 2, 2013). *Daytona Beach News Journal*. Retrieved from http://www.news-journalonline.com/article/20130502/OPINION/305019954.

Enterprise Florida. (2013). *Aviation and aerospace*. online: Enterprise Florida. Retrieved from https://www.enterpriseflorida.com/wp-content/uploads/brief-aviation-aerospace-florida.pdf.

Florida Space Day. (2013). *Economic analysis of aerospace in Florida - 2013*. online: Florida Space Day. Retrieved from http://floridaspaceday.com/fsd-content/uploads/2013/07/Economic-Impact-of-Space-in-Florida-2013.pdf

Fox, K., & Kumar, T. (2005). The functional economic area: delineation and implications for economic analysis and policy. *Papers in Regional Science, 15*(1), 57-85. http://dx.doi.org/10.1111/j.1435-5597.1965.tb01315.x

Friedman, M. (1953). The methodology of positive economics. *Essays in positive economics* (30-43). Chicago, IL: University of Chicago Press. Retrieved from http://www.ppge.ufrgs.br/GIACOMO/arquivos/eco02036/friedman-1966.pdf http://dx.doi.org/10.1017/cbo9780511581427.002

Galambos, E., & Schreiber, A. (1978). *Making sense out of dollars: Economic analysis for local government.* Washington DC: National League of Cities.

George, K. A., & Taylor, L. L. (1995). The role of merchandise exports to Mexico in the pattern of Texas employment. *Economic and Financial Policy Review*, Q(I). 22-30. Retrieved from http://econpapers.repec.org/RePEc:fip:fedder:y:1995:i:qi:p:22-30

Gertler, M. (2010). Rules of the game: the place of institutions in regional economic change. *Regional Studies, 44*(1), 1-15. http://dx.doi.org/10.1080/00343400903389979

Haig, R. (1928). *Regional survey of New York and its environs.* New York, NY: Committee on Regional Plans of New York and Its Environs.

Harrington, J., Lee, H., Tischner, C., & Duch, D. (March 2012). *Phase two: The economic impact of aerospace in Florida.* Center for Economic Forecasting and Analysis. Retrieved from http://www.cefa.fsu.edu/Projects/Current-Projects

Harris, R., & Cox, D. (1988). *The service sector and trade in the Canadian economy: an input-output analysis.* Vancouver, British Columbia: The Fraser Institute.

Hewings, G., & Jensen, R. (2000). Regional, interregional and multiregional input-output analysis. In Cheshire, P. and Mills, E. *Handbook of regional and urban economics* (295-355). Amsterdam: Elsevier. http://dx.doi.org/10.1016/s1574-0080(00)80011-5

Hilkevitch, J. (2013, September 9). O'Hare-area residents' bid to stop runway expansion, noise falls on deaf ears. *Chicago Tribune*. Retrieved from http://articles.chicagotribune.com/2013-09-05/news/chi-oharearea-residents-bid-to-stop-runway-expansion-noise-falls-on-deaf-ears-20130905_1_new-o-hare-runway-jet-noise-runway-expansion

Hong, J., Li, X., & Zho, Y. (2014). Assessing the efficiency of university science parks: from the perspective of value-added contribution. *Journal of Emerging Trends in Economics and Management Sciences, 5*(1), 64-69.

Hunk, L., & Snell, M. (1997). Comparative properties of local econometric models in the UK. *Regional Studies, 31*(9), 891. http://dx.doi.org/10.1080/00343409750130010

Hunt, L., Slaymaker, J., & Snell, M. (1996). Comparative properties of UK regional econometric models. *Regional Studies, 30*(8), 773. http://dx.doi.org/10.1080/00343409612331350068

Implan Group. (2004). *Implan pro V2 users guide*. Stillwater, MN: MIG, Inc.

Isard, W., Azis, M., Drennan, M., Miller, R., Salzman, S., & Thorbecke, E. (1998a). *Regional and interregional input-output analysis*. Brookfield, VT: Ashgate.

Isard, W., Azis, M., Drennan, M., Miller, R., Salzman, S., & Thorbecke, E. (1998b). *Regional and interregional input-output analysis, chapter 3*. Brookfield, VT: Ashgate.

Jensen, R. C. (1980). The concept of accuracy in regional input-output models. *International Regional Science Review, 18*(11), 15-18. http://dx.doi.org/10.1177/016001768000500203

Jones, A. (1992). On the interrelationships between the services-producing industries and the goods-producing industries of Canada. *The Service Industries Journal, 12*(4), 497. http://dx.doi.org/10.1080/02642069200000061

Jongwanich, J., Kohpaiboon, A., & Yang, C. (2014). Science park, triple helix, and regional innovative capacity: Province-level evidence from china. *Journal of the Asia Pacific Economy, 19*(2), 333. http://dx.doi.org/10.1080/13547860.2014.880285

Khandker, S., Koolwal, G., & Samad, H. (2010). *Handbook on impact evaluation: quantitative methods and practices*. Washington DC: The World Bank.

Kratke, S. (2002). *Medienstadt: urbane cluster und globale zentren der kulturproduktion*. Frankfurt, Germany: VS Verlag fur Sozialwissenschaften.

Kye's K.O's input-output studies. (1953, August 26). *Business Week,* 26.

Lal, K. (2000). Evolution of the Canadian input-output tables 1961 to date. *International Input-Output Association Meeting,* Macerata, Italy.

Lang, R. W. (1983). Using econometric models to make economic policy: a continuing controversy. *Business Review - Federal Reserve Bank of Philadelphia*, 3.

Leefers, L. (2007). The U.P. economy and the role of forest products industries. Retrieved from Michigan State University, Department of Forestry website: http://forestlands.mtu.edu/products/Appendix%20B%20Economic%20Impacts%20V1.pdf

Leontief, W. (1949). Structural matrices of national economies. *Econometrica, 17*, 273-82. http://dx.doi.org/10.2307/1907314

Leontief, W. (1966). *Input-output economics*. New York City: Oxford University Press.

Leontief, W. (1987). Input-output analysis. In J. Eatwell, M. Milgate & P. Newman (Eds.), *The new palgrave, a dictionary of economics* (860). New York City: Palgrave Macmillion. http://dx.doi.org/10.1057/9781137336583.1034

Lester, R. (2005). *Universities, innovation, and the competitiveness of local economies: a summary report from the local innovation systems project - phase I*. Boston, MA: Massachusetts Institute of Technology.

Letson, D. (2002). Methods of economic analysis. In D. Letson, & W. Milon (Eds.), *A guide to economic valuation and impact analysis* (15-24). Gainesville, FL: Florida Coastal Environmental Resources.

Levine, M. (2009). *The false promise of the entrepreneurial university: selling academic commercialism as an 'engine' of economic development in Milwaukee*. Mikwaukee, WI: Center for Economic Development.

Leyden, D. P., Link, A. N., & Siegel, D. S. (2008). A theoretical and empirical analysis of the decision to locate on a university research park. *IEEE Transactions on Engineering Management*, *55*(1), 23. http://dx.doi.org/10.2139/ssrn.900546

Link, A. N., & Link, J. R. (2009). University research parks. *Government as entrepreneurs*. Oxford, UK: Oxford University Press. http://dx.doi.org/10.1093/acprof:oso/9780195369458.003.0007

Link, A. N., & Siegel, S. S. (2007). University research parks. *Innovation, entrepreneurship, and technological change*. Oxford, UK: Oxford University Press. http://dx.doi.org/10.1093/acprof:oso/9780199268825.003.0009

Los, B. (2011). Keynote address: The output of input-output analysis: a bibliometric study (1996-2008). *19th International Input-Output Conference*, Alexandria, VA.

Lucas, R. (1976). Econometric policy evaluation: a critique. *Carnegie-Rochester Conference Series on Public Policy, 1*, 19-46. http://dx.doi.org/10.1016/s0167-2231(76)80003-6

Lynch, T. (2000). *Analyzing the economic impact of transportation projects using RIMS II, Implan, and REMI*. Washington D.C: U.S. Department of Transportation, Office of Research and Special Programs.

Mayer, H. (2007). What is the role of the university in creating a high-technology region? *Journal of Urban Technology, 14*(3), 33-58. http://dx.doi.org/10.1080/10630730801924225

Miller, R.E. & Blair, P.D. (2009). *Input-output analysis: foundations and extensions*. UK: Cambridge University Press. http://dx.doi.org/10.1017/cbo9780511626982

Miller, T. P. (2011). *Purdue research park, driving today's new economy*. Indianapolis, IN: Thomas P. Miller and Associates.

Min Tam, R. (2008). *Regional catalytic economic impacts and noise-damage costs of aviation growth.* (Doctor of Philosophy in Urban and Regional Planning, Massachusetts Institute of Technology). Retrieved from http://dspace.mit.edu/handle/1721.1/45423

Mishan, E. J., & Quah, E. (2007). *Cost benefit analysis*. New York City, NY: Psychology Press. http://dx.doi.org/10.4324/9780203695678

Momigliano, F., & Sinniscalo, D. (1982). The growth of the service sector: a reappraisal. *Banco Nazionale Del Lavoro Quarterly Review, 142.*

Montgomery, C. (1982). The measurement of firm diversification: some new empirical evidence. *Academy of Management Journal, 25*, 299-307. http://dx.doi.org/10.2307/255992

Nobel Media. (2013). Wassily Leontief - facts. Retrieved from http://www.nobelprize.org/nobel_prizes/economic-sciences/laureates/1973/leontief-facts.html

Nobel Media AB. (2014). The Sveriges Riksbank prize in economic studies in memory of Alfred Nobel 1973. Retrieved from http://www.nobelprize.org/nobel_prizes/economic-sciences/laureates/1973/leontief-facts.html

Oosterhaven, J., & Hewings, G. (2014). Interregional input-output models. In M. Fisher, & P. Niijkamp (Eds.), *Handbook of regional science* (875-901). New York, NY: Springer Publishing Company. http://dx.doi.org/10.1007/978-3-642-23430-9_44

Pehrsson, A. (2006). Business relatedness and performance: a study of managerial perceptions. *Strategic Management Journal*, *27*(3), 265-282. http://dx.doi.org/10.1002/smj.516

Pereira, A., & Polenske, K. (1996). Transportation policy and the 1990 clean air act. *Research in Urban Economics, 10*, 117-144.

Pisano, G. P., & Shih, W. C. (2009). Restoring American competitiveness. *Harvard Business Review*, (July), 3.

Polenske, K., Robinson, K. Hong, Y. H., Moore, J., & Stedman, B. (1992). *Evaluation of the south coast air quality management district's methods for assessing socioeconomic impacts of district rules and regulations.* (No. 67, Volume II: Technical Appendices).South Coast Air Quality Management District.

Porter, M. (1998). Clusters and the new economics of competition. *Harvard Business Review, 76*, 77-90.

Porter, M. (2000). Location clusters and company strategy. In G. Clark, M. Gertler & M. Feldman (Eds.), *Oxford handbook of economic geography*. Oxford, UK: Oxford University Press. 253-274.

Porter, M. (2003). The economic performance of regions. *Regional Studies, 37*(August). 549-578.

Pressman, S. (1999). *Fifty major economists*. New York City: NY: Routledge. http://dx.doi.org/10.4324/9780203286081

Quesnay, F. (Ed.). (1759). *Tableau economique* (M. Juczynski, R Meek Trans.). (3rd ed.). London: Macmillan.

Quintero, J. (2007). *Regional economic development: an economic base study and shift-share analysis of Hays County, Texas.* (Masters of Public Administration, Texas State University). Retrieved from https://digital.library.txstate.edu/handle/10877/3656

Romanelli, E., & Khessina, O. M. (2005). Regional industrial identity: cluster configurations and economic development. *Organization Science, 16*(4), 344-358. http://dx.doi.org/10.1287/orsc.1050.0131

Rose, A., & Miernyk, W. (1989). Input-output analysis: the first fifty years. *Economics Systems Research, 1*, 229-271. http://dx.doi.org/10.1080/09535318900000016

Rumelt, R. (1974). *Strategy, structure, and economic performance.* Harvard Business School. http://dx.doi.org/10.2307/3113729

Samuelson, P. (1958). An exact consumption-loan model of interest with or without the social contrivance of money. *Journal of Political Economy, 6*, 467-482. http://dx.doi.org/10.2307/3113729

Sandmo, A. (2011). *Economics evolving: a history of economic thought.* Princeton, NJ: University Press. http://dx.doi.org/10.1111/j.1468-0289.2011.00636_34.x

Sargento, A. (2009). *Introducing input-output analysis at the regional level: basic notations and specific issues.* Urbana, IL: Real Economic Applications Laboratory.

Saric, S. (2012). *Competitive advantages through clusters*. Heidelberg, Germany: Springer Gabler. http://dx.doi.org/10.1007/978-3-8349-3554-0

Shannon, C., & Weaver, W. (1949). *The mathematical theory of communication*. Urbana, IL: The University of Illinois Press.

Siemiatycki, E. (2013). A smooth ride? From industrial to creative urbanism in Oshawa, Ontario. *International Journal of Urban and Regional Research, 37*(5), 1766-1784. doi:10.1111/j.1468-2427.2012.01196.x.

Slaughter, S., & Leslie, L. (1999). *Academic capitalism: politics, policies, and the entrepreneurial university.* Baltimore, MD: Johns Hopkins University Press. http://dx.doi.org/10.5860/0590292

Space Florida. (March, 2014). SpaceFlorida. Retrieved from http://www.spaceflorida.gov/home

Srinivas, S., & Viljamaa, K. (2006). Emergence of economic institutions: analyzing the third role of universities in Turku, Finland. *Regional Studies, 42*(3), 323-341. http://dx.doi.org/10.1080/00343400701291534

Stimpert, J., & Dunhaime, I. (1997). Seeing the big picture: the influence of industry, diversification, and business strategy on performance. *Academy of Management Journal, 40*(3), 560-583. http://dx.doi.org/10.2307/257053

Stimson, R., Stough, R., & Roberts, B. (2002). *Regional economic development: analysis and planning strategy*. Berlin Heidelbert: Springer-Verlag. http://dx.doi.org/10.1007/978-3-662-04911-2

Tapscott, D., & Williams, A. (2006). *Wikinomics: how mass collaboration changes everything*. New York, NY: Penguin Group. http://dx.doi.org/10.1111/j.1468-0270.2008.864_2.x

Jennifer 8. Lee: The hunt for general Tso. Ted Talks (Director). (2008, July). [Video/DVD] TED Conferences, LLC.

The Commission on the Future of the U.S. Aerospace Industry. (2002). *U.S. aerospace and aviation industry: a state by state report.* Arlington, VA: The Commission on the Future of the U.S. Aerospace Industry.

The Netherlands Economic Institute. (1953). Input-output relations. *Proceedings of the Conference on Interindustrial Relations,* Driebergen, Holland.

U.S. Census Bureau. (2012). National accounting industry classification system. Retrieved from http://www.census.gov/eos/www/naics/index.html

United States Department of the Labor. (2011). Bureau of labor statistics. Retrieved from http://www.bls.gov/data/#wages

US Department of Commerce. (2011). In Bureau of Economic Analysis (Ed.), *National economic historical accounts*

US Department of Transportation. (2011). Bureau of transportation statistics. Retrieved from http://www.bts.gov

Venkatesh, H. (August 27, 2010). The power of collaborative innovation. Retrieved from https://www.youtube.com/watch?v=Wye5rh9roh0

Walras, L. (1877). *Elements of pure economics* (W. Jaffe Trans.). New York: Routledge.

Whealan George, K. (2013). The global economic inter-relationships of the US air transportation services industry using input-output analysis. *Advances in Applied Management and Economics*, *3*(3), 1-14.

Wiedmann, T. (2010). Book review: the sustainability practitioner's guide to input-output analysis. *International Journal of Sustainable Development*, *13*(3), 308-310. http://dx.doi.org/10.1504/ijsd.2010.037560

Wolfe, D., & Gerler, M. (2004). Clusters from the inside out: local dynamics and global linkages. *Urban Studies*, *41*(5/6), 1071-1093. http://dx.doi.org/10.1080/00420980410001675832

Yap, S. (2004). Sectoral responses to exogenous displacements: A suggested mode of analysis for a bimodular system. *Malaysian Journal of Economic Studies*, *41*(1/2), 107-119.